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Improving College Students' Depression During an Acute Pandemic Disease with the KEEP Application

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ABSTRACT

Background: During the Covid-19 epidemic, the number of downloads of sports apps surged, with people using sports apps to exercise and share social activities. **Objective:** This study aimed to explore the impact of college students using Keep APP to exercise on their mental health during the COVID-19 lockdown. **Methods:** This study utilized a longitudinal research methodology to conduct a 6-week intervention experiment with college students using the KEEP application based on the intervention criteria of the study. The psychological status of the university students before and after the experiment was evaluated through the Self-Rating Depression Scale (SDS) and Self-Rating Anxiety Scale (SAS). On the basis of satisfying the normal distribution, the was used for data analysis. **Results:** A total of 60 college students participated in this study (22 boys and 38 girls). Among them, 46 people (76.7%) were infected with COVID-19. After a 6-week exercise intervention using Keep APP, through paired-sample t-tests, significant differences were observed in SDS scores before and after the experiment ($t = 10.33$, $p = 0.051$). The mean difference was 5.82, with a 95% confidence interval of [6.436, 9.197], indicating a moderate effect on depressive emotions in the experimental group. Similarly, SAS scores also showed significant differences before and after the experiment ($t = 4.889$, $p = 0.005$). The mean difference was 2.18, with a 95% confidence interval of [1.88, 4.486], demonstrating a moderate to large effect.There was no statistically significant effect of choice of exercise modality and frequency of exercise per week on scores in this study ($P>0.05$). Additionally, the duration of exercise shows a significant effect on SAS scores ($P =0.027$). **Conclusion:** This study verified the impact of using Keep APP on the mental health of college students during the COVID-19 outbreak, and confirmed that the application can help improve students with mental health problems. These findings provide help in dealing with people's mental health problems during sudden infectious diseases. Similarly, it also provides valuable insights for further research on software applications.

Key words: COVID-19, College Students, Keep Application, Depression, Anxiety.

INTRODUCTION

The outbreak of the sudden infectious disease COVID-19 has seriously jeopardized people's health and caused disruption in the social order, which has not yet stopped spreading. Due to the widespread nature of the virus, China implemented a blockade policy during periods of high transmission. In this situation, schools also shifted their programs to online web-based instruction. This paradigm shift resulted in people beginning to suffer from psychological problems during the ongoing lockdown and caused people to begin to worry about the future(Hall et al., 2021; Mahase, 2020). However, the continued segregation limited people's physical activity and in order to maintain their physical activity routine, people began to exercise at home, during which time the download and use of exercise and health apps skyrocketed. One of the most downloaded apps was the Keep App, with 1.28 million monthly downloads in China (Market, 2022).

Anxiety and depression are the most frequent mental health diagnoses among college students, whose mental health status is crucial to their studies and lives. A cross-sectional survey study conducted by the China Mental Health Survey (CMHS) during the COVID-19 pandemic revealed a steep increase in the risk of depression among Chinese youth and college students (22.1% and 23.3%, respectively), and that college students affected by the embargo may experience severe psychological stress, thus increasing the incidence of depression(Chi et al., 2022; Holmes et al., 2020; Huang et al., 2019). When college students experience mental health problems, severe symptoms can undermine their relationships, academics, and physical health(Wang

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et al., 2020). Therefore, recognizing and managing these symptoms is critical for the well-being of college students.

Currently, treatment modalities regarding depression rely mainly on medication. Due to the lack of awareness of depression, some patients diagnosed with mild to moderate depression may refuse treatment due to the stigma of mental illness or abandon treatment due to the length of time and high cost of medication and the side effects that occur after taking medication(Faulkner et al., 2021). In the guidelines for non-pharmacological treatment of depression, patients are recommended to reduce their symptoms through physical activity(Ma et al., 2020). As early as 2003, during the SAERS virus epidemic, studies have shown that physical activity can significantly improve poor mental health due to sudden crisis events(Xie et al., 2021). Studies have confirmed that regular exercise reduces stress, decreases the prevalence of mental disorders, and contributes to the treatment of psychological disorders such as depression, anxiety, stress, and cognitive dysfunction(Yao et al., 2019).

College students are not suitable for medication due to their specific etiology and most of them are mildly depressed, so the use of exercise as an alternative therapy is a good choice(Li, 2014). Research has confirmed that aerobic exercise is an effective way to prevent and treat depression(Blumenthal et al., 2007; Carek et al., 2011; Gustafsson et al., 2009). During aerobic exercise, the body's metabolism speeds up and adrenal hormone secretion increases, and these physical changes lead to feelings of pleasure and well-being(Blumenthal et al., 2007). One study investigated the silver lining of physical activity levels on depression among college students and showed significant differences in depressive mood, cognition, and symptoms between activity level groups(Hua & Sun, 2021; Kim et al., 2021; Xue & Xu, 2020). However, there have also been studies indicating that the antidepressant effect of physical activity is not significant and may even increase the risk of psychiatric disorders such as depression (Fang & Guo, 2019).

Keep APP is characterized by providing people with professional fitness teaching guidance and scientific fitness(Keep, 2023). The content contains a variety of sports workout programs, suitable for different exercise groups. The most basic data recording function of the APP can monitor and record the user's exercise data and trajectory, combined with the relevant supporting equipment can also measure the body's indicators, analyze and monitor the user's heart rate and other data, to provide users with scientific and reasonable advice, so that users can target exercise. Secondly, the fitness teaching video, text and pictures in the sports APP can meet the different needs of exercisers. Sports APP can also recommend exercise programs for exercisers based on the exercise goals set by the exercisers themselves or the data monitored by the software during the exercise process, providing convenience for exercisers who can't make exercise programs.

The primary purpose for college students using sports apps is generally to improve physical fitness or share workout updates, with few utilizing sports apps concurrently to enhance their mental health. The impact of sports apps on college students is not only to maintain physical exercise, but also to establish social connections through interactive sharing with other users, reducing loneliness and benefiting mental health. By setting exercise goals and providing regular reminders, these apps can help users stick to their workouts and develop a healthy lifestyle, which can improve mental health.

Among the existing studies, the research on COVID-19 mainly focuses on epidemiological and clinical studies(Ochani et al., 2021; Sharma et al., 2021), while the research on sports APPs mainly focuses on technological upgrading and user satisfaction(Helleman et al., 2020; Rai et al., 2021; Soomro et al., 2019). Research on improving the mental health of college students has also focused mainly on campus counseling and service upgrades(Alvarez-Hernandez et al., 2022; Timmerman & Volpe, 2023). Studies validating the effects of exercise on mental health also mostly focus on athletes(Antoniak et al., 2022; Strohle, 2019). Therefore, there is an urgent need to propose more effective methods to improve the mental health of college students in the process of coping with sudden mass infections like COVID-19. In this study, we investigated the effects of using Keep APP on the mental health of college students in the context of the COVID-19 mass infection. In this way, it provides a reference for treating the mental health of college students and contributes to the future response to mental health problems caused by sudden infectious diseases. Meanwhile, the combination of KEEP APP and mental health provides new ideas for the program development of sports APP.

MATERIALS & METHODS

Participants and Study Design

This study was part of a PhD thesis in Exercise Science and was approved by the Research Ethics Committee of Universiti Putra Malaysia under the approval number: UPM.TNC-PI.800-2/1/7.

The study conducted a survey on college students in Shandong Province, China, using an online questionnaire. In the preliminary phase, a total of 360 students were recruited to participate in the survey. Strict inclusion and exclusion criteria were applied to screen participants based on the results of the SCL-90 questionnaire, resulting in 62 students voluntarily participating in the subsequent intervention experiment. After the experiment, a total of 60 students successfully completed the tasks, with 2 dropouts. The reasons for dropout were poor compliance (1 student unable to adhere to the training tasks, requesting voluntary withdrawal from the intervention) and failure to meet task requirements (1 student with attendance rate below 60%, excluded). To prevent any impact on the accuracy of outcome measures, these dropouts were excluded.

The inclusion criteria for the study were: age between 18 and 26, no contraindications for exercise, SCL-90 total score ≥160, signing the informed consent form, and cooperation with the research plan. Exclusion criteria included a history of mental illness, athletes or students with daily training tasks, and mid-term withdrawal or attendance below 85%.

During the experiment, participants were required to report their exercise status weekly, and professional researchers were available for answering questions and providing clarification. Please refer to Figure 1 for detailed procedures.

This study utilized a longitudinal research methodology to conduct a 6-week intervention experiment with college students using the KEEP application based on the intervention criteria of the study. The psychological status of the university students before and after the experiment was evaluated through the Self-Rating Depression Scale (SDS) and Self-Rating Anxiety Scale (SAS). Subjects were asked to perform exercises according to their chosen exercise style. The exercise intensity standard adopted Wang's exercises intervention program (Table 1)(Wang et al., 2022). Participants should pay attention to the following before engaging in aerobic exercise intervention: basic medical checks must be conducted to rule out contraindications to exercise; initial exercise should be gradual, with a progressive increase in exercise duration; precautions should be taken to prevent falls. In resistance training, the progression of exercise load should be gradual; prolonged breath-holding exercises should be avoided; equipment exercises should be performed under monitored conditions.

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 both domestic and international experimental studies. The Cronbach coefficient is 0.77 (P<0.01). The purpose of this test is to assess whether a person has certain 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. After the experiment, a total of 60 subjects completed the target tasks, and 2 subjects withdrew due to poor compliance and failed to complete the tasks. The basic characteristic indicators of the subjects have no statistical significance (P<0.05), which meets the experimental requirements.

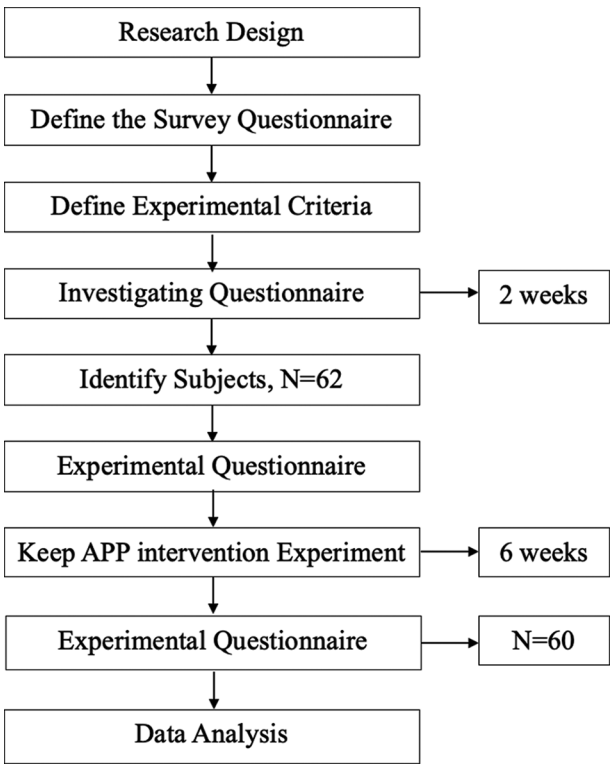

Figure 1. Flowchart of the study

Statistical Methods

Data analysis was performed using SPSS 26.0. Exploratory data were conducted using descriptive analysis and expressed as mean, standard deviation and percentage. For data normality analysis, the study used the Shapiro-Wilk test. The paired-sample t-test was used to validate the difference in the mean scores of SCL-90 between the intervention group before and after the intervention, comparing the effect of the Keep APP on depressive emotions during the COVID-19 period. In all analyses, P<0.05 indicated significant differences and statistical significance.

RESULTS

There was no statistical significance among the basic 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%.

The COVID-19 infection status was filled out by the subjects according to the actual situation through a online-questionnaire. Among the subjects participating in the experiment, 46 students (76.7%) were infected with COVID-19, and the infection levels were mostly moderate (40%) and mild (33.3%). 43.3% of patients recovered within 7 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.

After a 6-week exercise intervention using Keep APP, there were large changes in the mean total SDS and SAS scores of subjects before and after the experiment (Table 4). Through paired-sample t-tests, significant differences were observed in SDS scores before and after the experiment (t=10.33, p=0.051). The mean difference was 5.82, with a 95% confidence interval of [6.436, 9.197], indicating a moderate effect on depressive emotions in the experimental group. Similarly, SAS scores also showed significant differences before and after the experiment (t=4.889, p=0.005). The mean difference was 2.18, with a 95% confidence interval of [1.88, 4.486], demonstrating a moderate to large effect.

Keep APP was used to compare the effects of subjects' exercise styles, exercise frequency, and exercise duration

Table 1. Exercises 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; RPE11~6.	1RM的30%~80% RPE11~14.
Duration	45~60 minutes per time.	Complete 2~4 sets of each exercise, repeating each set 8 to 10 times.
Exercise Sequence	5-10 min/Low intensity 30-40 min/Moderate Intensity 5-10 min/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

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

on SDS scores and SAS scores. The duration of each exercise session had a statistically significant effect on scores (p=0.027). There was no statistically significant effect of choice of exercise modality and frequency of exercise per week on scores in this study (P>0.05). The exercise program criteria used in the study may have had an impact on the results, resulting in a non-significant difference in the effect of the subjects' choice of exercise modality and frequency of exercise on the scores (Table 5).

DISCUSSION

This study was conducted during the sweeping lockdown in China amid the outbreak of the COVID-19 pandemic. The purpose was to enable college students to improve their poor mental health conditions through exercise on the Keep APP. The combined effect of physical exercise and the Keep APP provides effective 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(Lee et al., 2021). Correspondingly, under 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 exactly the same. Colleges and universities and relevant departments should provide precise mental health education to college students(Chang et al., 2020). In our survey, the COVID-19 infection rate was as high as 88.1%, 13.6% of patients had severe symptoms, and 35.6% of patients had moderate infections. The survey results show the wide range of college students infected with COVID-19. A systematic review on the impact of COVID-19 on mental health demonstrated that exercise can intervene in anxiety and depression in human clinical trials(Hu et al., 2020).

Previous studies have confirmed that exercise has a positive effect on improving levels of depression and anx-

Table 4. Within-group comparison of SDS scores and SAS scores in subjects before and after intervention

Items	Pre-test (n=60)	Post-test (n=60)	95% Confidence Interval		*t*	P
	mean±SD	mean±SD	Lower	Upper		
SDS Score	45.52±3.09	39.7±4.19	6.436	9.197	10.33	0.051
SAS Score	39.78±4.09	36.6±3.25	1.88	4.486	4.889	0.005

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

Variables	Experiment (n=60)		*t*	P
	Frequency, n (%)	Mean±SD		
Exercise Styles				
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

iety, relieving stress, etc(Lin et al., 2022; Ni et al., 2019; Song et al., 2021).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 aeromotor training on depression(Smith & Merwin, 2021). In our study, we did not emphasize whether the participants' exercise style was aerobic or resistance training. Due to the diverse selection of exercise styles on the KEEP APP, we requested participants to exercise according to our intervention criteria in order to minimize interference with the results. Nowadays, with the development of online applications, researchers are exploring interventions for mental health treatment through online applications. A study found that intervention through the Facebook social network via e-health may assist cancer survivors in receiving health education information and potentially promote physical activity and other related health behaviors (Lin et al., 2022). 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(Hahn et al., 2021).

Therefore, our research is aimed at improving the mental health of college students by exercising through the Keep APP. Combined with the effectiveness of physical exercise in the treatment of people's psychological problems, the use of exercise apps during the COVID-19 pandemic has increased dramatically(Chen, 2023; Jin, 2022; Market, 2022). While there are studies on sports apps before 2019, the majority of the studies are aimed at user experience and software development aspects(Cao, 2022; Deng & Tan, 2022; Guo, 2023; Wang, 2023; Zhao, 2022). 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 and the effectiveness is weak, and therefore more and more research is using exercise as an auxiliary 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(Gilley et al., 2022; Han et al., 2022; Lee et al., 2021; Romero Blanco et al., 2020; Yuan et al., 2022). In our survey, students using sports apps accounted for 96.1%, indicating that sports apps are widely used among college students. After the end of the experiment, both SAS and SDS scores decreased, confirming the positive impact of sports apps on the mental health of college students. The results of this study indicate a significant improvement in the mental health condition of participants after a 6-week exercise intervention. Both SDS and SAS scores showed a decrease, but the significance level for SDS score was 0.051, which did not reach statistical significance in this study.

While our research does not specifically aim to explore the pathways or mechanisms linking mental health with triggering factors, the inclusion of various potential confounding factors may provide insights into this subject. In our study, there was an observed improvement in both depression and anxiety to some extent. Upon analyzing the intervention factors influencing the study results, variations were identified in the effects of exercise style, exercise frequency, and

exercise duration. Notably, the duration of exercise emerged as a significant factor affecting mental health scores. Previous studies suggest that individuals engaging in long-term exercise tend to experience lower levels of depression compared to non-exercisers. Long-term exercise has been associated with improvements in mental health and a reduction in the severity of depressive symptoms(Stanton & Reaburn, 2014). In our study, the influence of the chosen exercise styles and exercise frequency did not show statistical significance. This might be attributed to the training plan implemented for the participants, as detailed in Table 1, which was based on the program developed by Wang and others. This approach aimed to ensure a balanced training intensity for the subjects(Wang et al., 2022). The lack of noticeable results could also be influenced by conditional constraints, given the relatively short duration of our six-week intervention. In a study on the effectiveness and dose response of exercise therapy for depression, Dr. Andrian highlighted that the significant effects of physical activity on patients with mild to severe depression were observed after a 12-week intervention period(Dunn et al., 2005).

Elevated levels of individual negative emotions during significant public emergencies are linked to various epidemiological and social psychological factors, including the health status of individuals and their family members, media exposure, social support, and the implementation of policies (Han et al., 2022). Individuals who consistently engage with exercise apps tend to experience faster recovery in mental health, likely attributable to their heightened awareness of health. Regular app users are more conscious of the physical and mental health benefits associated with exercise, contributing to the maintenance of a positive mental state. Additionally, these apps facilitate the sharing of data, challenges, and achievements among users, fostering social interactions that provide crucial social support and motivation. This social connectivity plays a role in enhancing mental health outcomes. Generally, individuals who incorporate exercise apps into their routine exhibit better mental well-being, primarily due to the positive impact of regular exercise and a health-conscious lifestyle on their physical and mental health.

We explain the findings in this paper in a few constraints. First of all, the study was conducted in December 2022, at a time when China is in the stage of large-scale infection, with a nationwide blockade that restricts people's social activities, with students spread out at home or at school, with different environments and different psychological conditions. Secondly, college students' mental health symptoms are based on self-reporting rather than clinical diagnosis, and our research is limited by resources and cannot conduct routine face-to-face tests during the study, so that the information in self reporting may be biased. Finally, due to the small sample volume, there was no detailed analysis of the mixed factors affecting the mental health of university students, and there is no budget for possible deviations in experimental results.

Despite these limitations, our study provides useful information for improving mental health in response to future epidemics. First of all, the use of 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 a good mental health state at all times when facing a large-scale epidemic, and learn to use technological means to adjust their mentality. Even after the epidemic, college students should continue to exercise and maintain good physical and mental health in order to cope with emergencies that may occur in the future. Finally, the advancement of science and technology is due to the increase in public demand. We should create an environment that is conducive to ourselves under limited conditions. Through our research, people can understand sports APPs and use sports APPs 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.

Although this study has achieved some results, it provides important reference and guidance for the development of sports APPs and the improvement of mental health. It is of great significance for responding to mental health problems during sudden infectious diseases and the development of sports APPs. However, there are still many issues that require further research. For example, in this study, factors related to exercise were controlled, but some sociological factors (the impression of interrupted education and the impact of surrounding deaths due to COVID-19) need to be paid attention to. The impact of behavioral factors (the effects of alcohol and drug use) and public health measures on the mental health of college students. These can have long-term, unintended consequences for college students.

Therefore, future research can be dedicated to improving our research methods, in-depth exploration of the combined use of sports APPs and mental health, and extending our research to related fields.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The research design of this experiment was carried out under the supervision of Prof.Tengku and Dr.Roxana. The experimental manipulation and data collection were carried out by Chao Mengyao and Liu Xiaoxiao. The draft of the article was done by Chao Mengyao. Dr.Maizatul supervised the theory and Dr.Roxana proofreading of the article.

DATA AVAILABILITY

Specific research data can be requested by sending an email to the author, Chao.

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None.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Universiti Putra Malaysia under the approval number: UPM.TNCPI.800-2/1/7. All participants in this study have signed informed consent forms.

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