Physical Activity Plus Acceptance and Commitment Therapy Can Decrease Anxiety Symptoms and Insomnia Severity Among Individuals With Poor Sleep Quality

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Background and Objective  During the COVID-19 pandemic, there were increased reports of sleep problems. Individuals with poor sleep quality are at particular risk of reporting symptoms of anxiety, depression, and poor quality of life, along with substance abuse. The present study aimed to examine the effectiveness of combined physical activity and acceptance and commitment therapy (ACT) on anxiety and depressive symptoms and insomnia severity among individuals with poor sleep quality.

Methods  Participants were 60 males and females with mean age (standard deviation) of 39.29 (5.82) years. Participants were randomly divided into 4 groups of 1) physical activity, 2) ACT, 3) combination of physical activity and ACT, and 4) control. The study consisted of four stages: pre-test, interventions, post-test, and follow-up. Repeated measures analyses of variance were used to assess time by group interactions.

Results  The results showed that the symptoms of anxiety and depression and sleep problems were reduced for the physical activity, ACT, and combined groups, compared to the control group (p = 0.001). Superiority in all outcomes of the combined group was shown, compared to the other groups.

Conclusions  The present findings suggest that among individuals with poor sleep quality, combined physical activity and ACT intervention has the potential to reduce symptoms of anxiety and depression and insomnia severity. It further appears that health organizers should pay more attention to physical activity interventions in individuals with poor sleep quality.

INTRODUCTION

Insomnia is one of the most prevalent complaints in medical settings and is a public health issue. Insomnia is characterized by problems of going to sleep, staying asleep, and having trouble functioning during the day [1]. Chronic insomnia also increases the risk of immune dysfunction and other conditions, like depression, anxiety, substance abuse, and suicide [2]. Insomnia was once thought of as a symptom, but it is now recognized as a disorder, and given its own classification in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and International Classification of Sleep Disorders—
third edition (ICSD-3) [3].

Sleep problems and insomnia affect 10% to 15% of the general population, with higher prevalence rates among women, those who are divorced or separated, those who have lost loved ones, and older individuals [4]. Evidence shows that individuals have reported more sleep problems and higher levels of anxiety during and following the COVID-19 pandemic. Ramsawh et al. [5] showed that anxiety disorders were significantly associated with global sleep quality scores. However, there is bidirectional relationship between anxiety and sleep problems. Sleep deprivation for 24 hours leads to worsening of anxiety symptoms, such as panic attacks [6]. Conversely, anxiety is simply a marker for more sleep disorders. In general, anxiety can result in difficulty maintaining sleep, such as middle insomnia, and early morning awakenings, which is late insomnia [7]. Nevertheless, psychological techniques that can decrease anxiety to improve insomnia could be helpful for a patient suffering from poor sleep quality.

COVID-somnia is the unique term that has been coined for sleep problems during a pandemic. COVID-19 has caused sleep problems for many reasons, such as anxiety of potential infection [8], lockdowns and changes in sleep-wake cycle, feelings of non-restorative sleep because of stress related to fear of the psychosocial impact on daily living, such as loss of employment, and the actual psychological problems related to COVID-19 [9]. Anxiety is well known to have reciprocal relationships with insomnia, and it has been shown that during the pandemic, the prevalence of all forms of psychological distress in the general population was higher [10]. Polizzi et al. [11] showed that the COVID-19 pandemic led to feelings of fear, helplessness, unpredictability, and uncertainty about the future. Moreover, lockdowns, physical distancing, and economic breakdown resulted in mental problems in the general population. The inability to cope with high levels of stress and uncertainty can have a negative impact on psychological and mental health [12]. In this situation, there is a need to identify useful coping strategies to increase well-being and enhance coping resources. Meanwhile, many individuals have reported sleep problems as a result of the COVID-19 pandemic [13]. Therefore, it is recommended to use interventions to improve sleep quality in individuals with poor sleep quality.

It has been demonstrated that using psychological interventions, such as acceptance and commitment therapy (ACT), as a coping strategy can improve resilience and the acceptance of crisis circumstances, as well as lowering anxiety and stress levels [14]. Therefore, ACT aims to cultivate greater acceptance of ideas and feelings, rather than attempting to control them [11]. Evidence suggests that ACT can assist individuals in coping with difficult circumstances [15]. There is evidence that shows individuals who practice mindfulness as a component of ACT may be able to stay hopeful and optimistic, cope with failures and uncertainty, and decrease rumination and anxiety [15].

Meanwhile, physical activity can be useful in enhancing the quality and onset of sleep with easing tension. Previous clinical studies [16-18] have shown that physical activity interventions had favorable effects on sleep quality. Higher improvement in sleep quality was found for participants completing approximately 190 minutes a week of moderate aerobic exercise [19]. These studies did not directly examine the mechanisms by which the improvements may have occurred. Hypothetically, the improvements in sleep may have been related to decreases in hyper arousal or depression symptoms, the easing of tension, or the release of neurotransmitters. But sleep disorders can lead to imbalances in the production and release of neurotransmitters, such as serotonin and dopamine [20]. Most importantly, sleep problems resulted in increased inflammation [21]. However, physical activity may reduce inflammation of the nerves by increasing the proliferator-activated receptor-γ coactivator 1. Moreover, physical activity can decrease cortisol levels, halt the cycle of inflammation, and increase serotonin and dopamine levels [22]. In this respect, Brand et al. [23] demonstrated that physical activity can increase mitochondrial activity and mental health in individuals with burnout. They found that 12 weeks of moderate intensity of physical activity can improve mitochondrial activity and increase oxygen consumption. Mitochondria play a role in improving homeostasis in sleep. Moreover, there is much evidence that shows individuals with Mitochondria disease have sleep disorders. Therefore, it seems plausible that physical activity can improve mitochondria activity, and consequently improve sleep quality [23]. Therefore, regular exercise has a positive impact on mitochondrial activity and can decrease sleep problems and depressive symptoms.

Regular participation in exercise activities has the potential to decrease pain, improve mood, and positively impact mental health [24-26]. However, little is known so far as to exactly which interventions are most beneficial for individuals with poor sleep quality [11,13,27]. Furthermore, Simister et al. [28] found that ACT significantly reduced pain and improved quality of life. Wicksell et al. [29] found that ACT intervention led to significant reductions in pain, psychological inflexibility, depressive symptoms, and anxiety, and improvements in quality of life and self-efficacy, compared to the control group. However, little is known in regard to comparing these intervention effects, and whether positive effects can also be expected for anxiety and depression symptoms and sleep quality.

ACT is one of the recommended therapies to enhance sleep, decrease anxiety and depression, as well as improve emotional control [30]. However, according to the previous studies and to the best of our knowledge, the combination of physical activity and ACT has not been studied in the group of individuals with poor sleep quality [31]. As a result, it is necessary to investigate the combined intervention in individuals with poor sleep quality, particularly in pandemic conditions that have resulted in a reduction in psychological functions and sleep quality. Thus, it
was hypothesized that physical activity, ACT, and combined interventions would be effective at improving 1) anxiety, 2) depression, and 3) insomnia severity, compared to the control condition.

METHODS

Participants and Procedure

Eighty-three individuals with poor sleep quality who met the criteria of the study were invited to participate. Inclusion criteria were 1) provision of full consent to participate in the study; 2) having poor sleep quality based on Pittsburgh Sleep Quality Index (PSQI) ≥ 6; 3) not having severe depression (score higher than 30 in the Beck Depression Inventory [BDI] questionnaire [32]) and anxiety (score of 36 or above of the Beck Anxiety Inventory [BAI] questionnaire); 4) not losing 1st-degree family members during COVID-19; and 5) no history of participating in physical activity or psychological interventions. Participation in previous interventions can lead to learning, and this previous learning can interfere with the effectiveness of the intended intervention. Moreover, the exclusion criteria include 1) suicidal intention, 2) severe sensory-motor injury, 3) severe musculoskeletal medical injury, 4) implant caused by bone fracture, 5) recent head injury, 6) concurrently receiving other treatments, and 7) personality disorders and substance use disorders. The Research Ethics Committee of Sport Sciences Research Institute (Tehran, Iran) approved the study, which was conducted with the ethical principles laid down in the Declaration of Helsinki and its later amendments with the code IR.SSRI.REC.1401.1801.

To randomize participants, a computer-generated random number sequence was prepared, and tickets were consecutively numbered, put in a ballot box, and drawn by an independent researcher not further involved in the study to determine the condition of the participants.

Procedure

In total, 60 participants were randomly divided into four groups, 1) physical activity, 2) ACT, 3) combination of physical activity and ACT, and 4) control (waited list). At baseline, participants were assessed, then interventions were performed for 8 weeks. Participants completed a series of questionnaires assessing anxiety, depression, and insomnia severity, from baseline to intervention completion, and a follow-up that occurred 4 weeks after the completed interventions in person at the research laboratory. Each group of 15 participants performed their respective interventions for 45 minutes. After the treatment, post-test was performed on all groups, and after 4 weeks of treatment, the groups were followed up to evaluate the stability of the treatment. To avoid bias, participants were not informed about group divisions and other types of interventions. In general, the research design was single-blind (Fig. 1).

Tools

Depression symptoms

Severity of depressive symptoms was measured by the BDI. This questionnaire has 21 items for depressive symptoms that include apparent sadness, inner distress, reduced appetite, concentration difficulties, lassitude, inability to feel, pessimistic thoughts,
and suicidal thoughts. Answers were given on a 4-point Likert scale ranging from 0 to 3 (“never” to “always”), with higher scores reflecting more severe symptom. The Cronbach’s alpha for the translated Persian version of the BDI in a previous study was 0.82 [33].

Anxiety
To assess symptoms of anxiety, we used the BAI. The BAI consists of 21 items addressing cognitive, emotional, and physical symptoms of anxiety, such as fear of unpleasant events, inability to calm down, nervousness, numbness, and sweating. Answers were given on a 4-point Likert scale ranging from 0 to 3 (“not at all” to “severely/it bothered me a lot”), with higher sum scores reflecting greater symptoms of anxiety. Validity (Cronbach’s alpha = 0.83) measure of the Persian version of the BAI was confirmed.

Insomnia severity
Insomnia Severity Index
The insomnia severity was assessed with the 7-item Insomnia Severity Index (ISI), which includes severity of sleep-onset and sleep maintenance difficulties, satisfaction with current sleep pattern, interference with daily functioning, noticeability of impairment attributed to the sleep problem, and degree of distress or concern caused by the sleep problem. Answers were given on a 5-point Likert scale from 0 to 4, and the total score ranges are 0–28. A higher score suggests more severe insomnia. Validity (Cronbach’s alpha = 0.80) measure of the Persian version of the ISI was confirmed [34].

Interventions
Physical activity
Aerobic exercise was considered as physical activity intervention. Exercises were performed for 8 weeks and 2 sessions per week in person at the Imam Ali Hospital (Kermanshah, Iran). The exercises consisted of two parts—static and dynamic aerobic exercise, which generally included 4 main parts: 1) warm-up; included stretching movements, cross-arm movements, hand rotation, neck rotation, cross-leg movements, sit-ups; 2) static aerobic exercise; including mountain climber twist, plank, plank-to-knee tap, and skaters; 3) dynamic aerobic exercise, involving running at 70% of the maximum heart rate; and 4) cool down, including stretching, cross-linking, sitting, stretching, and candle movements. In addition, the Borg scale was used to measure the intensity of training during exercise. The participants were asked to pay attention to the Borg scale during exercise. The intensity of the training gradually increased to avoid creating a feeling of fatigue in the participants.

ACT intervention
ACT was performed for 8 weeks and 2 sessions per week in person at Farabi Hospital (Kermanshah, Iran). Participants attended the ACT program together as a group. In week 1, the participants were given a description of the therapy. The benefits of ACT for mental health were discussed. In week 2, the participants were instructed to concentrate on the present and cultivate self-compassion during the communication and conceptualization stages of ACT. Awareness of inner experiences was also practiced at the same time. In week 3, the participants were required to practice being mindful of their breathing, body, sight, and hearing. In week 4, behavioral flexibility in the face of insomnia was taught. The stages of practicing mindfulness and overcoming challenges included being present and avoiding failures and negative thoughts. Body scan, feedback and talking about body scan, meditation, relaxing muscles, breathing, and attention techniques training (ATT) were practiced. In week 5 (value identification or differentiation between goals of life), participants discovered goals and values objectively, without bias. They had recognized their thoughts and fleeting experience, rather than experiencing identity-related and permanent mindsets. The subjects reviewed the previous week’s assignment, and conducted sitting meditation and a 3-minute breathing practice. In reviewing the previous week’s assignment, they conducted a 5-minute practice of “seeing or hearing,” re-practicing mindful breathing, muscle relaxation, meditation, and body scan practice. In week 6 (cognitive, emotional, and behavioral flexibility), the participants were instructed not to regard their emotions, excitement, and thoughts of insomnia as being unchangeable. At this point, non-judgment and acceptance were practiced. This week’s activities included reviewing the previous week’s homework, breathing exercises, sitting meditation (awareness of breathing, body, sounds, and thoughts), explanations about stress and its relationship with sleep problems, thoughts, and body sensations. In week 7 (acceptance), participants became aware of their personal reactions, as well as their relationship to their thoughts and behavior. The participants were instructed not to avoid or try to control negative thoughts and feelings. The participants were asked to observe and accept negative thoughts about themselves or their insomnia and sleep problems as a developmental process, rather than a personal product. Inner language and specific behaviors were taught. “Thoughts are not facts.” Review of last week’s assignment, mindful yoga, discussion about seeing thoughts or alternative thoughts differently, session summary, discussion about program continuation. In the last week (review and application of learned assignments in daily life), participants were asked to use mindfulness in their daily life. Other aspects of this week included the description of the point “How can I take the best care of myself?” reviewing last week’s homework, repeating exercises from previous sessions, and making a list of enjoyable activities. In conclusion, mindful breathing may reduce anxiety with allowing subjects to focus their attention on...
the rhythm, feel, and sound of their breath. Another aspect of mindfulness practice is mindful walking, which allows them to concentrate on the present moment.

Combined physical activity and ACT

Combined intervention was performed for 8 weeks, with 2 sessions per week and 45 minutes per session, and was focused on cognitive-emotional enhancement. In this group, participants spent half of the treatment session (1 day/week) on ACT and the other half (1 day/week) on the physical activity. In the first part of the training session, conceptualizing physical activity was considered as an exercise in the treatment of ACT. Therefore, the importance of physical activity as a factor in overcoming negative thoughts and reaching the present was discussed. Non-judgment and acceptance were encouraged. Participants learned to look at their goals and values without negative or positive judgments. Valuing physical activity as an important part of life was included. The benefits of exercise in improving physical and mental health were discussed.

Control group

Participants in the control group gathered once a week in groups. They were asked about their physical and psychological condition. There was talk of general living conditions. They also had group discussions with the topics of recent newspapers and magazines. The main purpose of this gathering was to eliminate or minimize the effect of social contact and friendship group in the experimental groups.

Statistical Analyses

We compared age, highest educational level, and demographic information between the four groups via a series of independent one-way analysis of variance (ANOVA) tests. Next, a series of mixed ANOVAs was performed with the factors time (baseline, post-intervention, follow-up), group (physical activity, ACT, combined vs. control), and the time by group interaction, separately, for depression, anxiety, and insomnia severity as dependent variables. Because of deviations from sphericity, the mixed ANOVAs were performed using Greenhouse–Geisser corrected degrees of freedom, although the original degrees of freedom are reported with the relevant Greenhouse–Geisser epsilon value (ε). To test the strength of changes at baseline, post-intervention, and follow-up, we used one-way ANOVA. For mixed ANOVAs, effect sizes were indicated with the partial eta squared (ηp²), with 0.01 ≤ ηp² ≤ 0.059 indicating small, 0.06 ≤ ηp² ≤ 0.139 indicating medium, and ηp² ≥ 0.14 indicating large effect sizes. The level of significance was set at p ≤ 0.05, and all statistics were processed using SPSS 25.0 for Macintosh (IBM Corp., Armonk, NY, USA).

RESULTS

Sample Characteristics

Table 1 provides information about the sociodemographic background of the participants, separately for the physical activity, ACT, combined, and the control group. The inferential statistics show that the four groups did not significantly differ with respect to marital status, weight, height, age, educational levels, and employment status and baseline physical activity levels (all p > 0.5).

Table 2 provides the mean and standard deviation for all outcomes at baseline, post-intervention, and follow-up, separately for the interventions and control conditions.

Depressive symptoms

The mixed ANOVA indicates that across the sample as a whole, depressive symptom scores decreased from baseline to post-intervention and to follow-up (Table 2). The main group effect was significant (p = 0.006). Furthermore, the findings revealed that the main effect of time was significant (p = 0.001). There was also a significant interaction between time × group (p = 0.002). Bonferroni post hoc showed that there was no significant difference between the four groups at the pre-test stage (all p > 0.5), but there was significant difference in the post-test phase (all p < 0.5) and at the follow-up (all p < 0.5). As a result, the one-way ANOVA test was used to compare the four groups in the pre- and post-test to check the effects. In the pre-test stage, there was no significant difference between the four groups of physical activity, ACT, combined, and control (p = 0.147; F = 0.93). However, in the post-test phase, the difference between the groups was significant (p = 0.001; F = 5.97).

Furthermore, there was a significant difference at the follow-up between the groups (p = 0.015; F = 3.98). As a result, the type of intervention had a different effect on the participants’ depression symptoms and the groups progressed differently. Table 2 shows that at post-test, the combined group had a greater reduction in depression symptoms than the other groups (Fig. 2A).

Anxiety

The mixed ANOVA indicates that across the sample as a whole, anxiety scores decreased from baseline to post-intervention and to follow-up (Table 2). The results of the mixed ANOVA revealed that the main group effect was not significant (p = 0.41), as shown in Table 2. However, the main effect of time was statistically significant (p = 0.01). As a result, the type of intervention affected participant anxiety. Furthermore, the interaction between group and time was significant (p = 0.01). As a result, the interaction of the meetings, as well as the type of intervention, affected anxiety. Bonferroni post hoc showed that there was no significant difference between the four groups at the pre-test stage (all p > 0.5) and at the follow-up (all p > 0.5), while in the post-test phase, the difference was significant (all p < 0.5). However,
Table 1. Descriptive statistics and overview of sociodemographic background, separately for the physical activity, ACT, combined, and control groups at baseline

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n = 15)</td>
<td>Combined (n = 15)</td>
</tr>
<tr>
<td>Male/female</td>
<td>6/9</td>
<td>5/10</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>39.45 (4.37)</td>
<td>38.86 (5.15)</td>
</tr>
<tr>
<td>Age range (yr)</td>
<td>28–65</td>
<td>18–50</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.24 (14.40)</td>
<td>78.73 (20.71)</td>
</tr>
<tr>
<td>Weight range (kg)</td>
<td>60–91</td>
<td>45–100</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.32 (12.12)</td>
<td>160.33 (10.15)</td>
</tr>
<tr>
<td>Height range (cm)</td>
<td>150–182</td>
<td>152–180</td>
</tr>
<tr>
<td>Marital status</td>
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<tr>
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<td>13</td>
</tr>
<tr>
<td>Married</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Employment status</td>
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<td></td>
</tr>
<tr>
<td>Not employed</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Government employee</td>
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<td>1</td>
</tr>
<tr>
<td>Self-employed</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Baseline physical activity level (lower/upper)</td>
<td>15/0</td>
<td>13/2</td>
</tr>
<tr>
<td>Education level</td>
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<td></td>
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<tr>
<td>High school</td>
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<td>5</td>
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<tr>
<td>Bachelor</td>
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<td>10</td>
</tr>
<tr>
<td>Master</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Data are presented as mean (standard deviation) or numbers only unless otherwise indicated. 
ACT, acceptance and commitment therapy.

Table 2. Content-oriented description for anxiety, depression symptom severity, and insomnia severity, separately for groups and measurement points, and tests for time × group interaction effects

<table>
<thead>
<tr>
<th>Group</th>
<th>Physical activity (n = 15)</th>
<th>ACT (n = 14)</th>
<th>Combined (n = 15)</th>
<th>Control (n = 15)</th>
<th>Factors²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>Group</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>ηp²</td>
<td>Time</td>
<td>ηp²</td>
<td>Time × Group interaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ηp²</td>
</tr>
<tr>
<td></td>
<td>Depression symptoms (BDI)</td>
<td></td>
<td></td>
<td></td>
<td>4.91*</td>
</tr>
<tr>
<td>Baseline</td>
<td>20.14 (6.54)</td>
<td>21.50 (4.17)</td>
<td>22.13 (6.18)</td>
<td>21.22 (7.21)</td>
<td>1.68</td>
</tr>
<tr>
<td>Post-test</td>
<td>11.57 (8.52)</td>
<td>10.12 (2.99)</td>
<td>8.80 (6.59)</td>
<td>22.09 (8.96)</td>
<td>16.85 (7.26)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>10.24 (7.16)</td>
<td>9.45 (5.04)</td>
<td>11.20 (5.01)</td>
<td>18.36 (9.56)</td>
<td>27.42 (4.82)</td>
</tr>
<tr>
<td>Anxiety (BAI)</td>
<td>24.45†</td>
<td>0.63</td>
<td>43.89†</td>
<td>0.51</td>
<td>6.34*</td>
</tr>
<tr>
<td>Baseline</td>
<td>13.60 (5.02)</td>
<td>16.20 (4.63)</td>
<td>17.06 (4.37)</td>
<td>18.93 (2.49)</td>
<td>13.60 (5.02)</td>
</tr>
<tr>
<td>Post-test</td>
<td>6.40 (3.84)</td>
<td>7.70 (6.88)</td>
<td>5.25 (5.80)</td>
<td>18.60 (2.97)</td>
<td>6.40 (3.84)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>5.40 (4.39)</td>
<td>6.60 (5.08)</td>
<td>4.25 (5.61)</td>
<td>17.53 (4.29)</td>
<td>5.40 (4.39)</td>
</tr>
</tbody>
</table>

*p < 0.05; †p < 0.01; ‡Degrees of freedom: Time, (2, 84); Group, (3, 42); Time × Group, (6, 84).
ACT, acceptance and commitment therapy; BDI, Beck Depression Inventory; BAI, Beck Anxiety Inventory; ISI, Insomnia Severity Index.
one-way ANOVA was used to determine the point of interaction. Based on the results of one-way ANOVA, at the pre-test phase, there was no significant difference between the four groups of physical activity, ACT, combined, and control (p = 0.12; F = 1.97). However, at the post-test, the differences between the groups were significant (p = 0.001; F = 7.46). Furthermore, Table 2 and Fig. 2B show that the ACT group revealed the greatest reduction in anxiety when compared to the other groups. However, the follow-up phase showed no significant difference between the groups (F = 0.92; p = 0.43).

Insomnia severity
The mixed ANOVA indicates that across the sample as a whole, insomnia severity scores decreased from baseline to post-intervention and to follow-up (Table 2). The mixed ANOVA results revealed that the group effect is significant (p = 0.001). As a result, the type of intervention affected the severity of the participants’ insomnia. Furthermore, the main effect of time was significant (p = 0.01). Moreover, the interaction between group and time was significant (p = 0.01). Bonferroni post hoc showed that at the pre-test stage (all p > 0.5), there was no significant difference between the four groups, but in the post-test phase (all p < 0.5) and at the follow-up (all p < 0.5), the differences were significant. As a result, one-way ANOVA was used to check the interaction in various phases of the pre-test, post-test, and follow-up test. The results of the one-way ANOVA to investigate the interaction point revealed that there was no significant difference in the pre-test phase between the four groups of physical activity, ACT, combined, and control (p = 2.39; p = 0.07). However, at the post-test, the difference between the groups was significant (F = 22.50; p = 0.001). Furthermore, as shown in Table 2, the physical activity group experienced the greatest reduction in sleep problems, when compared to the other groups. Also, at follow-up, there was a significant difference between the groups (p = 0.001; p = 20.66), with the physical activity group showing more improvement (Fig. 2C).

DISCUSSION
The key finding of the present study was that the 8-week program of combined physical activity and ACT had positive effects on the depression, anxiety, and insomnia severity in individuals with poor sleep quality.

In the present study, three hypotheses were tested. Our first hypothesis was that, compared to the control condition, the physical activity, ACT, and combined groups would reduce depression symptoms over time. This expectation was fully confirmed. Successful experience is one of the results of physical activity. The physical activity environment can provide an opportunity to perform tasks and lead to competence. Moreover, an active lifestyle can be created with physical activity. There is evidence that shows rumination and dysfunctional thoughts are the main reasons for insomnia [35]. Thus, physical activity can improve the mental health of individuals with poor sleep quality with reducing rumination [23]. Our result showed that the combined group was better, compared to the other groups. This finding was consistent with Gerber et al. [36], who believed that to be more effective, physical activity should be combined with lifestyle and cognitive emotion changes. Moreover, Hallgren et al. [37] showed that physical activity can reduce depressive symptoms more than cognitive behavioral therapy alone, which is in line with our finding. Further, Levinson [38] claimed that individuals become depressed because they do not receive positive reinforcement. One of the tools to create a positive environmental reinforcement and motivation is physical activity. Combined physical activity and ACT can enhance the process of internal and latent motivation. Individuals with depression feel adequate...
and competent when performing motor tasks independently. As a result, individuals develop positive reinforcement and motivation, which can ultimately help prevent depression or improve depressive symptoms.

In our second hypothesis, we expected that participation in physical activity, ACT, and combined would show a more positive impact on anxiety, compared to the control group. This expectation was fully confirmed. In explaining the superiority of the combined group, we can mention the issue of motivation. Initiating and maintaining regular physical activity among inactive individuals are major challenges. ACT intervention and creating a sense of value and commitment to physical activity can facilitate the challenge of initiating and maintaining physical activity. In addition, depression is caused by dysfunctional emotional–cognitive processes that can interfere with self-regulatory behaviors [36]. ACT is effective in changing the processes of emotion and cognition with creating a sense of self-regulation and focusing on a sense of acceptance and non-connection to failure. Therefore, in the present study, for the first time, ACT was used with a focus on improving emotion–cognition in combination with physical activity, which was more effective than the two interventions of physical activity and ACT alone. Based on the present finding, it seems that such a combination can increase the effectiveness of physical activity. In addition, we used behavior change techniques to support individuals with poor sleep quality that partially removed barriers to initiating and maintaining physical activity.

Our third hypothesis was that, compared to control conditions, participation in the physical activity, ACT, and combined intervention led to improvement in insomnia severity. This expectation was fully confirmed. The results showed that physical activity and ACT interventions can improve insomnia severity, compared to the control group. Physical activity, as mentioned in the results section, leads to improved sleep quality, as well as lower levels of depression and anxiety among individuals with poor sleep quality. This result can be explained through physiological mechanisms. Physical activity can improve sleep quality and onset with reducing stress and facilitating neurotransmitter release. It can also reduce cortisol levels, the inflammatory cycle, and boost serotonin and dopamine levels [23]. Physical activity can provide an opportunity to complete tasks and develop competence; and can also lead to a more active way of life. There is evidence that rumination is a significant contributor to sleep disorders. Therefore, physical activity can improve sleep by decreasing rumination [23]. Physical activity based interventions have been proven in studies to have protective effects on the brain and mental health; they also have positive effects on cognitive function, stress and anxiety levels, depressive symptoms, and emotional stability, as well as sleep quality [26].

ACT is a novel, non-drug-based approach to treating chronic insomnia. It aims to increase the individual’s willingness to experience the conditioned physiological and psychological discomfort that comes with not sleeping. Paradoxically, such acceptance reduces the brain’s level of nocturnal arousal, favoring rest and sleepiness over struggle and wakefulness. Additional emphasis on value-driven behavior helps to avoid unhelpful patterns of experiential avoidance, and promotes the ideal safe environment for good quality sleep. The application and benefits of using ACT approaches for the treatment of chronic insomnia, such as acceptance and willingness, mindfulness and defusion, and values and committed action, are discussed and compared to traditional cognitive behavioral approaches.

Furthermore, our findings were consistent with Kredlow et al. [39], who found that physical activity improves total sleep time, sleep onset, sleep efficiency, and first stage sleep. It has a moderate effect on wakefulness and rapid eye movement sleep; further, physical activity causes the release of a high level of neurotropic factor [39]. Also, there is evidence [40] that shows neurotropic levels in individuals with insomnia are significantly lower than in healthy individuals. Neurotropic factors, as some of the brain’s growth-related factors, play an important role in sleep, cognitive, and psychological function. As a result, by increasing their levels through physical activity, it is possible to reduce sleep problems, depression, and decreased cognitive function associated with poor sleep quality. According to research, the hippocampus, the primary site of neurotropic factors, becomes bulky after physical activity. As a result, structural changes in the brain as a result of physical activity can play an important role in brain health, and help individuals with depressive symptoms reduce anxiety and stress [24]. However, our findings did not agree with those of Elavsky and McAuley [41], who found that low-intensity walking and yoga did not have a significant impact on sleep quality.

The findings revealed that, when compared to the control conditions, participation in the ACT intervention improved psychological indicators and sleep quality. For a variety of demographics, acceptance and mindfulness therapy has been recommended as an effective strategy [42]. According to the evidence, ACT generally results in a decrease in depressive and anxious symptoms, and an improvement in psychological well-being. Acceptance of feelings and emotions is considered during ACT intervention. This acceptance, along with living in the present moment, can lead to psychological flexibility. Furthermore, destructive thoughts can be classified as one of the most common causes of sleep disorders. ACT has been shown to improve sleep quality by decreasing disruptive sleep-related thoughts.

Additionally, the findings of the present study were consistent with Kang et al. [31], who looked at the efficacy of an online mindfulness program for breast cancer survivors during COVID-19 in China. They found that participants in the mindfulness group significantly outperformed those in the control group in terms of scores, and after 8 weeks of mindfulness practice, showed lower rates of sadness, anxiety, and sleeplessness. Based on the findings of the current study and the correlation between
ACT and physical activity in treating sleep disorders and improving mental health, psychologists, mental health professionals, and behavioral specialists can develop strategies to improve these factors.

The novelty of the findings should be balanced against the following limitations. First, participants were not blind as to treatment; therefore, expectancies and motivational processes might have biased the results. Second, we relied on self-ratings. Future studies might also collect expert ratings with regard to symptoms of anxiety and insomnia severity. Third, it could also be informative to assess psychophysiological markers, such as cortisol, brain-derived neurotrophic factor, and objective sleep [43]. Fourth, a main limitation of the present study was that sleep disorder variables, such as apnea, restless legs syndrome, and narcolepsy, were not assessed. It follows that future studies should pay particular attention to other sleep disorders.

There is mounting evidence that poor sleep quality has had a detrimental effect on mental health globally, as particularly evident during the COVID-19 pandemic. Interventions are therefore required to lessen the psychological impacts of sleep problems. Steps can be taken to enhance the mental health of these individuals. The findings of the present study show that among individuals with poor sleep quality, the combined intervention of physical activity and ACT can enhance mental health and sleep quality.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Author Contributions


Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Funding Statement

This work was supported by the Islamic Azad University, Science and Research Branch, Tehran, Iran.

Acknowledgements

We would like to extend our sincere thanks to all the participants for their presence and contribution to this research.

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