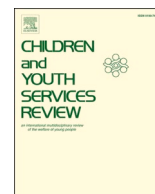




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Intervention of adolescent' mental health during the outbreak of COVID-19 using aerobic exercise combined with acceptance and commitment therapy

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ABSTRACT

Objective: To explore the intervention effect of aerobic exercise in combination with acceptance and commitment therapy on mental health of adolescents during the outbreak of COVID-19 based on the theory of the dual-factor model of mental health.

Methodology: 1200 adolescents aged 12–19 in Fujian Province, China were screened by means of the dual-factor model of mental health from March to April 2020. 30 vulnerable, 30 symptomatic but contented and 30 distressed adolescents were selected as the experiment objects, and these 3 types of adolescents were randomly divided into the intervention group and the control group. Among them, the intervention group received 8 weeks of aerobic exercise in combination with acceptance and commitment therapy, 3 times a week, about 40–60 min each time. The control group, however, didn't receive any intervention other than routine mental health education. Measurements were made before and after the intervention.

Results: (1) For vulnerable, symptomatic but contented and distressed individuals, before the intervention, there is no significant difference between the intervention group and the control group in terms of psychological distress, well-being and psychological flexibility ($P > 0.05$). After the intervention, psychological distress and experiential avoidance is significantly lower in the intervention group than in the control group, but all dimensions of well-being is significantly higher in the intervention group than in the control group ($P < 0.05$). (2) For vulnerable, symptomatic but contented and distressed individuals, before and after the intervention, there are significant differences in psychological distress, well-being and psychological flexibility of the intervention group ($P < 0.05$), but there are no significant differences in the control group ($P > 0.05$).

Conclusion: Attention should be paid to the problems of mental health of adolescents caused by the sudden outbreak of public health incidents. Aerobic exercise in combination with acceptance and commitment therapy is feasible and effective for the intervention in mental health of adolescents.

1. Introduction

Coronavirus disease 2019 (COVID-19) not only brings about huge economic losses to the society, but also imposes heavy economic and spiritual burdens on many families (Ahmed et al., 2020). In addition, it leads to more serious psychological problems in adolescents in the online learning environment. - Due to the absence of targeted drugs and regimens, as well as the strong infectivity of COVID-19, a certain degree of panic has been stirred among the public, bringing a negative influence on mental health of the public (Chang et al., 2020). On January 30, 2020, the WHO defined COVID-19 as a public health emergency of international concern. Public health emergencies refer to the sudden occurrence of major infectious diseases, unexplained mass diseases,

major food and occupational poisoning and other events that have caused or may cause serious damage to public health. During the COVID-19 epidemic, some researchers surveyed 7,236 Chinese netizens on the basis of social websites, and the results show that the incidence rate of generalized anxiety disorder is 35.1%, the prevalence rate of depression is 20.1%, and the prevalence rate of sleep disorder is 18.2%. The results also show that the prevalence rates of anxiety, depression and sleep disorder are significantly higher in low age groups than in high age groups (Huang & Zhao, 2020). To prevent and control the epidemic, protect health of adolescents, and minimize human-to-human transmission of COVID-19 at school, many nations specified that offline learning of adolescents should be changed to online learning. This chance lowers the interpersonal communication and perceived social

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support of adolescents (Dun, 2020). It was pointed out in some reports that this kind of online learning at home leads to lower mental health and more negative emotions in adolescents. Therefore, the psychological problems of adolescents are more prominent during the COVID-19 Epidemic in such an online learning environment (Song et al., 2019) (see Fig. 1).

Traditional mental health models mainly adopt negative psychopathological criteria, so that their reliability and validity are inadequate (Wang et al., 2011). With the development of positive psychology, the tradition of simply taking negative indicators as the diagnostic basis has been gradually improved. Researchers further supplemented positive indicators, for example, subjective well-being, and formed a dual-factor model of mental health (DFM) (Antaramian et al., 2015). DFM divides people into four categories according to the mental health: healthy, vulnerable, symptomatic but contented and distressed individuals, and advocates that mental health assessment should be conducted in two dimensions: negative mental health indicators and positive mental health indicators. The former mainly refer to psychopathological symptoms like depression and anxiety, while the latter mainly refer to subjective well-being, which is generally composed of three components: life satisfaction, positive affect and negative affect. DFM quadrant theory is one of the classification standards of DFM supported and held by many researchers (Suldo & Shaffer, 2008; Greenspoon & Saklofske, 2001). The advantage of DFM lies in its ability to distinguish and diagnose complete and partial states of mental illness and mental health, and provide more effective prevention and intervention plans. DFM has been adopted by mental health professionals to monitor and identify adolescents and adult citizens who are in need of assistance (Antaramian et al., 2015). Suldo and Shaffer (2008) explored the existence and validity of the dual-factor model of mental health in early puberty, and comprehensively measured mental health by using positive indicators of health (i.e. subjective well-being) and traditional negative indicators of diseases (i.e. psychopathology). Through self-reported scales, school records and teachers' reports, they evaluated subjective well-being, psychopathology, academic functions, social adaptability and physical health of 349 middle school students. This experiment supports the effectiveness of the dual-factor model and offers a new insight for the

comprehensive measurement of adolescents' mental health. DFM has also been verified to be completely applicable to Chinese adolescents due to its advantage of implementing mental health promotion plans in a targeted way. Therefore, it is very necessary to apply DFM in the field of promoting mental health of adolescents.

Previous studies have shown that physical exercise exerts a good intervention effect in improving the positive psychological state of adolescents and reducing their negative psychotic symptoms (Xiong et al., 2017; Rodriguez-Ayllon et al., 2019). However, physical exercise alone is slightly inadequate in improving positive mental quality of adolescents, especially their mental quality to deal with negative stress events (Wang & Zhang, 2011). At present, acceptance and commitment therapy (ACT) presents a good intervention effect on the improvement of mental health. It was found in experiments that ACT has a certain efficacy in relieving negative emotions, depression and anxiety that are triggered by long-term chronic pain (Wright et al., 2014). Afterwards, some researchers further expanded the application scope of ACT from the perspective of positive psychology, and confirmed that ACT produces an evident effect on the improvement of adolescents' self-compassion and well-being, and is also effective in the mental health education and prevention of psychological problems in adolescents (Armstrong et al., 2013). However, at present, there are no literatures on the application of ACT in the research of mental health problems of adolescents. In summary, under the influence of the current epidemic, it is especially important to pay attention to mental health of adolescent. In this study, the adolescents were first divided according to the classification standard of the dual-factor model, and aerobic exercise was innovatively combined with ACT to formulate a set of acceptance and commitment interventions. The application of this approach in the intervention experiment is expected to offer a new insight and reference for the intervention in adolescents' psychological problems in particular cases such as online learning and sudden public health emergencies.

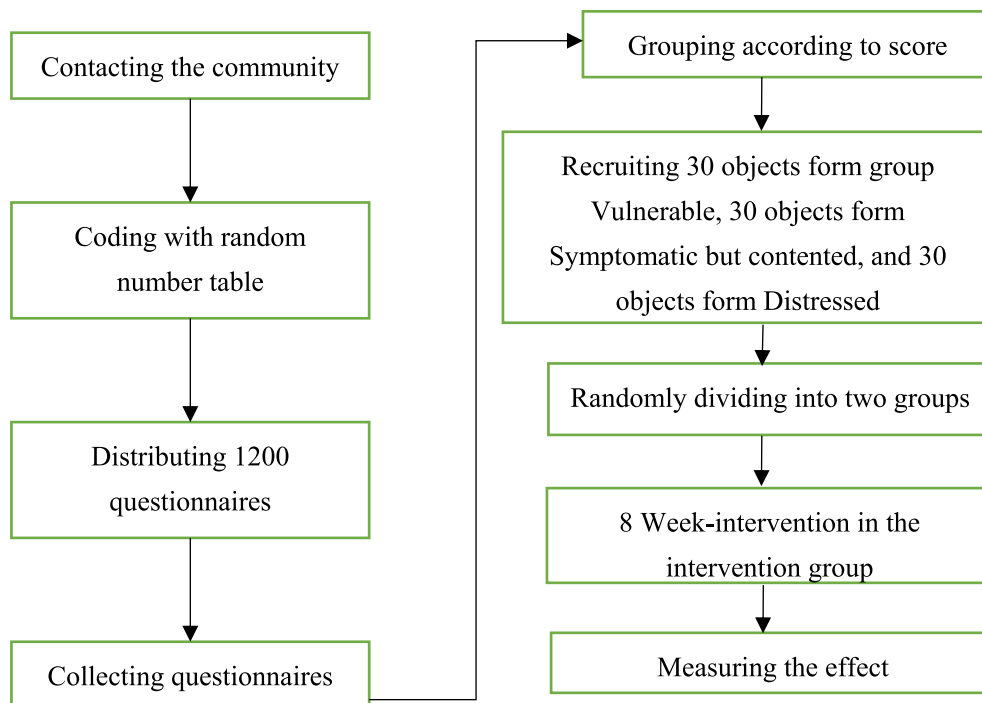


Fig. 1. Experiment sample selection process.

2. Objects and methodology

2.1. Research objects

The objects of this study are 1200 adolescents in Fujian Province of China aged 12–19 years, with an average age of 13.99 ± 0.49 . A total of 1,200 copies of the questionnaire were distributed, and 1,018 valid copies were collected after the invalid ones were eliminated, and the recovery rate is 84.83%. The questionnaire includes gender (460 males and 558 females), age (13–19 years) and whether the only child or not (413 with yes and 605 with no). All the participants got involved on a voluntary basis. Before the survey, they had been informed of the research purpose, content and intervention methods and all the scales were filled in anonymously. This study was approved by the medical ethics branch of Fujian Medical Association before the implementation of intervention. The first step after being approved by the medical ethics branch was to contact and explain the content of the study to the school administrators and teachers and to get their approval and support. Secondly, the purpose, method and content of the study were explained to the participants, with emphasis on voluntary participation and the requirements of participation. Then, the purpose and method of the study were explained to the parents (guardians) of the participants, to obtain their permission and support, and ensure that each participant has a guardian to sign the informed consent. Finally, the participants were determined through the three steps above, and then the participants were asked to sign the informed consent.

2.2. Tools

(1) General Health Questionnaire (GHQ-12) (Goldberg & Hillier, 1979) was developed by Taiwan scholar Zheng Tai'an who incorporated Chinese cultural characteristics into General health Questionnaire-12 (GHQ-12). This scale is composed of 12 items and the standard scoring method of GHQ-12 was employed in this study. 0 point would be scored for the first two options of the question and 1 point would be scored for the last two options of the question. The total score ranges from 0 to 12. A higher score means worse mental health. Among them, 3 points is the cut-off value. Domestic studies have shown that this scale has a high sensitivity in epidemiological surveys of all kinds of mental diseases. It is a suitable screening tool for mental disorder and can be used in the dual-factor model of mental health. The internal consistency of the study is 0.807 (Li & Li, 2015).

(2) W-E Well-being Scale (Tennant et al. 2007), also known as Warwick-Edinburgh Mental Well-being Scale (WEMWBS), was developed by Tennant et al. (2007). There are a total of 14 positively worded items and Likert's 5-point scoring method is employed. The original scale has been widely used in the UK, showing good reliability and validity, with its test-retest reliability being 0.83 and internal consistency reliability being 0.91. It has been proved to be suitable for the evaluation of positive mental health and has the following three characteristics: first of all, it is concise and easy-to-operate; secondly, it integrates positive emotions (3, 5, 7 and 14), positive psychological functioning (1, 6, 8, 9, 10 and 11) and interpersonal relationship satisfaction (2, 4, 12 and 13) that reflect mental health, basically consistent with Keyes and Annas' (2009) proposal that positive mental health is mainly divided into emotional well-being, psychological well-being and social well-being. Thirdly, it can be applied to students and general population and has good reliability and validity. The Cronbach's α of this scale in this study is 0.83.

(3) Acceptance and Action Questionnaire-2nd Edition (AAQ-II) (Bond et al., 2011). This scale was originally developed by Bond et al. based on the acceptance dimension of ACT theory and is used to assess the level of experiential avoidance. Cao et al. (2013) introduced it to China and revised it into the Chinese version which is composed of 7 items in total, scoring from 1 (never) to 7 points (always). Those with high scores have higher levels of experiential avoidance, as well as lower

psychological flexibility. In this study, the Cronbach's α of this scale is 0.88 and the reliability and validity are good. Currently, quite a few studies have taken psychological flexibility as the intervention goal of ACT. Therefore, whether individual psychological flexibility has been improved is also the best indicator reflecting the intervention effect of ACT (Cao et al., 2013).

2.3. Research methods

The copies of the questionnaire were distributed in a collective way in the community. Unified questionnaire instructions were used. The objects of this study are adolescents in the community. The data were input and sorted out using Excel 15.41 and SPSS24.0 was used to analyze the data.

2.3.1. Grouping

1,018 students were selected according to the following criteria: after psychological measurement with the dual-factor model of mental health (the results are shown in Table 2), they were divided into four types: healthy, vulnerable, symptomatic but contented and distressed individuals. Then, volunteers for this study were recruited from these three groups: vulnerable, symptomatic but contented and distressed individuals. Exclusion criteria: ① those who were at risk of suicide; (2) those who took psychotropic drugs or received psychotherapy in the last three months; (3) those who were unwilling to take part in this study, or cannot ensure to participate in this study for 8 successive weeks. ④ through one-on-one interviews, the researchers excluded those who were unfit for group intervention based on ACT. With the informed consent of the volunteers, 30 adolescent who met the requirements above were selected from each type as the experiment objects, and randomly divided into the intervention group and the control group (Details are shown in Table 1).

2.3.2. Intervention plan

The intervention group received aerobic exercise in combination with ACT as an online intervention for 8 weeks, 3 times a week, about 40 ~ 60 min each time, while the control group didn't receive any intervention. Before and after the intervention, measurements were adopted to compare the effects. During the intervention experiment, 1 vulnerable individual in the intervention group did not join in the intervention of ACT. 2 symptomatic but contented individuals and 3 distressed individuals dropped out. Finally, there are 14 vulnerable, 13 symptomatic but contented and 12 distressed individuals in the intervention group. In the control group, only 1 distressed individual dropped out. Finally, there are 15 vulnerable, 15 symptomatic but contented and 14 distressed individuals in the control group.

According to their personal preferences, the intervention group selected jogging, yoga, basketball and other activities for aerobic exercise intervention. All activities were conducted in the form of group activity, except jogging of which the time and frequency was recorded by punching in a sports APP. The sports APP used in this experiment is Keep (Ma & Yuan, 2018). This punch-in software can connect a sports watch to the computer side, and record all details of the exercise such as calorie consumption and length of exercise etc. by means of punch-in. The punch-in plan can be preset by the members of the research team. If the exercise plan established is not finished on time, reminders would

Table 1
Measurement grouping standard of the dual-factor model.

| | Subjective well-being < 56 | Subjective well-being \geq 56 |
|---------------------------------|----------------------------|---------------------------------|
| Psychological distress < 3 | Vulnerable | Healthy |
| Psychological distress \geq 3 | Distressed | Symptomatic but contented |

be given unceasingly in the form of alarm clock on the watch. The punch-in data of all the participants can be shared on the computer, so that the members of the research team can monitor exercise quality, so as to guarantee the authenticity and reliability of the study. The intervention time in this experiment is 8 weeks, 3 times a week, 40 ~ 60 min each time. During the intervention, the researchers should communicate with the participants in a timely manner and learn about their inner thoughts, feeling, effect of the exercise, etc. While the control group did not participate in aerobic exercise and basically did not take any long-term and regular physical exercise. Both the intervention group and the control group took results of Study I as the pre-test results and received a post-test uniformly after the intervention.

Before the intervention, an online informed consent meeting was held to give an outline of the intervention, explain the discipline and requirements of group activity and collected signed informed consent forms from all members of the intervention group. In the intervention stage, two postgraduates in psychology who had the experience of leading group psychological counseling and received systematic trainings on ACT (one was the main leader of the team and the other was an assistant) served as the researchers, and two clinical psychologists served as the counselors. The ACT intervention was carried out on weekends, once a week, about 40–50 min each time, for 6 successive weeks. During the intervention in the intervention group, the control group did not receive any materials related to the content of the intervention.

The ACT intervention was scheduled as follows: Week 1: consolidating understanding about sudden public health emergencies and emotions, and learning to make peace with emotions. Week 2: inspiring team members to accept themselves, including their own merits and demerits, etc. Week 3: learning to respond to all kinds of ideas in the brain using cognitive defusion. Week 4: helping team members establish correct and active values. Week 5: encouraging members to fight for their dreams and fulfill their commitments. Week 6: summing up the activities, sharing growth and changes in this intervention, recommending books on positive psychology, and reminding members to take action.

2.4. Statistical analysis

The data were analyzed by SPSS15.0 statistical software, and the quantitative data were expressed as mean \pm standard deviation ($m \pm SD$). Because most of the interaction of group and time in this study is statistically significant, the objects were divided into different groups and different time for independent effect analysis. The specific methods include: *t* test was used to analyze whether there is significant difference in each variable between the two groups before and after the intervention; Paired *t*-test was used to analyze whether there is significant difference in each variable before and after the intervention in each group, with $P < 0.05$ suggesting that the difference is statistically significant.

3. Results

3.1. Mental health of adolescents

According to the studies by relevant scholars, most people score 45 ~ 56 in the W-E Well-being Scale. Those with an average score ≥ 56 are considered to have high subjective well-being, while those with a score

< 56 are considered to have low subjective well-being (Jiang, 2009). The best cut-off value of the Chinese version of GHQ-12 is 3 points. Those with an average score ≥ 3 points are considered to have high mental illness, and those with a score < 3 are considered to have low mental illness (Li & Li, 2015).

According to the criteria of the dual-factor model of mental health, as well as the results shown in Table 2, it can be found that 49.31% of the adolescents surveyed are completely healthy during the outbreak; 15.03% were vulnerable; 13.06% were symptomatic but contented, and 22.59% were distressed. Among those who are vulnerable, symptomatic but contented and distressed, 30 adolescents were selected from each type as the experiment objects with their consent, and randomly and equally divided into the intervention group and the control group.

3.2. Intervention effect of aerobic exercise in combination with acceptance commitment therapy on vulnerable individuals

From Table 3, it can be learned that before the intervention, there is no significant difference between the intervention group and the control group in terms of psychological distress, well-being and psychological flexibility, indicating that the two groups have the same baseline levels. However, after the intervention, the intervention group is significantly lower than the control group in psychological distress and experiential avoidance, but significantly higher than the control group in all dimensions of well-being, indicating that the intervention is somewhat effective.

From Table 4, it can be seen that there are significant differences before and after the intervention in the intervention group in terms of psychological distress, well-being and psychological flexibility ($P < 0.05$), but no significant differences in the control group, which further illustrates the effect of intervention.

3.3. Intervention effect of aerobic exercise in combination with acceptance commitment therapy on symptomatic but contented individuals

From Table 5, it can be learned that before the intervention, there is no significant difference between the intervention group and the control group in terms of psychological distress, well-being and psychological flexibility of symptomatic but contented individuals, indicating that both groups are at the same baseline level. After the intervention, the intervention group is significantly lower than the control group in psychological distress and experiential avoidance, but significantly higher than the control group in all dimensions of well-being, indicating that the intervention is somewhat effective.

From Table 6, it can be seen that there are significant differences before and after the intervention in the intervention group in terms of psychological distress, well-being and psychological flexibility ($P < 0.05$), but no significant differences in the control group, which further indicates the effect of the intervention.

3.4. Intervention effect of aerobic exercise in combination with acceptance commitment therapy on distressed individuals

From Table 7, it can be seen that for distressed individuals, before the intervention, there is no significant difference between the intervention group and the control group in all dimensions. However, after the intervention, the intervention group is significantly lower than the

Table 2
Mental health distribution of adolescents.

| | Healthy | Vulnerable | Symptomatic but contented | Distressed |
|-------------------|---|--|--|---|
| Grouping standard | Psychological distress < 3 Subjective well-being ≥ 56 | Psychological distress < 3 Subjective well-being < 56 | Psychological distress ≥ 3 Subjective well-being ≥ 56 | Psychological distress ≥ 3 Subjective well-being < 56 |
| N | 502 | 153 | 133 | 230 |
| Percent | 49.31% | 15.03% | 13.06% | 22.59% |

Table 3

Comparison between the intervention group and the control group in terms of pre-test results of vulnerable individuals before and after intervention (M ± SD).

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|-------|--------------------|---------------|---------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 1.50 ± 0.51 | 1.53 ± 0.51 | -0.17 | 0.57 ± 0.51 | 1.40 ± 0.63 | -3.85** |
| Well-being | 47.57 ± 2.84 | 49.86 ± 2.92 | -1.11 | 52.86 ± 2.82 | 48.20 ± 3.01 | 3.88** |
| Positive emotions | 12.71 ± 1.27 | 11.93 ± 1.03 | 1.82 | 13.28 ± 1.27 | 11.73 ± 1.38 | 3.08** |
| Positive psychological functioning | 20.85 ± 0.94 | 20.13 ± 1.18 | 1.80 | 22.21 ± 1.12 | 20.86 ± 1.35 | 2.90** |
| Interpersonal relationship satisfaction | 13.28 ± 1.38 | 12.20 ± 1.69 | 0.15 | 13.78 ± 0.70 | 12.46 ± 1.30 | 3.36** |
| Experiential avoidance | 19.35 ± 1.46 | 20.40 ± 1.54 | -1.87 | 18.35 ± 1.21 | 19.86 ± 1.24 | -3.30** |

Table 4

Comparison between the intervention group and the control group in terms of mental health and experiential avoidance of vulnerable individuals before and after intervention.

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|---------|--------------------|---------------|-------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 1.50 ± 0.51 | 0.57 ± 0.51 | 4.76** | 1.53 ± 0.51 | 1.40 ± 0.63 | 1.46 |
| Well-being | 48.64 ± 2.97 | 52.86 ± 2.82 | -4.23** | 49.87 ± 2.92 | 48.20 ± 3.56 | 1.26 |
| Positive emotions | 12.71 ± 1.27 | 14.93 ± 1.20 | -6.62** | 11.93 ± 1.03 | 11.73 ± 1.38 | 0.44 |
| Positive psychological functioning | 20.85 ± 0.94 | 22.21 ± 1.12 | -4.18** | 20.13 ± 1.18 | 20.86 ± 1.35 | -1.41 |
| Interpersonal relationship satisfaction | 13.28 ± 1.38 | 14.72 ± 1.20 | -4.16** | 13.20 ± 1.70 | 12.47 ± 1.30 | 1.70 |
| Experiential avoidance | 19.35 ± 1.46 | 17.71 ± 0.99 | 3.54** | 20.40 ± 1.55 | 19.86 ± 1.25 | 1.19 |

Table 5

Comparison between the intervention group and control group in terms of mental health and experiential avoidance of symptomatic but contented individuals before and after intervention (M ± SD).

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|-------|--------------------|---------------|---------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 5.23 ± 1.36 | 5.13 ± 1.12 | 0.21 | 3.00 ± 1.29 | 4.86 ± 0.74 | -4.77** |
| Well-being | 57.69 ± 3.30 | 57.46 ± 2.47 | 0.21 | 62.38 ± 3.23 | 57.86 ± 3.36 | 3.62** |
| Positive emotions | 13.31 ± 1.31 | 14.00 ± 1.36 | -1.36 | 15.46 ± 1.56 | 14.13 ± 1.45 | 2.33** |
| Positive psychological functioning | 24.15 ± 1.62 | 24.13 ± 1.46 | 0.04 | 25.92 ± 1.70 | 24.20 ± 1.47 | 2.87** |
| Interpersonal relationship satisfaction | 17.46 ± 1.26 | 18.01 ± 1.07 | -1.22 | 19.54 ± 1.51 | 17.67 ± 1.11 | 3.77** |
| Experiential avoidance | 29.38 ± 2.98 | 28.00 ± 2.50 | 1.33 | 20.53 ± 3.45 | 27.40 ± 1.50 | -6.98** |

Table 6

Comparison between the intervention group and control group in terms of mental health and experiential avoidance of symptomatic but contented individuals before and after intervention (M ± SD).

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|---------|--------------------|---------------|-------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 5.23 ± 1.36 | 3.00 ± 1.29 | 4.76** | 5.13 ± 1.36 | 4.86 ± 0.74 | 1.46 |
| Well-being | 57.69 ± 3.30 | 62.38 ± 3.22 | -3.75** | 57.46 ± 2.47 | 57.86 ± 3.35 | -0.35 |
| Positive emotions | 13.31 ± 1.31 | 15.46 ± 1.56 | -4.94** | 14.00 ± 1.36 | 14.13 ± 1.45 | -0.20 |
| Positive psychological functioning | 24.15 ± 1.62 | 25.92 ± 1.71 | -2.76** | 24.13 ± 1.45 | 24.20 ± 1.47 | -0.13 |
| Interpersonal relationship satisfaction | 17.46 ± 1.26 | 19.54 ± 1.50 | -3.57** | 18.03 ± 1.06 | 17.67 ± 1.12 | 0.89 |
| Experiential avoidance | 29.54 ± 2.98 | 20.54 ± 3.45 | 6.34** | 28.00 ± 2.50 | 27.40 ± 1.50 | 1.14 |

Table 7

Comparison between the intervention group and control group in terms of mental health and experiential avoidance of distressed individuals before and after intervention (M ± SD).

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|-------|--------------------|---------------|---------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 6.41 ± 1.37 | 6.43 ± 1.39 | -0.02 | 4.33 ± 1.07 | 6.29 ± 1.33 | -4.08** |
| Well-being | 38.75 ± 1.95 | 39.07 ± 2.40 | -0.37 | 42.08 ± 1.38 | 39.50 ± 2.37 | 3.31** |
| Positive emotions | 10.25 ± 1.13 | 10.21 ± 1.12 | 0.08 | 12.25 ± 1.13 | 11.14 ± 0.77 | 2.94** |
| Positive psychological functioning | 19.58 ± 2.11 | 19.07 ± 1.85 | 0.66 | 21.83 ± 1.75 | 18.71 ± 1.86 | 4.38** |
| Interpersonal relationship satisfaction | 12.08 ± 0.90 | 11.71 ± 0.61 | 1.23 | 13.33 ± 1.23 | 12.43 ± 0.64 | 2.39* |
| Experiential avoidance | 33.58 ± 1.51 | 32.71 ± 1.38 | 1.54 | 30.75 ± 1.28 | 32.57 ± 1.55 | -3.22** |

control group in psychological distress and experiential avoidance, but significantly higher than the control group in well-being.

From Table 8, it can be seen that there is significant difference before

and after the intervention in the intervention group and it is noteworthy that after the intervention, the control group has significantly higher positive emotions and interpersonal relationship satisfaction than before

Table 8

Comparison between the intervention group and control group in terms of mental health and experiential avoidance of distressed individuals before and after intervention (M ± SD).

| Item | Before intervention | | T | After intervention | | T |
|---|---------------------|---------------|---------|--------------------|---------------|---------|
| | Experimental group | Control group | | Experimental group | Control group | |
| Psychological distress | 6.41 ± 1.38 | 4.33 ± 1.07 | 9.10** | 6.43 ± 1.39 | 6.28 ± 0.74 | 0.49 |
| Well-being | 38.75 ± 1.95 | 42.08 ± 1.37 | -5.28** | 39.07 ± 2.40 | 39.50 ± 2.37 | -0.38 |
| Positive emotions | 10.25 ± 1.13 | 12.25 ± 1.13 | -7.27** | 10.21 ± 1.12 | 11.14 ± 1.12 | -2.74* |
| Positive psychological functioning | 19.58 ± 2.11 | 21.83 ± 1.75 | -2.25** | 19.07 ± 1.86 | 18.71 ± 1.85 | 0.61 |
| Interpersonal relationship satisfaction | 12.08 ± 0.96 | 13.33 ± 1.23 | -2.39** | 11.71 ± 0.61 | 12.43 ± 0.64 | -3.68** |
| Experiential avoidance | 33.58 ± 1.50 | 30.75 ± 1.28 | 4.93** | 32.71 ± 1.38 | 32.57 ± 1.55 | 0.46 |

the intervention.

4. Discussion

4.1. Mental health of adolescents during the epidemic

The mental health of 1,018 adolescents was first investigated in this study. According to the classification standard, healthy individuals account for 49.31% of the total number, vulnerable individuals for 15.03%, symptomatic but contented individuals for 13.06%, and distressed individuals for 22.59%. This finding is basically consistent with those of Suldo and Shaffer (2008) and Suldo et al. (2016). In the online learning environment during the epidemic, adolescents have low psychological distress, high subjective well-being and high mental health, which is probably closely related to the active psychological building and counseling for adolescents ever since the outbreak (Zhu et al., 2020). Notably, vulnerable and distressed individuals were also found in this study to make up certain proportions. This finding is similar to the results of the investigation by Golberstein, Wen and Miller (2020). Hence, it can be seen that a part of adolescents still have low subjective well-being during the epidemic (Li & Li, 2020). As for the reasons, first of all, the infectivity and severity of COVID-19 have led to a certain degree of psychological panic among adolescents, and brought about a negative impact on their mental health. Secondly, this should be related to the shift of adolescents' learning mode from school learning to full-time online learning. It was indicated in some studies that in an information-based learning environment, physical and mental health of students were more vulnerable and they are most likely to suffer from poor spirits and decreased physical health, etc., so that their subjective well-being is negatively affected. This result also suggests that even if some adolescents do not show obvious psychological problems for the time being, it is still necessary to take psychological defense measures on adolescents universally and give them positive support, in order to protect their mental health and help potential vulnerable and symptomatic but contented individuals to restore to a healthy level as far as possible.

4.2. Intervention effect of aerobic exercise in combination with ACT on mental health of vulnerable individuals

According to the results of this study, after the intervention by aerobic exercise in combination with ACT, compared with the control group, vulnerable individuals in the intervention group have significantly lower psychological distress, but significantly higher subjective well-being (including positive emotions, positive psychological functioning and interpersonal relationship satisfaction), and significantly lower experiential avoidance. This result is consistent with those of Chen, Hu, He and Lai (2018) and Mansfield et al. (2018). According to the dual-factor model of mental health, mental health includes both the absence of negative psychological symptoms and the presence of positive psychological state. On this account, minimizing negative psychological state and improving positive psychological state should also be taken into consideration when carrying out intervention in mental

health (Suldo et al., 2019). But Suldo et al. pointed out that targeted interventions should be adopted for different types of mental health problems. For vulnerable individuals, their psychological distress and subjective well-being are both low. Previously, this group was excluded in numerous intervention researches, because according to the traditional viewpoints, those who do not show negative psychopathological symptoms require no intervention (Dong et al., 2018). However, Suldo and Shaffer (2008) thought it necessary to intervene in vulnerable individuals, especially to improve their subjective well-being. It was documented in previous studies that physical exercise can not only effectively improve individuals' positive emotions, for example, self-satisfaction (Garcia & Archer, 2016), but also work well for those with mild psychological distress, such as mild depression and anxiety (Gujral et al., 2019).

ACT based on mindfulness focuses on improving psychological flexibility of individuals, helping individuals defuse negative experiences cognitively, lowering their experiential avoidance, and enhancing their subjective well-being (Xu et al., 2019). Influenced by the epidemic, adolescents have less direct contact with the outside world, lack interpersonal interaction with peers and have a narrow space in family life. The heavy tasks in online learning and other reasons lower their positive emotional experience and result in their dissatisfaction with interpersonal relationship (Duan et al., 2020). Nevertheless, the intervention of ACT is able to enhance psychological flexibility of adolescents, so that they no longer avoid unpleasant experience and emotions in the current life, but accept and commit to acting with self-value, so that their subjective well-being is increased.

4.3. Intervention effect of aerobic exercise in combination with ACT on mental health of symptomatic but contented individuals

According to the results of this study, before the intervention, symptomatic but content individuals in the two groups are at the same baseline level, but after the intervention, the intervention group has significantly lower psychological distress and experiential avoidance, but significantly higher subjective well-being. On the other hand, there is no significant difference before and after the intervention in the control group. This finding is consistent with that of consistent with that of Bauer et al. (2020) who conducted sports and mental health intervention in German adolescents during the epidemic. First of all, symptomatic but contented individuals have not only high psychological distress (i.e. negative psychological state), but also high subjective well-being. Suldo and Shaffer (2008) contended that due to a high positive psychological state, symptomatic but contented individuals perceive decreasing pain and discomfort. But at the same time, it should be noted that this group also has higher negative psychological symptoms. Without necessary intervention, their positive psychological state may be negatively affected, and this group is more likely to be converted to distressed individuals. According to the results of this study, it can be learned that in the online learning environment during the epidemic, -symptomatic but contented individuals account for about 12% of all the adolescents, a figure that cannot be ignored. There are two reasons why the intervention of aerobic exercise in combination with ACT can

effectively reduce the negative psychological symptoms of symptomatic but contented individuals and significantly improve their positive psychological state. First of all, it is easy for adolescents to engage in aerobic exercise, which is a simple and easy-to-operate form of physical exercise, during the epidemic, (Chen, 2020). Exercise itself can help adolescents stretch their body and develop a sense of power, further enhance their physical self-image and cultivate their self-identity. It also allows adolescents to discharge the sense of helplessness or pressure induced by online learning and anxiety induced by the inability to interact with others (Bailey et al., 2017). To sum up, physical exercise can improve and alleviate the physical symptoms of adolescents and directly promote their mental health. Secondly, exercise in combination with ACT, more importantly, lowers experiential avoidance of adolescents and enhance their psychological flexibility. Previous studies have demonstrated and proved the positive effect of ACT on the improvement of psychotic symptoms, including pain, depression and anxiety, etc. (Hughes et al., 2017). What's more, Casey et al. (2018) found that compared with physical exercise intervention alone, the comprehensive intervention of exercise in combination with ACT can improve individuals' persistence in physical exercise, thus maximizing the intervention effect.

4.4. Intervention effect of aerobic exercise in combination with ACT on mental health of distressed individuals

Similarly, aerobic exercise in combination with ACT can significantly lower psychological distress of distressed individuals, significantly increase their subjective well-being, lower their experiential avoidance and enhance their psychological flexibility. A slight difference is that distressed individuals in the control group have significantly higher positive emotions and interpersonal relationship satisfaction after the intervention. Suldo and Shaffer (2008) showed clearly that social functioning, learning adaptability and physical health of distressed individuals are lower than those of other types. Particularly during the COVID-19, due to the fear of the spread of this disease and ballyhoo of social media, etc., adolescents generally have a low sense of self-efficacy as to whether they can resist this disease or not (Davis et al., 2020). Aerobic exercise intervention can directly reinforce their bodily functions, enhance their vitality in physical exercise and improve their physiological health (Luo et al., 2020). As mentioned above, ACT can promote the intervention effect of physical exercise.

In addition, ACT can effectively improve psychological flexibility of adolescents, lower their experiential avoidance and help them accept their existing unpleasant life experience. More importantly, they can accept, defuse, be mindful and make commitments and take actions with an observational self-value orientation (Xu et al., 2019). However, Hayes et al. (2006) pointed out that ACT focuses on changing individuals' psychological functioning, rather than changing their symptoms. The lower the previous psychological functioning, the longer it takes to change. And this is the reason why the number of distressed individuals in the intervention group who have changed after the intervention is lower than that of symptomatic but contented individuals. Specifically, symptomatic but contented individuals have a higher level of positive psychology, which can help promote the intervention effect. However, distressed individuals have impaired positive psychological functioning and severe negative psychological symptoms, so that longer-term intervention is required to improve their mental health (Suldo et al., 2019). This also indirectly reveals that the intervention mode of aerobic exercise in combination with ACT -is effective for the promotion of mental health of distressed individuals. This indicates that in the future, the intervention time for distressed individuals can be extended appropriately. Moreover, for distressed individuals in the control group, the significant increase in positive emotions and interpersonal relationship satisfaction is probably caused by factors in the external environment. With the decrease of the level of epidemic prevention and control, schools across the country have gradually resumed classes, while students have also gradually entered an offline

learning environment, got in touch with their peers and took part in interpersonal activities, etc., which satisfies their basic psychological demands and enhanced their positive emotions (Luo et al., 2017).

5. Conclusion

During the sudden public health emergency of the COVID-19, health adolescents still account for nearly 50%, but the proportions of symptomatic but contented adolescents and distressed adolescents are high, which suggests grim mental health status of adolescents. Noticeably, aerobic exercise in combination with ACT effectively improves subjective well-being of vulnerable, symptomatic but contented and distressed individuals, lowers their psychological distress, and especially has a prominent intervention effect on the vulnerable group. This indicates that we should not only pay attention to negative psychological distress of adolescents during the epidemic of sudden public health emergencies, but also keep an eye on changes in their positive psychological state. Educators and parents involved should encourage adolescents to exercise moderately, provide them psychological counseling whenever necessary, enhance their psychological flexibility and lower their experiential avoidance. Nevertheless, there are still some shortcomings in this study. First of all, the intervention lasted only 8 weeks, but it is a long-term process for changes in psychological flexibility. Therefore, in future studies, the intervention time can be prolonged appropriately. Secondly, the relationship among psychological distress, subjective well-being and experiential avoidance was not explored in depth. Previous studies have shown that ACT affects mental health by improving psychological flexibility and lowering experiential avoidance. Therefore, the mediating role of psychological flexibility can be further examined in future studies. Thirdly, aerobic exercise and ACT were conducted simultaneously in this study. In the future, other control groups can be established to investigate the differences between aerobic exercise alone and aerobic exercise in combination with ACT.

Compliance with ethical standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical. Informed consent was obtained from all individual participants included in the study.

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CRediT authorship contribution statement

Wenxin Xu: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Wei Shen:** Data curation, Visualization, Investigation, Writing - original draft. **Shen Wang:** Investigation, Supervision, Software, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.chilgyouth.2021.105960>.

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