Comparative Efficacy of Seven Exercise interventions for Symptoms of depression in college students: a network of meta-analysis

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Abstract
Background Depression among college students is common, exercise interventions are valued as one of the most widely prescribed interventions for depressed college students, however, it is especially difficult for university administrators to determine which exercise intervention is most effective, and efficacy of exercise interventions among depressed college students have not been evaluated.
Objectives To systematically review and compare the efficacy of Seven Exercise interventions for Symptoms of depression in college students. Method A network of meta-analysis was conducted to fill the objectives. PubMed, Embase databases, and two Chinese language electronic databases WANFANG and CNKI were searched for the related articles. Eligibility criteria Randomized controlled trials comparing the efficacy of Seven Exercise interventions with usual care of college students with depression were included in the review. Main outcomes The Primary outcome of the present study were standardized mean difference(SMD) and the mean change of depressive symptoms. Results 14 trials were identified, including 2010 depressed college students. The result of direct meta-analysis of this review indicated exercise interventions overall had a significantly lower mean depression scores (SMD=-1.13) when compared with usual care. The result of NMA indicated when comparing with badminton intervention, yoga(SMD=-7.7, 95%CI -14 to -0.93) and tai chi (SMD=-9.4, 95%CI -16 to -2.7) can significantly decrease depression scores of the depressed college students. The rank of seven exercise interventions with respect to efficiently decrease symptom of depressed undergraduates was Tai chi > Yoga > Volleyball > Dance > Run> Basketball> Badminton,
respectively. Conclusions Tai chi exhibited the highest probability that became the most efficacy intervention among the comparions, and Yoga showed the second most effectiveness to alleviate depressive symptoms of depressed college students, and dance ranks the third, followed by run, volleyball, basketball, badminton respectively.

Background
Depression is common in some age groups, which cause the global disease burden increased greatly[1]. Studies indicated that depression can seriously affect the physical and mental health of patients, and was associated their poor life quality[2]. Mountaining studies have revealed that the
prevalence of depression among college students was much higher compared the same age group[3] and the adult group[4]. It is estimated that the prevalence of depression in university students is about 40% or more[5], which influence their mental health greatly, and study also shows that the students who have symptoms of depression were significantly related to their poor academic performance[6]. According to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV), depression can be classified as mild, moderate and severe with respect to the severity[7]. For most reported depression college students, their symptoms of depression belong to mild to moderate, which can effectively be relieved with appropriate interventions[8-9]. Although there are different interventions to provide for depressed college students, however, some interventions have limited effect for their depressive symptoms. For example, antidepressants are the first recommended intervention by many psychiatrists, however, due to the side effects and resistance of this medicines, the intervention of antidepressants has very limited effect for most depressed college students[10]. Some studies have proved the effectiveness of alternative interventions for depression of college students, such as psychological treatments[11], exercise therapy[12]. Most of psychological interventions are generally free from side effects and are recommended by many college psychological counselors, however, studies indicated that many students refused to receive this kind of intervention due to its low expectations of positive outcome, which also deepen the perceived stigma of depressed students[13].

Exercise intervention can alleviate symptoms of depression and improve overall emotional well-being, which is important to relief from depressive symptoms[14]. A large number of studies have indicated that exercise can be viewed as an effective treatment for depressed patients[15-16]. For college psychological counselor, exercise therapy is ideal intervention for depressed students because there are various sports grounds and facilities on university campuses. Moreover, depressed students can effectively reduce their stigma by taking part in sports, increasing the opportunities to communicate with others, which is vital to maintain their mental health[17].

Several meta-analysis have been conducted to analysis the effectiveness of exercise intervention on depression of different patients, all conclusions are consistent to proved the effectiveness of such
interventions[18-19]. However, we have not found any network of meta analysis to compare the efficacy of different exercises on depression of college students. Because previous study have indicated that different kind of sports may have variety effectiveness when they were used as an alternative treatment for depression[20]. Thus, some exercise interventions may be an very effective treatment for mild to moderate depressive college students, while others may have not the same effectiveness. So, it is important to assess which kind of exercises is the most effective for depressed college students. Meta-analyses were limited by few trials with direct comparisons between two treatments, Instead, a network meta-analysis (NMA) can combine both direct and indirect evidences into one single comparison[21], and can provide ranking of the efficacy of subject exercise interventions.

In this study, we conducted a NMA to assess the efficacy of seven exercise interventions for symptoms of depression in college students, so we can provide valuable information for college psychological counselors to relieve the symptom of depressed college students.

Methods

Search strategy

We searched Embase, Web of science, PubMed and two Chinese language electronic databases WANFANG and CNKI for relative studies. Studies from onset up to May to 2019 were identified to evaluate the efficacy of seven exercise (Badminton, Basketball, Dance, Volleyball, Run, Taichi and Yoga) interventions on the symptom of depressed college students. Only English and Chinese language were searched. “Exercise(s)” or “Sport(s)” or Badminton, Basketball, Dance, Volleyball, Run, Tai chi, Yoga were combined with “depressed college students(undergraduates)”,” depression of college students(undergraduates)” were used as Medical Subject Heading (MeSH) terms for relative studies.

Risk of bias assessment

We assessed the risk of bias according to the guidelines of the Cochrane reviews[22]. Two of our authors conducted the evaluation independently on such information: representativeness of sample(whether it satisfies the principle of random and blind method) and information integrity.
Included studies were classified as ‘low risk of bias’, ‘unclear risk of bias’, or ‘high risk of bias’, with respect to the aboved information.

**Interventions of interest**

In this study, exercise interventions were defined as in order to get the objective of improving or maintaining health of physical and mental fitness, a planned, structured, repetitive and purposive physical activity was conducted[23]. Usual care was defined as only the school administration paid attention to their mental health, without any special intervention to ensure consistency with the intervention group in other aspects[24]. Exercise intensity is determined by heart rate and oxygen intake, for moderate intensity, the range of heart rate was 100-150 per minute, Oxygen intake is 50%-60% of the maximum oxygen intake[25].

**Study selection**

We included such studies that meet all the follow criteria: (i) comparison among Badminton, Basketball, Dance, Volleyball, Run, Taichi, Yoga and usual care; (ii) the subject samples were college students with depressive symptoms, in this study, students with depressive symptoms were defined as after screening with the depression scales, students with scores above the critical threshold, for Beck Depression Inventory-II, scores greater than 13 indicate depressive symptoms; for Self-rating depression scale(SDS), scores greater than 50 indicate depressive symptoms; or have been diagnosed with depression according to clear diagnostic criteria such as DSM-IV or ICD-10 or CCMD-3; (iii) language was English or Chinese; (iv) included studies should provide such informations: depression scores of depressed students before and after intervention, sample size, specific depression assessment scales and criteria; (V) included studies should be randomized controlled trials, which the allocation of participants to treatment and comparison groups was described as randomized. We excluded such studies: sample size was less than 20; the trial time was less than 4 weeks; not comparison between the above items; without needed information.

**primary outcome**

The mean change of depressive symptoms was the primary outcome of interest, which was assessed by by different validated scales, from baseline to post-intervention. Standardized mean difference
(SMD, 95% confidence interval; CI) was calculated to compare the difference of depressive scores between intervention and control groups.

**Data extraction**

Relevant data were independently extracted from the included articles by our two authors, including name of first author, year of publication, study design, duration of treatment, number of samples. For intervention and control groups, the depressive symptom scores of any validated scale, along with their standard deviation (SD) from baseline to post-intervention were extracted. In some studies, the abovementioned information were not provided, the mean change and SD from pre- and post-test was used.

**Statistical analysis**

Network of meta analysis was used to compare the mean change of depressive symptoms of seven exercise interventions. A Bayesian model network meta-analysis was conducted to combine both direct and indirect evidences into one single comparison. Standardized mean difference (SMD) and corresponding 95% confidence intervals (CIs) were calculated. $I^2$ test was used to assess the heterogeneity, if $I^2 > 50\%$, indicating the existence of heterogeneity[26]. $P$ values were calculated to identify the difference between direct and indirect evidences. And the node-splitting plot was applied to check the consistency. Publication bias of this study was checked by Egger’s test and the result was shown in funnel plot. R version 3.4.4 (R Project for Statistical Computing, Vienna, Austria) were used to conduct the abovementioned statistical analysis. $P < 0.05$ was considered to be significant.

**Results**

**Study selection**

Related database were searched according to the search strategy, and found 2751 potentially eligible trials, after removing 439 duplicates, there were still 2041 studies left, after screening titles and abstracts, we screened the rest 271 full text studies, among of them, 257 studies were ruled out due to without valuable outcome which we wanted to research. So a total of 14 [27-40] articles with 2010 depressed undergraduates were included in the present study to evaluate the efficacy of seven exercise interventions on their depressive symptoms, the flow chart was schematically shown in
Study characters

Among the identified articles, there were 25 comparisons which contain 10 two-arm studies, 3 three-arm studies and 1 four-arm study. Four trials compared the efficacy of Basketball and Dance, which contain 459 depressed undergraduates. Four studies were aimed to compare the effectiveness of Badminton and Basketball, containing 423 depressed college students, other comparison also include 3 trials of Badminton and Dance, which contain 268 depressed undergraduates, 2 trials of Badminton and Volleyball, 1 trial of comparison between Taichi and Yoga, 1 trial of Run and Yoga, and comparison between above mentioned seven exercise interventions and usual care respectively. The general characters of included studies were shown in Table 1. Overally, the included studies had low assessment scores, Six literatures cannot meet the principle of randomization and blind method when grouping, Only 6 papers scored above 5 points, six papers scored only 3 points, which suggests that the quality of the included studies is not very high. The risk of bias assessment was shown in Table 2. A total of 2010 depressed college students were involved in this study, among of them, 251 (12.48%) depressed undergraduates received Badminton intervention, 255 (12.69%) students received Basketball intervention, 224 (11.14%) students received Dance intervention, 85 (4.23%) students received Run intervention, the number of receiving Taichi, Yoga, volleyball, usual care was 69 (3.43%), 80 (3.98%), 77 (3.83%), 163 (8.1%) respectively. Network plots of SSRIs were shown in Figure 2.

Exercise interventions versus Usual care

Among the included studies, 11 comparisons of seven studies which contains 573 depressed college students, were analysed to compare the effect of exercise interventions versus usual care. Depression scores were assessed at the end of treatment, which ranged from 6 to 24 weeks. The random effects model was selected due to $I^2=73\%$ (Heterogeneity test), the SMD was $-1.13$ (95%CI -1.48 to -0.78), and $P<0.01$, which indicates that depressed students receiving exercise interventions had significantly lower mean depression scores (by 1.13 units) than students receiving usual care. The detail result was shown in Figure 3.

Analysis of NMA
As shown in Figure 4, the forest plot of network results indicated that when comparing the effectiveness of Badminton intervention, Yoga intervention can significantly decrease depression scores of the depressed college students (SMD = -7.7, 95% CI -14 to -0.93, Figure 4B), while comparing with badminton intervention, Tai chi intervention also showed significant effect in reducing depressive symptoms (SMD = -9.4, 95% CI -16 to -2.7, Figure 4B). Compared with usual care, Dance, Run, Tai chi and Yoga showed their significant effect in reducing depressive symptoms, the SMD and their 95% CI were -5.5 (-11, -0.39) for Dance, -6 (-10, -1.6) for Run, -11 (-16, 6) for Tai chi, -9.1 (-14, -4) for Yoga, respectively (Figure 4H). Among other comparions, the effect did not reach statistical significance, which can be seen in Figure 4 A, C, D, E, F, G.

**The Efficacy ranks of Seven Exercise interventions**

The ranking diagram and rank probability were shown in Table 3 and Figure 5. The exercise interventions were ranked according to the efficacy of seven exercise interventions on depressive symptom of college students. The ranking is from high to low, and the larger the number was, the efficacy of the intervention was indicated better. The result showed that Tai chi intervention had the highest probability that became the most efficacy interventions with respect to reducing depressive symptom of college students (probability = 0.6733). The seconde was Yoga (probability = 0.2182), and then was Volleyball (probability = 0.0635), Dance (probability = 0.0232), Run (probability = 0.0182), Basketball (probability = 0.0035), Badminton (probability = 0.0001), and usual care (probability = 0.0000) exhibited the worst reliable performance in comparison with other interventions with respect to reducing depressive symptom of college students. So, the efficacy rank of seven exercise interventions with respect to efficiently decrease symptom of depressed college students was Tai chi > Yoga > Volleyball > Dance > Run > Basketball > Badminton, respectively.

**Heterogeneity, Consistency and publication bias**

The result of heterogeneity test indicated that there were significant heterogeneity among the included studies (I^2 > 50%), so the node-splitting plot was used to check the consistency of related studies. The detail result could be seen in Table 4 and Figure 6. Some significant differences were observed in the present study, two comparions of related studies exist significant inconsistency,
which may be the source of heterogeneity. Eggers’ test was used to identify whether exist publication bias in the study, and there was not any significant publication bias was identified, the result of publication bias analysis is presented in Figure 7.

Discussion
The result of this study indicated that exercise interventions can significantly decrease depressive symptoms of depressed undergraduates when compared usual care, which is consistent with previous studies on other different age groups[41]. Exercise interventions can reach high magnitude of treatment effect to depressive symptoms of depressed college students, the SMD of exercise treatments versus usual care was -1.13. A previous meta-analysis by Sukhato etal[42] has concluded that the SMD of exercise intervention versus usual care was -0.73, which is less than our result. They mainly focused on depression in adults, which was different from the present study. Moreover, samples of included studies were not clinically diagnosed with depression, although they had depressive symptoms. So, exercise interventions may be more effective in depressed college students than in other depressed people, but more randomized controlled trials are needed to confirm this conclusion.

In our study, the results of NMA indicated that compared with Badminton intervention, Taichi and Yoga both has a significant effectiveness on decreasing depressive symptoms of depressed undergraduates. Some researchers do not think Tai chi is only a kind of exercise, when practice it, the meditation can play a role in the relieving of depressive symptoms[43], which is the same to Yoga[44]. And both of Tai chi and Yoga have show their significant effectiveness on prenatal depression, anxiety and sleep disturbances[45]. When compared with usual care, exercise interventions except basketball all show better effect to depressive symptoms of depressed college students. Previous studies have confirmed that basketball, as a team sport, has a good therapeutic effect on depression[46], our results contradict this, possibly due to publication bias. We also ranked these exercise interventions with respect to their Efficacy in depressed college students, so can provide potential guidance to college psychological counselors and other university administrators. In the present study, the result of NMA showed that students treated by Tai chi was associated with a
significant relieving of depressive symptoms compare to other six exercise interventions, and Yoga was the second most effective exercise. In our analysis, the effect of dancing on depressive symptoms was ranked third among all interventions, higher than volleyball, running, basketball and badminton. A systematic review about the effectiveness of dance for people with a diagnosis of depression has been conducted by Mala et al[47], and they concluded that dancing has positive effects on depression due to it contains some characteristics of art therapy. Among other comparions, volleyball and basketball are better than badminton in treating depression. This conclusion is consistent with previous study[48], which suggest that volleyball and basketball belong to team sports, and indicated they were better at alleviating depression symptoms than individual sports such as badminton.

As one of the most widely prescribed interventions for depressed college students, dispute about the efficacy of exercise has been existed, it is especially difficult for university administrators to determine which exercise intervention is most effective.

As the first NMA study, the present study can provide valuable information for psychological counselors when they faced to depressed college students, and may be beneficial to effectively improve the depression symptoms of college students, reduce the risk of further worsening of symptoms. However, some limitations should be noted, for the first, though we had conducted a thorough literature search, most included studies still were published in Chinese, which may be exist publication bias. Second, symptoms of depression were not a predefined outcome, and therefore may not have been accurately evaluated, and among the included studies, there were three evaluation scales, they were BCD-II, HAMD and SDS, which may influence the result. Third, significant variation existed in the number of studies with respect to each comparison, for example, there were four trials compared the efficacy of Badminton and Basketball, only 1 trial of Taichi and Yoga, 1 trial of comparison between Run and Yoga. So, this may result in a wide confidence interval for summary statistics.

Conclusions
Tai chi exhibited the highest probability that became the most efficacy intervention among the
comparisons, and Yoga showed the second most effectiveness to alleviate depressive symptoms of depressed college students, and dance ranks the third, followed by run, volleyball, basketball, badminton respectively.

Abbreviations

standardized mean difference: SMD, network of meta-analysis: NMA

Declarations

Ethics approval and consent to participate

The data analysed in this study came from publicly accessible papers, thus it was not applicable or necessary to institutional review board approval.

Consent to publish

All authors agree with publish the work in this journal.

Availability of data and materials

All data generated or analysed during this study are included in this published article

Competing interests

The authors have declared that no competing interests exist.

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Authors' Contributions

Conceived and designed the analysis: SG, YY. Performed the analysis: SG, LC, FL. Wrote the paper: GS, YY.

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### Tables

Table 1. The basic information and data of all included studies in the meta-analysis.

| Study/author | year | Interventions       | Sample size | Baseline depression sore | Sd(Baseline) |
|--------------|------|---------------------|-------------|--------------------------|--------------|
| Duan YM[27]  | 2014 | Dan/Bas/Bad         | 30/41/38    | 58.74/58.67/58.71        | 4.18/4.1/4.12 |
| Yang PP[28]  | 2018 | Dan/Bas/Bad         | 103/103/103 | 58.75/58.68/58.72        | 4.23/4.33/4.24 |
| Wang B[29]   | 2016 | Dan/Bas             | 60/60       | 65.84/63.56              | 3.56/2.69    |
| Ma MK[30]    | 2017 | Dan/Bas/Bad/usual   | 31/31/31/31 | 58.74/58.69/58.74/58.76 | 4.19/4.12/4.14/4.21 |
| Wang J[31]   | 2016 | Bad/Vol             | 39/37       | 58.64/58.59              | 4.23/4.37    |
| Zhao YF[32]  | 2016 | Run/Bas             | 20/20       | 25.23/25.02              | 2.65/3.89    |
| Zhao HQ[33]  | 2017 | Run/usual           | 14/14       | 63.92/63.44              | 6.87/7.27    |
| Yan J[34]    | 2016 | Tai/Yoga            | 22/22       | 27.09/27.68              | 6.2/5.67     |
| Song XY[35]  | 2017 | Yoga/Run            | 28/27       | 27/27.8                  | 6.2/4.99     |
| Su Y[36]     | 2010 | Tai/usual           | 15/15       | 27.13/28.13              | 6.94/6.52    |
| Huang B[37]  | 2008 | Tai/usual           | 32/32       | 14.95/14.11              | 4.42/4.67    |
| Zhu L[38]    | 2011 | Run/usual           | 24/24       | 46.43/46.53              | 5.33/4.88    |
| Xiong M[39]  | 2014 | Yoga/usual          | 30/27       | 22.3/21.1                | 5.9/5.8      |
| Study          | Random sequence generation | Allocation concealment | Blinding | Incomplete outcome data | Selective reporting |
|---------------|-----------------------------|------------------------|----------|------------------------|---------------------|
| Duan YM[27]   | U                           | U                      | U        | L                      | L                   |
| Yang PP[28]   | L                           | U                      | U        | L                      | L                   |
| Wang B[29]    | L                           | U                      | U        | L                      | L                   |
| Ma MK[30]     | L                           | L                      | U        | L                      | L                   |
| Wang J[31]    | U                           | U                      | U        | L                      | L                   |
| Zhao YF[32]   | L                           | L                      | U        | L                      | L                   |
| Zhao HQ[33]   | U                           | U                      | U        | L                      | L                   |
| Yan J[34]     | L                           | L                      | U        | L                      | L                   |
| Song XY[35]   | U                           | U                      | U        | L                      | L                   |
| Su Y[36]      | L                           | L                      | U        | L                      | L                   |
| Huang B[37]   | L                           | L                      | U        | L                      | L                   |
| Zhu L[38]     | U                           | U                      | U        | L                      | L                   |

Table 2. Risk of Bias Assessment. L indicated low risk, H: high risk, U: unclear risk.
Table 3. Rank probability of Exercise interventions
Rank probability, preferred direction = 1

| Drugs     | 1        | 2        | 3        | 4        | 5        |
|-----------|----------|----------|----------|----------|----------|
| Badminton | 0.00013  | 0.00060  | 0.00240  | 0.00828  | 0.02938  |
| Basketball| 0.00345  | 0.01440  | 0.04986  | 0.14037  | 0.29367  |
| Dance     | 0.02321  | 0.06747  | 0.18426  | 0.28651  | 0.28787  |
| Run       | 0.01816  | 0.07075  | 0.31185  | 0.25448  | 0.17705  |
| Taichi    | 0.67332  | 0.22445  | 0.05948  | 0.02292  | 0.01148  |
| Usual     | 0.00000  | 0.00005  | 0.00022  | 0.00297  | 0.01127  |
| Volleyball| 0.06348  | 0.11587  | 0.24301  | 0.22091  | 0.15460  |
| Yoga      | 0.21822  | 0.50640  | 0.14890  | 0.06352  | 0.03465  |

Table 4. Results of consistency analysis by node-splitting plot.
Node-splitting analysis of inconsistency

| Comparison | P value | SMD(CrI) |
|------------|---------|----------|

**Basketball. Badminton**

direct 0.642 -3.2 (-9.1, 2.7)

indirect -0.23 (-14., 13.)
| Activity                  | Direct | Indirect | Network       |
|--------------------------|--------|----------|---------------|
| **Dance. Badminton**     | 0.851  | -2.8 (-20., 14.) | -4.0 (-8.1, 0.087) |
| **Usual. Badminton**     | 0.559  | -1.3 (-14., 12.) | 1.5 (-3.1, 6.3)   |
| **Basketball.Run**       | 0.516  | -0.11 (-8.0, 7.6) | -1.7 (-7.2, 3.7)  |
| **Usual. Basketball**    | 0.790  | 3.8 (-3.5, 11.)  | 4.3 (-0.47, 9.2)  |
| **Usual. Dance**         | 0.956  | 5.4 (-2.7, 13.)  | 5.6 (-3.1, 14.)   |
| Activity       | Direct    | Indirect  | Network      |
|---------------|-----------|-----------|--------------|
| **Usual. Run** | 0.646     | 4.9 (-2.4, 12.) | 6.0 (1.6, 11.) |
| **Run. Yoga**  | 0.204     | 0.21 (-7.5, 8.1)  | -3.2 (-8.7, 2.5)  |
| **Usual. Taichi** | 0.0002   | 22. (17., 27.) | 11. (6.0, 16.) |
| **Taichi. Yoga** | 0.0002   | -6.8 (-11., -2.4) | 1.8 (-3.9, 7.6) |
| **Volleyball. Usual** | 0.982   | -6.2 (-15., 2.6) |             |
Yoga. Usual

direct 0.199 -13. (-20., -5.0)

indirect -6.5 (-13., -0.067)

network -9.2 (-14., -4.0)

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Figures

Figure 1

Flowchart presenting the steps of the literature search and selection.
Figure 2

Network plots of exercises. The width of the lines represents the total number of trials for each comparison.
Figure 3

The forest plot of the effect of exercise interventions versus usual care.
Figure 4

The forest plot of network results, A: comparisons between Basketball and other six interventions, B: comparisons between Badminton and other six interventions, C: comparisons between Dance and other six interventions, D: comparisons between Volleyball and other six interventions, E: comparisons between Run and other six interventions, F: comparisons between Taichi and other six interventions, G: comparisons between Yoga and other six interventions, H: comparisons between usual care and other six exercise interventions,
Figure 5
The Efficacy ranks of Exercise interventions

Figure 6
The heterogeneity of the included studies
Figure 7

Funnel plot of publication bias