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ORIGINAL ARTICLE

Improvement in College Students' Mental Health with KEEP Application during the COVID-19 Outbreak in China

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ABSTRACT

Background. The COVID-19 outbreak in 2019 has hit people hard. **Objectives.** This study explored the impact of college students using Keep Application to exercise on their mental health during the COVID-19 lockdown. **Methods.** Sixty college students who met the experimental criteria were recruited online for a 6-week intervention via the Keep APP. Mental health status was assessed by measuring the symptom self-rating scale (SCL-90) scores before and after the intervention. Data were analyzed using a paired-sample t-test that conformed to a normal distribution. **Results.** Three hundred sixty students participated in the screening, and 60 (22 male and 38 female) met the criteria for the experiment. The prevalence of COVID-19 infection among the participating students was 76.7%. The paired samples t-test showed a statistically significant difference in SCL-90 total scores (t=10.733, p=0.021). The average difference between total scores was 31.75, and the 95%CI was [0.204, 0.448], among which somatization (P=0.002), obsessive-compulsive symptoms (P=0.005), anxiety (P=0.011), and phobia (P=0.043), the factor difference is significant. There were no significant differences in factors such as sensitivity, depression, hostility, paranoia, and psychosis. **Conclusion.** This study verified that using Keep APP during the COVID-19 outbreak helped improve students with mental health problems. This has important implications for coping with mental health problems during outbreaks and the creative use of sports APPs.

KEYWORDS: ***Mental Health, Keep Application, College Students, Depression, Anxiety.***

INTRODUCTION

The COVID-19 outbreak in 2019 has hit people hard. It brings not only harm to people's health but also disorder of social order. Lockdowns were imposed across the country due to the widespread spread of the virus. Students have, therefore, switched their learning mode to online mode. This paradigm shift has led to people starting to suffer from psychological issues amid the ongoing lockdown and has led to fears about the future (1, 2). However, the continued isolation has restricted people's physical activities. In order to maintain daily physical exercise, people have begun to exercise at home. During this period, the downloads and usage of sports and health applications have increased dramatically. The most downloaded one is the Keep App, which has been downloaded more than 1.28 million times a month in China (3).

Mental health is part of college students' physical and mental health and is crucial to their

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studies and lives. The most common mental health diagnoses among students are anxiety and depression. A cross-sectional survey conducted by the China Mental Health Survey (CMHS) during the COVID-19 pandemic shows that Chinese youth and college students have a sharp increase in the risk of depression (22.1%, 23.3%, respectively) and that college students affected by the blockade may experience severe psychological stress, thereby increasing the incidence of depressions (4-7). When college students develop mental health issues, severe symptoms can disrupt college students' relationships, academics, and physical health. Therefore, identifying and controlling these symptoms is critical to the health of college students.

Currently, treatment for depression is mainly dependent on drug therapy. However, due to insufficient awareness of depression, patients with a partial diagnosis of mild-moderate depression may refuse treatment because of mental illness or because of the high cost of drug treatment, long duration of treatment, and side effects (8). Non-pharmacological treatment guidelines recommend physical exercise to reduce symptoms (9). As early as the 2003 SAERS virus epidemic, studies showed that physical exercise can significantly improve the adverse mental health conditions caused by sudden public crises (10). Research has confirmed that regular exercise can reduce stress, reduce the incidence of mental disorders, and help treat a series of psychological problems, such as depression, anxiety, stress, cognitive dysfunction, and many other mental disorders (11). College students are not suitable for drug treatment due to their particular causes, and most of them suffer from mild depression, so using exercise as an alternative therapy is a good choice (12). Research has already shown that aerobic exercise is an effective way to prevent and treat depression before the Covid-19 outbreak (13-17). The body's metabolism speeds up during aerobic exercise, and adrenaline secretion increases, making people happy (13). Some studies have investigated the impact of physical activity levels on depression in college students, and the results show that there are significant differences in depressive mood, cognition, and symptoms between different activity level groups (18-20). However, some studies have shown that the antidepressant effect of physical exercise is not significant and may even increase the risk of mental diseases such as depression. Randomized trial results also have similar findings (21).

Keep APP is characterized by providing professional fitness instruction and scientific fitness (22). The contents include various exercise programs suitable for different groups of people. The app's most basic data recording function can monitor and record the user's movement data and trajectory, combined with the related supporting equipment, can also measure the body's indicators, analyze the monitoring of the user's heart rate and other data, provide users with scientific and reasonable advice, so that users are targeted to exercise. Secondly, the fitness instruction videos, texts, and pictures in the sports APP can meet the different needs of exercisers. Third, the sports APP can also recommend exercise plans for athletes based on their own exercise goals or data monitored by the software during exercise, providing convenience for athletes who cannot formulate exercise plans. The purpose of college students using sports APPs is basically to keep fit or share fitness updates. Few people combine sports APPs with improving mental health. The impact of sports apps on college students is to maintain physical exercise and establish social connections through interactive sharing with other users, reduce loneliness, and benefit mental health. By setting exercise goals and providing regular reminders, these apps can help users stick to their workouts and develop a healthy lifestyle, improving their mental health.

Among existing studies, research on COVID-19 focuses on epidemiology and clinical research, while research on sports APPs mainly focuses on technology upgrades and user satisfaction. Research on improving the mental health of college students is also mainly focused on on-campus counseling and service upgrades. Most of the research examining the impact of exercise on mental health has focused on athletes. Similarly, in the process of responding to sudden large-scale infections like COVID-19, there is an urgent need to come up with more effective methods to improve the mental health of college students. This study investigates the impact of college students' use of KEEP APP on their mental health in the context of large-scale COVID-19 infection. This will provide a reference for treating the mental health of college students and contribute to future responses to mental health problems

caused by sudden infectious diseases. At the same time, the combination of KEEP APP and mental health provides new ideas for the development of sports APP projects.

MATERIALS AND METHODS

The study has been approved by the Research Ethics Committee of Universiti Putra Malaysia under the approval number UPM.TNCPI.800-2/1/7.

Subjects. An online questionnaire survey was conducted among college students in Shandong Province, China. Taking college students in Shandong Province as the research object will bring a certain degree of homogeneity, but the reason for choosing this specific population is that this college's students represent the Chinese population of about 1.4 billion. The population of Shandong Province is more than 100 million, and there are even more students from colleges and universities all over the country. This experiment occurred in 2022, during China's most severe COVID-19 outbreak, when the national policy mandated a complete lockdown. Infected individuals were sent to designated isolation sites, while non-infected individuals were subjected to home isolation and were not allowed to go out freely. Therefore, we recruited participants online. Three hundred sixty students participated in the survey, and after the screening, 62 met the experimental criteria, with 60 ultimately completing the experiment. Due to logistical challenges and the urgent need to address mental health issues during the COVID-19 outbreak, the sample size was limited. While it provides preliminary insights, this limitation does affect the generalizability of our study's findings. These dropouts were excluded to prevent any impact on the accuracy of outcome measures. The inclusion criteria were age between 18 and 26, no contraindications to exercise, SCL-90 total score ≥160, signed experimentally informed consent, and cooperation with the research plan. Exclusion criteria: students with a history of mental illness, sports students, or students with daily training tasks dropping out midway or attending less than 85% of the time. During the experiment, participants were required to report their exercise status weekly, and professional researchers were available to answer questions and provide clarification. Please refer to Figure 1 for detailed procedures.

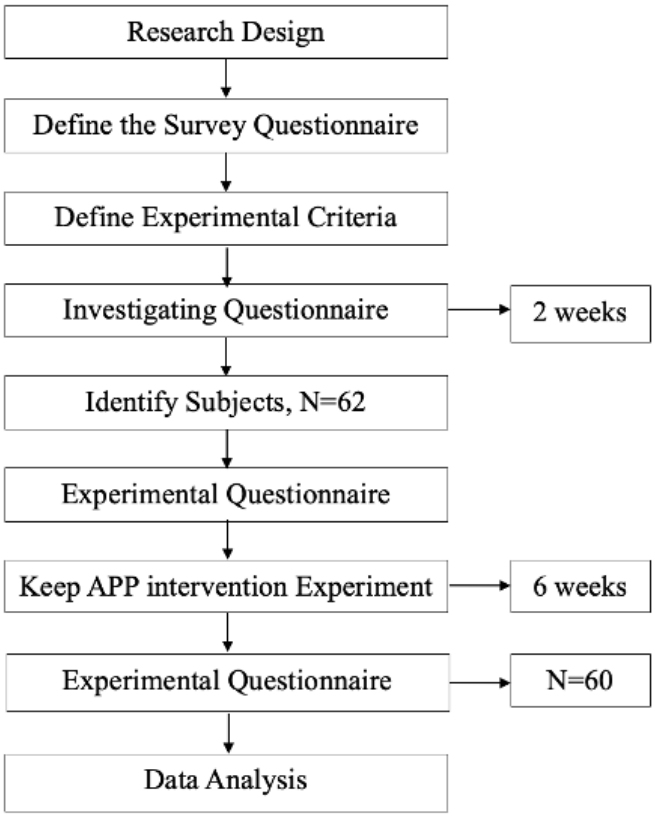

Figure 1. Flowchart of the study.

A 6-week intervention experiment was conducted using the KEEP APP. Subjects were required to exercise at least thrice a week, lasting no less than 45 minutes. The exercise intensity standard adopted Dr. Wang's intervention program (Table 1) (23). This duration was chosen based on preliminary evidence suggesting that initial changes in mental health can be observed within this timeframe. While we recognize that longer-term effects are crucial, the short-term results provide an essential foundation for understanding the potential impact of the KEEP APP.

The questionnaire used the Self-rating Symptoms Scale-90 (SCL-90). This questionnaire is a professional questionnaire related to assessing psychological problems. It is the most widely used mental disorder and mental illness checklist in outpatient settings, providing ten aspects of mental health information. This scale has a high level of validity and reliability and has been used extensively in domestic and international experimental studies. Its Cronbach coefficient is 0.77 ($P<0.01$). This test assesses whether a person has specific psychological symptoms and their severity from multiple aspects such as feelings, emotions, thinking, consciousness, behavior, living habits, interpersonal relationships, diet, and sleep. Subjects were assessed with questionnaires before and after the experiment. We know the potential biases introduced by relying on self-reported data for mental health assessments. Self-reported data, while subjective, provides direct insights from the participants and can be a valuable tool in understanding their experiences. We used validated questionnaires to mitigate bias and ensured participant anonymity, encouraging honest and accurate reporting. After the experiment, 60 people completed the target tasks, and two people withdrew due to poor compliance and failed to complete the tasks. The primary characteristic indicators of the subjects have no statistical significance ($P<0.05$), which meets the experimental requirements.

Table 1. Exercise intervention program for participants exercising using the Keep APP

Exercise Type	Aerobic Exercises	Resistance Exercises
Exercise Style	Running, cycling, Tai Chi, etc.	Free strength exercises (sit-ups, etc.), equipment exercises (dumbbells, etc.)
Exercise Frequency	3~5 times a week.	2~3 times a week.
Exercise Intensity	50%～80% Hrmax; RPE11～16.	1RM 30%～80%; RPE 11～14.
Duration	45~60 minutes per time.	Complete 2 ~ 4 sets of each exercise, repeating each set 8 to 10 times.
Exercise Sequence	5-10min/Low-intensity 30-40min/Moderate Intensity 5-10min/Relax	Start with 1 set of 8 reps, RPE 11 or 12, and gradually increase reps, sets, and resistance.

HRmax: maximum heart rate; RPE: subjective fatigue perception scale; 1RM: maximum weight that can be lifted for 1 maximum repetition.

Statistical Methods. Data analysis was performed using SPSS 26.0. Exploratory data were collected using descriptive analysis and expressed as mean, standard deviation, and percentage. For data normality analysis, the study used the Shapiro-Wilk test. The independent sample t-test was used to verify the difference in mean SCL-90 scores between groups before and after the intervention experiment and to compare the effect of Keep APP on the mental health of college students. In all analyses, $P<0.05$ indicated significant differences and statistical significance.

RESULTS

There was no statistical significance among the fundamental specific indicators of the subjects ($P>0.05$), which met the experimental requirements (Table 2). Among them, 22 were boys (36.7%) and 38 were girls (63.3%). There is little difference in the overall distribution between urban and rural areas, accounting for 55% and 45%, respectively. Students in their fourth year of college accounted for up to 35%, and students without scholarships accounted for 71.7%.

Among the subjects participating in the experiment, 46 students (76.7%) were infected with COVID-19, and the infection levels were moderate primarily (40%) and mild (33.3%). 43.3% of patients recovered within seven days, but most patients recovered in about 14 days. Among the subjects participating in the experiment, there were only 5 patients who were not infected with COVID-

19, accounting for 8.3% of the total number. There was no statistical difference in the above indicators between groups (P>0.05), which met the experimental requirements. See Table 3 for details.

Table 2. Demographic Characteristics of the Subjects

Variables		Experiment (n=60)		*t*	P
		Frequency, n(%)	Mean±SD		
Gender	Male	22, (36.7)	1.63±0.49	-2.614	0.11
	Female	38, (63.3)			
Region	Urban	33, (55.0)	1.45±0.50	-0.24	0.81
	Rural	27, (45.0)			
Academic Year	Freshmen	15, (25.0)	2.67±1.20	0.893	0.372
	Sophomore	11, (18.3)			
	Junior	13, (21.7)			
	Senior	21, (35.0)			
Scholarship	Yes	17, (28.3)	1.28±0.45	2.55	0.13
	No	43, (71.7)			

Values are mean ± standard deviation.

Table 3. Infection of Subjects during COVID-19

Variables		Experiment (n=60)		*t*	P
		Frequency, n(%)	Mean±SD		
Infected COVID-19	Yes	46, (76.7)	1.38±0.74	0.341	0.733
	No	5, (8.3)			
	Possible	9, (15.0)			
Severity of Symptoms	Severe	11, (18.3)	2.32±0.87	1.696	0.091
	Moderate	24, (40.0)			
	Slightly	20, (33.3)			
	Uninfected	5, (8.3)			
Duration of Infection	<7 days	26, (43.3)	1.85±0.94	1.102	0.271
	<14 days	22, (36.7)			
	>14 days	7, (11.5)			
	uninfected	5, (8.3)			

Values are mean ± standard deviation.

After a 6-week exercise intervention using KEEP APP, the subjects' total SCL-90 scores and the levels of each factor changed significantly before and after the experiment (Table 4). The differences between SCL-90 total and post-intervention were statistically significant (t=10.733, P=0.021) after analysis of subjects. The average difference between total scores was 31.75, and the 95% confidence interval was [0.204, 0.448], among which somatization (P=0.002), obsessive-compulsive symptoms (P=0.005), anxiety (P=0.011), and phobia (P=0.043), the factor difference is significant. There were no significant differences in factors such as sensitivity, depression, hostility, paranoia, and psychosis.

Table 4. Within-group comparisons of subjects' SCL-90 scores and factor scores before and after intervention

Items	Pre-test (n=60) Mean±SD	Post-test (n=60) Mean±SD	*t*	P
Somatization	2.04±0.32	1.63±0.24	6.754	0.002*
Obsessive-compulsive symptoms	2.07±0.04	1.63±0.03	2.884	0.005*
Sensitivity	2.09±0.26	1.72±0.21	3.064	0.058
Depression	2.18±0.29	1.66±0.24	3.488	0.053
Anxiety	2.18±0.33	1.66±0.27	8.886	0.011*
Hostility	2.27±0.05	2.21±0.04	1.014	0.315
Phobia	2.05±0.36	1.67±0.24	6.803	0.043*
Paranoia	2.18±0.05	2.10±0.04	1.198	0.236
Psychosis	2.10±0.04	2.01±0.05	1.51	0.136
SCL-90 score	175.52±18.34	143.77±10.85	10.733	0.021*

*: P<0.05

The effects of subjects' exercise style, frequency, and duration on SCL-90 scores using the KEEP APP were compared. The duration of each exercise session had a statistically significant impact on SCL-90 scores (P=0.027). The choice of exercise style and weekly exercise frequency had no statistically significant impact on the SCL-90 score in this study (P>0.05). The standard of the exercise program used in the study may impact the results, thus causing the subjects to choose different exercise styles and exercise frequencies to have an insignificant difference in the impact on SCL-90 scores (Table 5).

Table 5 Subject Intervention of the Keep App during COVID-19

Variables		Experiment (n=60)		*t*	P
		Frequency, n(%)	Mean±SD		
Frequency of exercise	Aerobic exercise	39, (65.0)	1.55±0.81	1.034	0.304
	Resistance exercise	9, (15.0)			
	Others	12, (20.0)			
Frequency of exercise per week	Less than 3 times	8, (13.3)	1.13±0.34	-0.18	0.858
	More than 3 times	52, (86.7)			
Duration per workout	Less than 35 minutes	3, (5.0)	2.13±0.96	2.225	0.027
	45 minutes	21, (35.0)			
	60 minutes	23, (38.3)			
	120 minutes	13, (21.7)			

Values are mean ± standard deviation.

DISCUSSION

The study was conducted during a sweeping lockdown in China during the COVID-19 outbreak. The purpose is to allow college students to improve their poor mental health through exercise on the KEEP APP. The combination of physical exercise and KEEP APP provides practical evidence for alleviating mental health problems among college students. Our study also found that exercise duration had a significant effect on depression and anxiety levels. Isolation during the COVID-19 pandemic has restricted people's physical and social activities, leading to an increase in the prevalence of mental disorders. Depression and anxiety are the most common mental illnesses, which seriously affect an individual's quality of life (24). Correspondingly, in this situation, college students experience varying degrees of psychological problems, such as anxiety and depression. Depression and anxiety are highly correlated, and the influencing factors of different levels of anxiety and depression are not the same. Colleges, universities, and relevant departments should provide precise mental health education to college students (25). In our survey, the COVID-19 infection rate was as high as 88.1%; 13.6% of patients had severe symptoms, and 35.6% had moderate infections. The survey results show a wide range of college students infected with COVID-19. A systematic review of the impact of COVID-19 on mental health demonstrated that exercise can intervene in anxiety and depression in human clinical trials (26).

Previous studies have confirmed that exercise has a positive effect on improving levels of depression and anxiety, relieving stress, etc (27-29). While increasing research supports the effectiveness of aerobic and resistant movement patterns in treating anxiety and post-traumatic stress disorders, most of the evidence linking physical activity to mental health outcomes is focused on the effects of aero-motor training on depression (30). With the rapid development of network applications, people have begun to study the intervention of people's mental health treatment through network applications. Valle and colleagues showed in a recent study that Facebook social network intervention via e-health may help cancer survivors receive health education information and potentially promote physical activity and other related health behaviors (28). However, not all apps have an impact on mental health outcomes. Through popular smartphone apps, Hahn and others introduced female college students to dietary self-monitoring to determine whether it affects other aspects of mental health or health behavior, including dietary intake and exercise (p>0.05) (31).

Therefore, our research aims to improve college students' mental health by exercising

through the KEEP APP. Combined with the effectiveness of physical exercise in treating people's psychological problems, the use of exercise apps during the COVID-19 pandemic has increased dramatically (3, 32, 33). While there were studies on sports apps before 2019, most were aimed at user experience and software development aspects (34-38). However, with the rapid development of society and the increasing number of people with mental health problems caused by various factors, exercise is an effective and convenient means of improving the level of mental health in cases where the side effects of drug therapy are large. The effectiveness is weak, and therefore, more and more research is being done on using exercise as an alternative therapy for treatment. Combining the circumstances of the COVID-19 period with the continuing longevity, we have applied the sports APP to improve the mental health of college students.

The study was carried out during the second massive outbreak of COVID-19 in China, and the blockade policy was strictly enforced in all parts of the country, so we surveyed the high infection rate of university students participating in the questionnaire survey (70.3%), the subjects in the experimental study confirmed infection with Covid-19 was 76.7%, and the non-symptomatic infection was 15.0%. Subjects had higher than normal mental health scores prior to participation in the experiment. This is consistent with previous cross-sectional studies on the prevalence of college student depression and anxiety symptoms during the outbreak of COVID-19 (24, 39-42).In our survey, 96.1 percent of students used a sports app, indicating the widespread use of a sports app among college students. After the experiment, SCL-90 scores decreased, confirming the exercise app's positive impact on college students' mental health.

While our research does not examine the pathways or mechanisms involved in the link between mental health and triggering factors, several potential mixed factors may inspire this topic. In our study, both depression and anxiety have improved to some extent. In the analysis of the intervention factors that influenced the study results, it was found that the effects of the exercise style, the frequency of exercise, and the duration of exercise vary. The duration of exercise has a significant effect on SCL-90 scores. A systematic review has shown a significant moderating effect on the "exercise duration" of training prescribers, as prolonged exercise duration enhances the antidepressant effect of endurance exercise interventions. Studies have shown that the longer 0.62 minutes of exercise, the greater the increase in the magnitude of the antidepressant effect by 10 minutes (43). People who exercise for a long time tend to suffer less from depression than those who do not exercise. Long-term exercise can help improve mental health and reduce the severity of depressive symptoms (44). The influence of the choice of exercise mode and the frequency of exercise in this study is not significant, which may be because the training plan developed for the subjects (Table 1) that we are conducting in the study based on the training program of Wang and others, ensures that the training intensity of the subject is balanced (23). The lack of noticeable results may also be due to conditional constraints, with our intervention only six weeks and a shorter intervention time. In an exercise therapy-effectiveness and dose-response study of depression, Dr. Andrian noted that the effect of motion therapy in patients with mild to severe depression was significant after 12 weeks (45).

High levels of individual negative emotions in the face of major public emergencies are associated with various epidemiological and social-psychological factors, such as the health status of individuals and family members, media exposure, social support, and policy implementation (42). People who regularly use exercise apps recover from their mental health faster, probably because people who frequently use exercise apps tend to pay more attention to their health. They may be better aware of exercise's physical and mental health benefits, which helps maintain a positive mental state. Moreover, the app allows users to share data, challenges, and achievements with friends or community members. Such social interactions can provide social support and motivation that can help improve mental health. People who regularly use exercise apps are generally better mentally, mainly because they have improved their physical and mental health through exercise and a healthy lifestyle.

We explain the findings in this paper in a few constraints. First, the study was conducted in December 2022, when China was in the stage of large-scale infection, with a nationwide blockade restricting people's social activities, with students spread out at home or school, with different environments and psychological conditions.

Moreover, the small sample size of 60 participants limits the generalizability of the findings. The focus on college students in Shandong Province introduces a homogeneity that may not apply to other regions or age groups. The study did not account for external factors such as social support, financial stress, or academic pressure, which could influence mental health during the pandemic. Addressing these issues through more rigorous and comprehensive research designs will enhance the validity and applicability of the findings. Additionally, the scope of analysis is limited, primarily focusing on anxiety, depression, and a few other mental health factors without considering a broader range of psychological outcomes or the mechanisms involved. A deeper discussion of potential mechanisms would provide greater insight into the findings.

Although we relied on self-reported data for mental health assessments, which may introduce potential bias, self-reported data provide direct insights from participants and are valuable for understanding their experiences. We used validated questionnaires to mitigate bias and ensured participant anonymity, encouraging honest and accurate reporting. The six-week intervention period was chosen based on preliminary evidence suggesting that initial changes in mental health can be observed within this timeframe. While we recognize that long-term effects are crucial, the short-term results provide an important foundation for understanding the potential impact of the KEEP APP.

We acknowledge that the absence of a control group is also a limitation. However, we employed pre- and post-intervention comparisons to attribute changes to the KEEP APP. Additionally, qualitative feedback from participants helped us understand their experiences and perceived benefits of the intervention. We plan to conduct further research with longer intervention periods and control groups to comprehensively validate our findings and address these limitations. Future research can aim to improve our study methods, explore integrating fitness apps with mental health, and extend our research to related fields.

Despite these limitations, our study provides valuable information for improving mental health in response to future epidemics. First, using sports APP provides convenience for college students' physical exercise and can better stimulate college students' interest in exercise. Secondly, through our research, we can make everyone realize the importance of maintaining good mental health when facing a large-scale epidemic and learn to use technological means to adjust their mentality. Even after the pandemic, college students should continue to exercise and maintain good physical and mental health to cope with emergencies that may occur. Finally, science and technology advancements are due to increased public demand. We should create an environment that is conducive to ourselves under limited conditions. Through our research, people can understand sports APP and use sports APP rationally.

CONCLUSION

In summary, the analysis of the mental health of college students during the COVID-19 pandemic by the KEEP APP has confirmed that the use of exercise apps by college students can alleviate mental health problems, and these findings help to deal with mental health issues of people during the period of acute infectious diseases. Similarly, it provides valuable insights for further research into software applications.

APPLICABLE REMARKS

- The present study has confirmed that the use of exercise apps by college students can alleviate mental health problems, and these findings help to deal with mental health issues of people during the period of acute infectious diseases.

AUTHORS' CONTRIBUTIONS

Study concept and design: Chao Mengyao, Roxana Dev Omar Der. Acquisition of data: Chao Mengyao, Liu Xiaoxiao. Analysis and interpretation of data: Chao Mengyao. Drafting the manuscript: Chao Mengyao. Critical revision of the manuscript for important intellectual content: Tengku Fadilah Tengku Kamalden. Statistical analysis: Chao Mengyao, Roxana Dev Omar Der. Administrative, technical, and material support: Tengku Fadilah Tengku Kamalden, Maizatul Mardiana Binti Harun. Study supervision: Maizatul Mardiana Binti Harun.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FINANCIAL DISCLOSURE

The authors declare that they have no financial interest in the material in the manuscript.

FUNDING/SUPPORT

The authors declare no funding.

ETHICAL CONSIDERATION

The authors declare that this study has obtained informed consent from all participants and was approved by the Ethics Committee of Universiti Putra Malaysia. The approval number is UPM.TNCPI.800-2/1/7. Relevant details are provided in the "Materials and Methods" section of the article.

ROLE OF THE SPONSOR

The authors declare that this study has no funding and, thus, no conflicts of interest.

ARTIFICIAL INTELLIGENCE (AI) USE

This article results from the authors' independent efforts, and no AI tools were used in its creation.

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