

Dose–Response Parameters of Digital Music-Based Interventions for Depression: A Systematic Review

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Abstract. This systematic review examined the dose–response relationship of digital music-based interventions for depression, with a focus on session duration, intervention frequency, and total treatment length. We systematically screened all studies published between 1990 and 2026 that assessed the effects of music interventions on mental outcomes related to depressive symptoms, focusing specifically on music therapy in digital formats. The included study types comprised controlled trials, clinical studies, and observational studies, whilst review articles, theoretical papers, preprints, and non-peer-reviewed manuscripts were excluded. Given the high heterogeneity of music therapy research, particularly regarding the diverse methods of incorporating music into treatment, this review employs a narrative approach to synthesise the findings. The analysis revealed that, of the included studies, the most commonly studied intervention duration was between 20 and 60 min, while the studies investigating 30 to 60 min music therapy were associated with the biggest decrease in depressive symptoms. The most commonly used intervention frequency was daily and twice-weekly sessions which were both associated with significant depressive symptom reduction. Long-term music therapy was found to be associated with sustained reduction in depressive symptoms if the therapy was more than six weeks in duration. To sum up, our review revealed that there exists a general dose-effect relationship between digital music therapy and the improvements of depressive symptoms, that is, the longer the treatment duration, the more the depressive symptoms would be reduced. Due to the high heterogeneity in the types and methods of music therapy used in the included studies, as well as the significant variations reported, it is not able to determine a definitive optimal threshold for duration of music therapy or the minimum effective duration in this review. Our review revealed that duration should be viewed as a crucial dose-related factor in music therapy for depression. Different durations of music therapy should be tailored to individuals with different degrees of depressive symptoms to achieve optimal therapeutic effects. Our study provides guidance for future standardised and controlled trials of digital music therapy.

Keywords: Depression, Dose–response relationship, Music therapy, Systematic review

1. Introduction

Depression is a common mental disorder. It can reduce the well-being of individuals and cause serious problems. For example, patients can have impaired social functioning, anhedonia, and suicide risk [1, 2]. So how to intervene in depression and increase the well-being of these patients is an important social issue and needs attention. The main symptoms of depression include difficulty managing emotions and loss of appetite. Also patients have a lack of energy and reduced interest in life, and find it hard to work [3]. Currently, the main treatment methods for depression are pharmacotherapy and psychotherapy. Pharmacotherapy includes serotonin-related medications to regulate mood. Psychotherapy includes cognitive behavioral therapy, which can help identify and change negative thought patterns, and it is used in clinical practice. But these methods have some limitations. For example, the counseling has high costs for low-income groups. In the areas where medical resources are insufficient, the accessibility can be limited and patients may need to wait a long time [1]. These challenges show the need of new approaches that can be scaled. It is important to explore alternative methods and complementary approaches to support individuals with depression.

Music therapy has received much attention in recent years. It is non-invasive and has low side effects, and also it shows good effectiveness. Previous studies showed that music can influence the emotional processing in nervous system, including amygdala and reward-related pathways, and it can modulate the autonomic nervous system and emotional responses [4-6], so this may help alleviate depression and improve patients' positive mood. In fact, compared to traditional talk therapy alone, music can be an additional tool for therapists. It provides patients with a means of emotional expression, which is helpful for those who cannot express their emotions appropriately [7, 8]. It is worth noting that clinical studies show that passive music therapy, such as guiding patients to listen, can help alleviate depressive symptoms in counseling sessions, and active music therapy, such as guiding patients to create or perform, is expected to improve patients' positive emotions [9].

Music therapy is evolving with the development of technology. In the past, it was used as a tool in the counseling. However, now more and more individuals choose it as a standalone treatment. The application can expand from offline to online [2]. This means people can receive music therapy on their phones, tablets, computers and other devices, and in principle they do not need to go to a designated location such as a hospital. The digital music therapy is flexible because it depends on individual needs, which enhances its personalized and tailored potential, allowing for flexible scheduling based on individual availability, while also increasing the consistency and long term usage of music therapy. Digital music therapy, as part of or an additional form of electronic mental health intervention, has made significant contributions to the well-being of suburban residents, low-income groups with limited economic means, or those without access to traditional medical counseling or psychological support [10, 11].

While music therapy has gained increasing attention in academia and clinical practice as a tool, and its development has been progressive, some questions remain unresolved. One of the most significant is whether there is a dose-response relationship between the duration and frequency of music therapy and the degree of relief of depressive symptoms. For instance, whether longer therapy sessions lead to better symptom relief, or whether shorter sessions are ineffective. Furthermore, is there a threshold, or a certain duration of music therapy required for it to be effective? These two questions are crucial because they directly impact the allocation of medical resources and the development of treatment plans by physicians and clinicians, and affect the treatment outcomes for potential patients [1, 12]. Considering the complex differences in form and content between the

digital music therapy and traditional music therapy, especially the more flexibility of digital platforms which gives individuals more freedom to choose when and where to treat, the targeted nature of the treatment may be reduced.

This review seeks to synthesize the existing evidence on digital music therapy as an intervention for relieving depressive symptoms. More specifically, two questions are addressed: (1) Among the duration of a single session, the total intervention duration, and the frequency of music therapy, which parameter(s) are associated with improvements in depression treatment? (2) What intervention duration is optimal for music therapy? By resolving these two questions, a clearer understanding of music therapy may be obtained, thereby supporting the development of better treatment plans.

2. Methodology

2.1. Study design

This study complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to examine the dose–response relationship of digital music-based interventions for depressive symptoms.

2.2. Types of studies

Eligible studies should be empirical studies, studies assessing depressive symptoms, and studies reporting intervention effects on depression. Depression diagnosis was established via structured clinical interviews, such as SCID or MINI, medical records, or based on self-reported depressive symptoms. Excluded studies included review articles, such as systematic reviews and meta-analyses. In addition, commentaries, dissertations, conference abstracts and non-peer-reviewed manuscripts were excluded.

2.3. Types of participants

Studies involving participants of any age with clinically significant depressive symptoms or a formal diagnosis of depression were included. Depression had to be assessed using validated measurement tools, such as the Patient Health Questionnaire (PHQ-9), Beck Depression Inventory (BDI), Hamilton Depression Rating Scale (HAM-D), Center for Epidemiologic Studies Depression Scale (CES-D), or Geriatric Depression Scale (GDS). Studies focusing exclusively on other psychiatric conditions without reporting depressive outcomes were excluded.

2.4. Types of interventions

Eligible interventions were defined as digital music-based interventions aimed at reducing depressive symptoms. These included mobile applications, web-based platforms, virtual reality systems, AI-adaptive music programs, and hybrid models where digital delivery constituted the primary intervention component. Interventions were required to involve intentional and structured engagement with music (e.g., guided listening, therapeutic playlists, music creation, or interactive music activities). Studies involving incidental or background music exposure without therapeutic intent were excluded.

2.5. Types of outcome measures

Studies were required to report at least one validated measure of depressive symptoms assessed both before and after the intervention. Outcomes included total scores or changes in scores on standardized depression scales.

2.6. Search strategy

A systematic search was conducted using Google Scholar to identify relevant studies published between 1990 and 2026. To enhance coverage, the first 200 search results for each query were screened, and reference lists of included studies were manually searched to identify additional eligible articles. Search terms combined three key domains: (1) depression, (2) digital delivery, and (3) music-based interventions. A representative search strategy was as follows: Depression-related terms: "depression" OR "major depressive disorder" OR "depressive symptoms". Digital-related terms: "digital" OR "mobile app" OR "virtual reality" OR "AI" OR "web-based". Music-related terms: "music therapy" OR "music intervention" OR "music-based". These terms were combined using Boolean operators. Only studies published in or translated into English were included.

2.7. Study selection

The study selection process consisted of two stages. First, titles and abstracts of all identified records were screened to exclude studies that clearly did not meet the inclusion criteria, particularly those not involving digital music-based interventions or not reporting depressive outcomes. Second, full texts of potentially eligible studies were assessed in detail against the predefined inclusion criteria. Studies that did not meet all criteria were excluded at this stage.

2.8. Data extraction

Data were extracted using a structured approach in order to ensure consistency across studies. Extracted information included study characteristics, participant characteristics, intervention format, dose parameters, and depressive outcomes. More specifically, information was collected on authorship, year of publication, study design, sample characteristics, type of digital platform, mode of music engagement, session duration, intervention frequency, total treatment length, depression measures used, and the main findings related to depressive symptoms. Data extraction was carried out by one reviewer and subsequently checked for accuracy against the original sources.

2.9. Data synthesis

This review employed narrative synthesis for the reason of significant heterogeneity among different music therapy literatures. For example, previous review showed that studies measured depression differently and individuals received different forms of music in the therapy. Some samples were medically diagnosed, while others were self-reported. This substantial heterogeneity makes meta-analysis less consistent and reliable.

Table 1. Characteristics of included studies

Study	Design	Population	Intervention Type	Session Duration	Frequency	Treatment Length	Outcome Measure	Key Findings
Erkkilä et al., 2018	RCT	Adults with depression	Individual music therapy	60 min	2/week	20 sessions (~3 months)	MADRS	Significant reduction in depressive symptoms vs standard care
Castillo-Pérez et al., 2010	Controlled trial	Adults with depression	Music listening intervention	50 min	Daily	8 weeks	Depression scale	Greater symptom reduction than CBT-based psychotherapy
Chu et al., 2013	RCT	Elderly with dementia	Group music therapy	30 min	2/week	6 weeks	Depression scale	Reduced depressive symptoms and improved mood
Jasemi et al., 2016	Clinical trial	Cancer patients	Music listening	≥20 min	Daily	3 days	Anxiety & depression scales	Short-term reduction in depression and anxiety
Guetin et al., 2009	Observational	TBI patients	Music therapy	60 min	Weekly	20 weeks	Mood scale	Progressive improvement over time (dose-response pattern)
Zhou et al., 2011	Clinical study	Breast cancer patients	Music listening	30 min	2/day	Not specified	Depression scale	Significant reduction in depressive symptoms
Geipel et al., 2022	Pilot study	Adolescents with depression	Music therapy	Not specified	Not specified	12 sessions	Clinical outcomes	Potential improvement in depressive symptoms
Ray et al., 2018	Intervention study	Dementia patients	Music-based activities	Not specified	Daily activities	~4 weeks	Depression scale	Reduced depression and improved wellbeing

3. Results

Table 1 summarizes the main characteristics of the studies included in this review. The results show that some interventions lasted only a few days, while others were long-term structured programs lasting three or six months. This indicates a difference in the duration of music therapy across all studies, with both short-term and long-term forms. Furthermore, in terms of study design, some used rigorous controlled trials to demonstrate the effectiveness of music therapy, while others were small-sample exploratory studies. Despite these many differences, we have identified some stable patterns

related to treatment duration, the frequency of each intervention, and the total duration of treatment completed by participants. In details, interventions lasting 30 to 60 minutes were the most commonly used in all studies and predicted reductions in depressive symptoms across different populations. Shorter sessions, which were usually around 20 minutes, have also been reported to produce measurable improvements, particularly in clinical populations with other comorbid mental disorders. In contrast, longer sessions of approximately 60 minutes are used in more structured treatment settings.

The review is unable to directly compare the difference of intervention frequencies, because the differences on study design and population characteristics were too huge across projects. Several studies found that high-frequency interventions, especially daily exposure, led to steady reductions in depressive symptoms. This held true for most of the participants in their samples. Intervention frequencies ranged widely, from daily sessions to two or more sessions per week. Also, moderate frequency, like twice-weekly sessions, seemed to have good effect as well, though not as consistently reported as daily ones.

In terms of length of interventions, there are a lot of variations. Some are just short-term ones that last a few days, others are longer programs running for weeks or even months. The longer interventions, particularly those that go past six weeks, may lead to more sustained symptom improvement on treatment period. Short-term interventions seem to bring immediate reductions in depressive symptoms. Looking across various studies, interventions with more sessions or longer treatment duration often report gradual improvement in depressive symptoms over time. We can also spot a general dose-response pattern based on cumulative exposure. The more cumulative exposure someone gets, the greater the reductions in their depressive symptoms tend to be. However, the available evidence doesn't clearly define the functional form of this relationship, and no consistent thresholds for minimum or optimal dose were identified either.

Importantly, many studies included people with different kinds of health problems, like dementia, cancer, or neurological conditions, so their results may not work well for those with primary depressive disorders. Also, a lot of studies didn't write down dose parameters in enough detail, which makes it hard to compare one study's results to another. Then, interventions were set up in so many different ways, and outcome measurements focused on different aspects of depression. As a result, we couldn't conduct quantitative synthesis.

4. Discussion

We find some evidence for dose-response relationship in music-based interventions for depression but it is hard to derive guidelines for digital intervention design from these patterns. In fact, although results show that when the intervention is designed properly and the participants follow the protocol correctly, longer and more frequent exposure can relate to improved outcomes, more consideration is needed for the mechanisms behind these effects. Therefore, our research can guide adjustments to music therapy for different groups, improving the adaptability of music therapy and balancing resources and effects.

Our findings on relationship between the dosage of music and the improvement of depressive symptoms can be partly explained by the fact that the pleasure derived from music is associated with the activation of the dopaminergic limbic reward pathway. The amygdala, due to its high structural and functional centrality, can initiate, maintain, and terminate emotions, and plays a key role in regulating the emotional network [4-6]. Repeated and prolonged exposure to musical stimulation may also stimulate hippocampal activity, which plays a role in the generation of attachment-related emotions. Therefore, when music interventions are longer and the overall exposure is greater,

depressive symptoms may be more steadily reduced. For individuals with verbal expression problems or an inability to express emotions, music intervention provides an alternative method for processing emotions [7, 8]. Furthermore, clinical studies have confirmed that music therapy, whether actively participated in (e.g., the client plays the music themselves) or passively (e.g., the client listens to live or recorded music), has a therapeutic effect on depressive symptoms [9]. Our findings can help optimize digital mental health interventions, incorporate music therapy modules, and increase the likelihood of users receiving continued treatment [2]. Unlike traditional treatments, digital therapy allows for higher treatment frequency and shorter treatment durations, thus reducing the patient's cognitive burden.

Our study has limitations. First, our sample size is relatively small, and we lack sufficient long-term studies to verify causality; therefore, its clinical interpretation should be approached with caution. As shown in Results, studies used different designs and intervention formats and the outcome measures are not the same across different studies so it is hard to compare results directly and we cannot know which intervention is better for patients. So we can only draw weak conclusions because of this heterogeneity and we should be careful when interpreting the findings. In fact previous systematic reviews found similar problems in music intervention research and they mentioned that the reporting quality is low. They noted that many studies do not report treatment parameters in standardized way [1, 12]. It is worth noting that this issue is important for digital interventions because the platform characteristics can affect results. In the digital settings, platform design and user interaction can influence treatment outcomes and adherence is a key factor that should be considered when we evaluate the effect.

Future studies should pay more attention to examination of dose parameters in digital music-based interventions. Researchers should test session duration and intervention frequency in controlled study designs and total exposure time should be tested. This can help us know which treatment configurations are most effective. Also, future research should give a clear description of intervention components. It is worth noting that user engagement should be included. These details can make findings easier to compare across studies. As digital technologies are used more and more in mental health care, this line of research is important and it can support development of evidence-based interventions for depression. Also, these interventions should be scalable.

5. Conclusion

We summarize evidence on dose-response parameters of the digital music interventions for treating patients with depression. Several patterns are identified and these can provide guidance for future interventions. Most interventions included in this review consist of 30-60 minute sessions which are administered over several weeks and this duration is common in current practice. In addition, there is a link between the duration of music therapy exposure and mood changes. Short-term music therapy predicts momentary mood changes, while long-term exposure predicts stable mood improvements. Therefore, consistent, long-term music therapy is important for patients with depression, especially those with a history of long-term mood problems.

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