Review

MUSICÆ SCIENTIÆ

Musicae Scientiae
1–21

DOI: 10.1177/10298649211046979
journals.sagepub.com/home/msx
SAGE

Is music listening an effective intervention for reducing anxiety? A systematic review and meta-analysis of controlled studies

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Abstract

Anxiety is the most commonly diagnosed mental health disorder in the EU and 18% of the US population experiences an anxiety disorder at any one time. However, only 20% of individuals experiencing anxiety receive a formally administered intervention, highlighting a need for evidence-based interventions that can be self-administered. Music listening can be flexibly self-administered and may be useful for anxiety reduction, but further evidence is needed. The current paper addressed this by conducting the first systematic review and meta-analysis of controlled studies testing music listening interventions for naturally occurring state anxiety. A protocol was registered on PROSPERO ID: CRD42018104308. Searches were carried out of the Cochrane Library, Ovid MEDLINE, PsycINFO, Embase, Web of Science and CINAHL databases, yielding 6208 records. After screening for eligibility, 24 controlled studies were included in the review and 21 were included in the meta-analysis. Results of the meta-analyses showed that music listening had an overall significant large effect on alleviating anxiety ($d = -0.77$ [95% CI = -1.26, -0.28], $k = 21$). It was concluded that music listening is effective for reducing anxiety in a range of groups. Further research should focus on clinical groups with diagnosed mental health problems.

Keywords

Naturally occurring anxiety, self-report anxiety, state anxiety, passive music interventions, alternative interventions

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Generalised anxiety disorder (GAD) is defined as excessive worry and fear, often leading to suffering and negative implications in daily life (Gale & Browne, 2003; National Health Service, 2018). It is the most prevalent diagnosed disorder in the EU and highly prevalent globally, with 18% of the population in the US experiencing an anxiety disorder (Remes et al., 2016; Simpson et al., 2010). One-third of individuals experience clinical levels of anxiety in their lifetime (Bandelow & Michaelis, 2015). An ongoing survey assessing mental health during the Coronavirus outbreak has indicated that average levels of anxiety have increased across the population, fuelling concerns that Covid lockdowns could result in a mental health pandemic (Fancourt et al., 2020; Yao et al., 2020).

The most established treatments for anxiety are medication or psychotherapy, such as cognitive behavioural therapy (CBT) (Bandelow et al., 2017). However, a large European study found that, of those who approached healthcare services, 23.2% received no treatment at all (Alonso & Lépine, 2007), and a recent review reported that only 20% of patients receive some form of treatment (Mangolini et al., 2019), indicating a decline in support over the last decade. This decline may be linked to pressured healthcare systems in high demand, as well as the resource-intensive nature of more traditional treatments (whether financially or through human resources). This pressure on healthcare systems will only worsen during, and after, the Coronavirus pandemic. Alternative treatments that are cost effective, low in risk of side effects and which can be delivered remotely are consequently in high demand (de Witte et al., 2019).

Music listening (ML) interventions

ML is a promising alternative treatment for anxiety as it is accessible, inexpensive and easy to incorporate into everyday life (Finn & Fancourt, 2018; de Witte et al., 2019). Some individual studies indicate that ML may be effective for anxiety reduction (Burrai et al., 2020; Sung et al., 2010). ML involves either pre-recorded or live music presented to an individual or a group. Unlike music therapy, ML does not require a qualified therapist or trained facilitator so can be delivered by healthcare professionals or self-administered. ML differs from music making in that it involves less active engagement from participants, which could be more suitable for a range of patient groups. ML interventions have also been linked to high adherence rates, high levels of enjoyment and low drop-out rates, highlighting further their appeal as an alternative intervention for anxiety (Dingle & Fay, 2017; Maratos et al., 2008). Importantly, ML interventions can be delivered remotely, which is useful while social distancing and isolation measures are in place during the Coronavirus pandemic.

ML and anxiety

There are a range of functions proposed in the literature that may be used to explain the relationship between ML and anxiety reduction. Firstly, ML has been linked to decreasing physiological indicators of anxiety, such as heart rate and blood pressure (de Witte et al., 2019). ML may also modulate the stress response, through decreasing cortisol levels (Finn & Fancourt, 2018). Similarly, an extensive amount of literature has focused on how ML can be used for affect regulation, which encapsulates mood, emotion and arousal (Baltazar & Saarikallio, 2016; Saarikallio, 2012; Schäfer et al., 2013). As a method of self-regulation and when used positively, it can support coping by reducing and preventing symptoms of anxiety (Miranda, 2012). In the Music in Mood Regulation scale, Saarikallio (2008, 2012) proposed seven regulation strategies: entertainment, revival, strong sensation, diversion, discharge, mental work and solace. Similar functions have also been explored in the research linking ML and wellbeing. Groarke and Hogan (2016, 2018, 2020) proposed a model to explain the adaptive effects of ML associated with wellbeing through incorporating social cognitive theory (SCT; Bandura, 2001). Within the model, they refer to affective experiences and regulation but also emphasise the importance of social and eudaimonic experiences on wellbeing.

To the best of our knowledge there is only one systematic review and meta-analysis on ML for anxiety, conducted by Panteleeva et al. (2017). Findings from this review demonstrated an overall decrease in self-reported anxiety. However, within this review, 62% of studies involved experimentally manipulated anxiety such as a psychosocial stress test (Thoma et al., 2013), rather than naturally occurring or persistent (i.e., state) anxiety. Additionally, Panteleeva et al. (2017) only included studies which had anxiety as a primary outcome, so a large number of studies which measured anxiety as a secondary outcome were not included. The present review excluded studies investigating experimentally manipulated anxiety in order to assess whether ML may be useful for reducing levels of state anxiety. To reduce publication bias and maximise the number of comparisons, we included all studies that measured anxiety as an outcome, regardless of whether this was considered a primary or secondary outcome within the original papers.

Additionally, the impacts of potential moderators and differences in strength of effects across and between studies are yet to be fully explored in this area (de Witte et al., 2019). One pertinent question regarding ML interventions relates to whether they are more effective when administered to individuals or groups. A great deal of literature suggests the presence of others can enhance emotional experiences and promote a sense of shared experience (de Witte et al., 2019). Within the literature on music making for wellbeing, it seems that the majority of interventions involve group activity, strengthened by the social element of the intervention (Hallam et al., 2012). However, outcomes for group ML are still unclear (Greb et al., 2018). This issue is particularly important given the current social context, with Covid-19 restrictions making group ML interventions challenging to deliver in their traditional formats. To the best of our knowledge there is only one review which has compared individual and group music interventions, which found individual setting to be more successful than group interventions for stress reduction (Pelletier, 2004). The present review aimed to provide an updated comparison.

A second question relates to music selection. That is, it is unclear whether the effectiveness of ML for anxiety reduction is impacted by whether the participant themselves chooses the music they listen to, or whether this is chosen by the facilitator and simply presented to participants. A previous review including studies of both ML and music-making interventions indicated there may be no difference (de Witte et al., 2019) but this has yet to be tested in ML interventions alone.

In addition, a third pertinent question relates to the use of control conditions in ML studies. A recent meta-analysis assessing music interventions (including studies of both ML and music making) for anxiety found a larger overall effect size for studies involving a control condition aimed at stress reduction such as muscle relaxation (de Witte et al., 2019). However, it is unclear whether the nature of the control condition influences the apparent effectiveness of ML for reducing anxiety.

It is unclear whether ML interventions are equally effective across settings, or whether some settings (such as health or social care settings) may facilitate better results than community settings. Further exploration comparing the effects of ML in different settings is required.

Finally, it has been suggested that the relationship between the dosage of ML and its impact on anxiety is unclear (de Witte et al., 2019). Previous reviews have focused on comparing the differences between single-session interventions versus interventions involving more than one session (Pelletier, 2004; de Witte et al., 2019). Some research suggests that 30 minutes or above is an acceptable duration for a single session (see review by Nilsson, 2008), although to the best of our knowledge this is yet to be confirmed in a meta-analysis of this kind. Therefore, we aim to test this suggestion by comparing effect sizes of ML dosage involving 30 minutes and above with less than 30 minutes of ML.

Aims

(1) To assess whether ML interventions are effective for reducing naturally occurring, state anxiety.
(2) To test whether the effectiveness of ML interventions for anxiety reduction is influenced by music delivery (group vs. individual), music selection (experimenter vs. participant), control condition type setting and single-session ML dosage.

Method

Protocol and registration

A protocol for this review was registered on PROSPERO, ID:CRD42018104308; http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018104308

Eligibility criteria

PICOS criteria, as suggested by Cochrane, were used in this review. For population, both clinical and non-clinical adult samples were included. Children were not included in the review. Any type of intervention involving ML was accepted. For comparison, any type of non-music control was considered, including intervention or waiting list. For outcome measure, the review focused on anxiety. This is defined as an unpleasant emotional response involving perceived feelings of worry, tension and hyperarousal. We specifically aimed to test levels of anxiety in the absence of an anxiety manipulation. There is a body of work examining how ML has an impact on experimentally manipulated anxiety. We aimed to provide useful information for those who are experiencing anxiety generally, and not as a result of manipulation. It was decided that only validated measures of anxiety, such as the State-Trait Anxiety Inventory (Spielberger et al., 1983), would be included to maintain validity of findings.

In addition, studies were eligible if they were written in English and published in a peer-review journal. In terms of study design, and in line with Cochrane guidelines (see Ryan, 2013), it was decided at the full-text stage to include randomised control trials (RCTs) and controlled before-and-after studies (CBA). This was because both study designs involve an appropriate level of standardisation for the effects of intervention and control groups to be compared across studies.

Due to the high heterogeneity of studies discovered, additional exclusion criteria were added after abstract screening and before full-text (FT) screening. The additional criteria excluded studies involving anxiety associated with medical procedures (e.g., pre-operative anxiety) and studies involving music performance anxiety, as these specific types of anxiety may not accurately reflect natural, persistent or state anxiety, which was the focus of this review.

Information sources

The following bibliographic databases were used in this review: Cochrane Library, Ovid MEDLINE, PsycINFO, Embase, Web of Science and EBSCO database: CINAHL. In addition, further searches were carried out by reading reference lists of relevant studies and reviews. The search was conducted from database inception to 26 January 2018 (updated search to 21 April 2020).

Search strategy

The search strategy consisted of two key blocks of terms, which were "music listening" and "anxiety," through a combination of medical subject headings (MeSH terms) and text words.

The strategy was cross referenced with previous systematic reviews to ensure that the included key terms allowed for all key papers to be retrieved. The full search strategy can be found in the supplementary material.

Study selection

After the articles were collated and combined from all databases, duplicates were removed. The remaining papers were assessed in three phases: title, abstract and full text. At all stages, the PICOS criteria (as stated above) were used to assess eligibility. If the article's content was not clear in the initial stage, it was kept until eligibility could be confirmed or excluded. The initial reviewer, CH, completed the screening following the standard process. A second reviewer, MU, checked 5% at the title and abstract stages. These articles were chosen through random number generation in order to obtain objectivity. An inter-rater agreement of $\kappa = 0.74$ was obtained. Discrepancies were discussed and amended accordingly. FT screening was then conducted, adhering to the amended eligibility criteria (as mentioned above). All FTs were double screened, and discrepancies were resolved by discussion (CH and ABW). Study selection is illustrated in Figure 1.

Data collection process

Quantitative data for the meta-analysis were extracted onto an Excel spreadsheet. Descriptive data were also extracted onto an Excel spreadsheet using the Cochrane library resources as a template for data items, to ensure consistency across data extraction of each article included in the review.

Data items

The following descriptive information was extracted from each article onto an Excel spreadsheet by the first reviewer. A narrative synthesis of the data was deemed appropriate alongside the meta-analysis to provide an accurate summary of the study characteristics. This was then checked by a second reviewer.

- **General information:** authors, year
- **Characteristics of included studies:** design, control condition, recruitment method, sample size, gender, age, sample type (e.g., healthy individuals, individuals diagnosed with dementia), clinical/non-clinical, setting, considerations of environment
- **Intervention:** theoretical model, participant selected versus experimenter selected music, music details, delivery (group/individually), length of intervention, number of sessions, time per session, total dose of intervention (min)
- **Outcome:** primary outcome measure, secondary outcome measure, validity of tool/outcome, time points tested, retention at follow-up (%), notable findings, any information on adherence rate/drop out number.

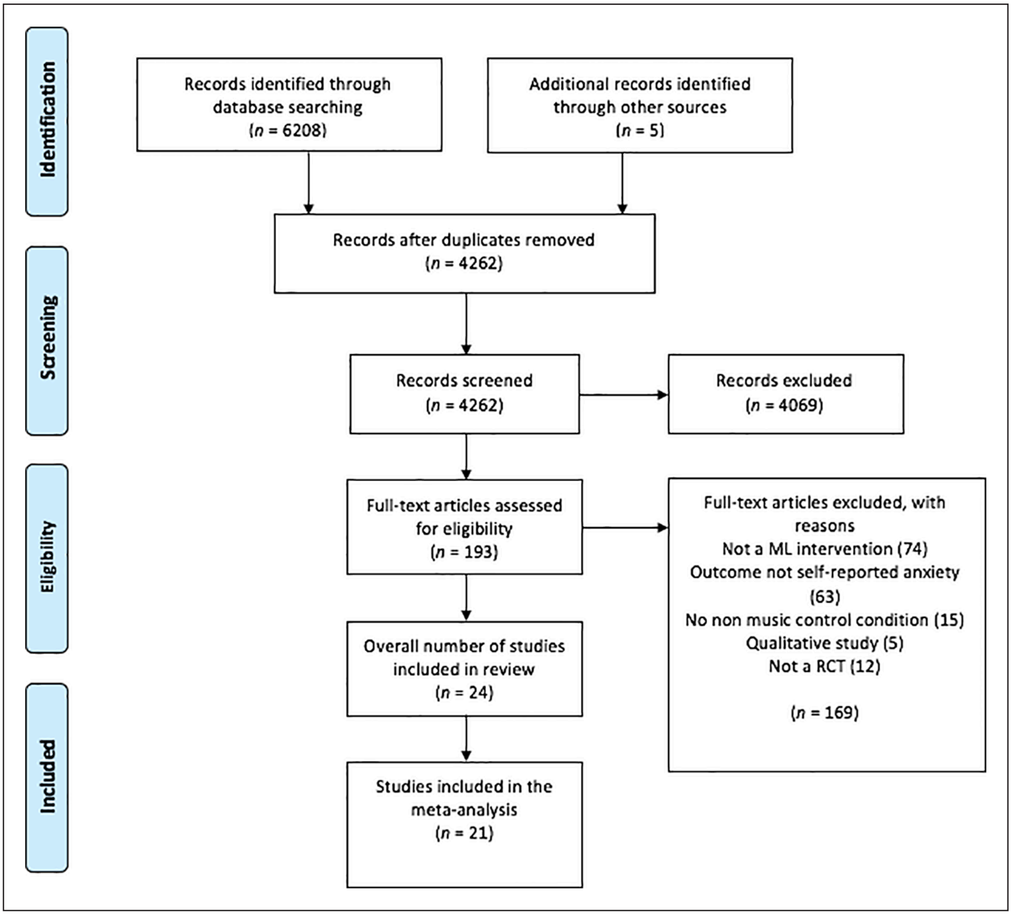

Figure 1. PRISMA flow diagram for study selection.

Risk of bias in individual studies

The risk of bias assessment was carried out according to the revised Cochrane guidelines for assessing risk of bias (RoB 2.0; Higgins et al., 2019). The following areas were assessed for each study: randomisation process, deviations from intended interventions, missing outcome data, measurement of outcome, selective outcome reporting and other risk of bias. Each criterion was measured on a 3-point scale (high risk of bias, some concerns, low risk of bias) and an overall rating for each study was decided. A study was deemed as low risk of bias if four or more of the six items were rated as having a low risk of bias.

Summary measures

The primary measures involved in this review were self-reported anxiety outcomes, which were continuous and on a scale. There were no secondary outcomes. The mean differences or standardised mean differences were compared between control and experimental conditions, post-intervention.

Planned methods of analysis

The meta-analysis focused on the effectiveness of ML on anxiety outcome measures. This was deemed the most appropriate analysis to test the strength of evidence, which was in line with the aims of this review. Through the use of a random effects model, an assessment of effect size and of confidence intervals was carried out. Additionally, a sensitivity analysis involving low risk of bias studies only was conducted to test the robustness of the effect. Heterogeneity of included studies was assessed using the Q statistic. Publication bias was determined through a funnel plot and Egger's Regression test (Egger et al., 1997). The software used for the analyses was ProMeta 3.0.

Additional analyses

In order to understand the contribution of various characteristics on the effect of ML on anxiety, as set out in the Introduction, categorical moderation was performed using ProMeta 3.0. Comparisons of effect sizes were carried out to consider differences between group and individual ML interventions; healthcare (including care homes) and non-healthcare settings; sitting-in-silence control and other control condition; and experimenter and participant/combination of participant and experimenter music selection. In addition, single-session dosage of up to 30 minutes was compared with dosage of 30 minutes and above.

Results

Study selection

As shown in Figure 1, the database searches yielded 6208 records. Searching through other sources retrieved an additional five records. After removal of duplicates, there were 4262 records to screen. Abstract and title screening removed 4069 records, leaving 193 records for full-text screening. Eligibility assessment at full-text stage excluded a further 169 articles. This left a remaining 24 articles for narrative synthesis. Three papers were excluded from the quantitative meta-analysis due to insufficient data available. Two attempts were made to contact authors for this information, where possible. Of the three papers, two did not provide contact information or there was an error in the email address provided. For the third article, we did not receive a response from the authors. This left 24 papers for the narrative synthesis and 21 papers remaining for meta-analysis.

Characteristics of the studies and participants

Characteristics for studies and participants are summarised in Table 1. Of the 24 included studies, there were 2062 participants, of which 33% ($n = 682$) were male. Four studies did not include gender information. The majority of studies were carried out in the United States ($n = 5$), followed by Taiwan ($n = 4$), India ($n = 3$), the UK ($n = 2$), Turkey ($n = 2$) and France ($n = 2$). One study was conducted in each of the following: Australia, Spain, Hong Kong, Italy, Israel and Iran.

In terms of participant groups, the undergraduate student population were included in six studies. Additionally, the elderly were involved in six studies, three of which concerned the elderly diagnosed with dementia. Three studies involved pregnant women and two studies involved prisoners. One study was conducted with each of the following populations: high school students, caregivers, post-partum mothers, patients with dyspnea, stroke patients, patients with heart failure and individuals with chronic skin disease. In terms of setting, the most common was health facility

Table 1. Study characteristics for participants of included studies.

Study	Country	Design	Sample (*N*)	Age *M* (*SD*)	Gender (M/F)	Male %	Population type	Setting
Amiri et al., (2019)	Iran	RCT	30	Exp=27.48, Control=27.12	30/0	100	Students with insomnia	Psychiatric treatment centre
Barde et al., (2019)	India	RCT	150	n/a	n/a	n/a	Older adults	Care home
Bassett, et alJ. E., Blanchard, E. B., Estes, L. (1977)[a*]	USA	RCT	60	23.4 (4.55)	60/0	100	Prisoners	Prison
Baylan et al., (2020)	UK	RCT	72	64	45/27	70	Stroke patients	Hospital
Bekiroglu, et al.T., Ovayolu, N., Cetin Ekerbicer, H. (2013)	Turkey	RCT	30	*M* not reported, range 60–-89.	17/13	57	Elderly with hypertension	Care home
Bensimon, et alM., Einat, T., Gilboa, A. (2015)	Israel	CBA	48	Exp = 29.8 (6.8) Control = 31.1 (9.2)	48/0	100	Prisoners	Prison
Burrai et al., (2020)	Italy	RCT	159	73.1	99/60	62	Patients with heart failure	Medical centre (cardiology)
Chang, et alM. Y., Chen, C. H., Huang, K. F. (2008)	Taiwan	RCT	236	Exp =30.48, Control = 29.58	0/236	0	Pregnant women	Medical centre
Cheung et al., (2018)	Hong Kong	RCT	104	Exp = 84.50 Control= 85.58	25/82	30	Older adults with dementia	Residential care facility
Choi, Y. K. (2010)	USA	RCT	32	*M* not reported, range 45–-94	11/22	34	Caregivers, spouse (20), adult child (12)	Hospice
Demirtas et al., (2020)	France	RCT	50	60.7	31/19	62	Individuals with chronic skin disease	Hospital
Ergin, et alE., Sagkal Midilli, T., Baysal, E. (2018)	Turkey	RCT	60	61.21	36/24	60	Patients with dyspnea	Hospital
Ergin, E., & Yücel., S. C. (2019)	Spain	RCT	56	*M* not reported, 60+	n/a	n/a	Older adults	Nursing home

(Continued)

Table 1. (Continued)

Study	Country	Design	Sample (*N*)	Age *M* (*SD*)	Gender (M/F)	Male %	Population type	Setting
Guéetin et al., (2009)	France	RCT	30	Exp = 85.2 (6.0) Control = 86.9 (5.2)	n/a	n/a	Individuals with mild to moderate dementia	Care home
Gupta, U., & Gupta, B. S. (2005)	India	RCT	80	*M* not reported, range 19–-24	80/0	100	Healthy individuals	Lab based/ university
Gupta, U., & Gupta, B. S. (2016)*)[a]	India	CBA	80	*MM* = 36.7 (4.9) *FM* =35.9 (4.7)	40/40	50	Healthy individuals	Lab based/ university
Guyer, N. P., & Guyer, C. G. (1984)	USA	RCT	48	17 (0.64)	24/24	50	Students (high school)	High school
Liu, et alY-H., Le, C. H., Yu, C-H., Chen. C-H. (2016)	Taiwan	RCT	121	18+	0/121	0	Pregnant women	Antenatal clinic
Nwebube et al, C., Glover, V., Stewart, L. (2017)	UK	RCT	222	18+	0/222	0	Pregnant women	Online study
Oxtoby, J., Lurie-Beck, J.et al. (2013)*)[a]	Australia	RCT	127	23.31 (7.18)	69/58	54	Students	University
Robb, S. L. (2000)	USA	RCT	60	22.2	n/a	n/a	Students	University
Russell, L. A. (1992)	USA	RCT	78	19–-43	38/40	49	Students	University
Sung, et alH-C., Chang, A. M., Lee, W-L. (2010)	Taiwan	RCT	52	80.12 (7.55)	29/23	56	Older adults with dementia	Care home
Tseng, et alY – F., Chen, C-H., Lee, C, S. (2010)	Taiwan	RCT	77	Exp= 30.43 (3.87) Control = 30.78 (4.77)	0/77	0	Post-partum mothers	Teaching hospital

Note: RCT = randomised control trial. CBA = controlled before and after. FM = female mean. MM = male mean.
[a]* Not included in the meta-analysis.

(including hospital, medical centre, antenatal clinic, psychiatric treatment centre, hospice; $n = 9$) followed by nursing home ($n = 6$), university ($n = 5$) and prison ($n = 2$). One study was conducted in each of the following settings: online and high school.

Characteristics of intervention and comparison

Characteristics of interventions and comparison conditions are summarised in Table 2 in the supplementary material. Of the studies that reported music session length, the most common was 30 minutes ($n = 12$). This was followed by 20 minutes ($n = 3$), then 15 minutes ($n = 2$) and 60 minutes ($n = 2$). The following amounts were included in one study each: 25 minutes, 40 minutes and 45 minutes. Two studies did not state amount of time per session. Total minutes of ML ranged from 15 to 3360 minutes. The frequency of listening sessions ranged from 1 session to 90 sessions. Most studies involved participants listening to music individually ($n = 17$) followed by in a group ($n = 4$). Some studies did not include this information ($n = 3$). For the majority of included studies, music was experimenter selected ($n = 18$), followed by participant selected ($n = 4$). Some studies involved a combination of participant and experimenter for music selection ($n = 2$).

A table detailing music used across studies involving experimenter selected music ($n = 18$) can be found in Table 3 in the supplementary materials. The most common style of music used was instrumental music ($n = 13$), such as classical, contemporary classical, meditative, ambient or new age. Most music did not include vocals. The music used in the three studies involving pregnant or post-partem women included the same set of pre-recorded CDs which contained lullabies, nature sounds and children's rhymes or songs (as well as classical music). A further study involving pregnant women used original music created for the study by a composer and involved lullabies and motherese alongside acoustic instruments. One further study included a popular folk-rock album in the ML condition.

In terms of the comparison condition, the most common was sitting in silence or no music ($n = 9$).

Other comparisons included: standard routine care (if in medical facility or care home, continue with treatment as normal) ($n = 4$), reading material ($n = 2$), relaxation/rest ($n = 2$), waiting list to take part in study at later date ($n = 2$). The following control conditions were included in one study each: regular bedtime routine, listening to a history tape, audio book and social activity. One study did not provide any information on the control condition.

Outcome characteristics for included studies

Of the 24 studies, 15 measured anxiety as the primary outcome measure and nine measured anxiety as a secondary outcome measure. The most common measure was the State-Anxiety Inventory ($n = 14$; Spielberger et al., 1983). Other measures included were: Hamilton Anxiety Rating Scale ($n = 2$; Hamilton, 1959), Rating Anxiety in Dementia ($n = 2$; Shankar et al., 1999), Hospital Anxiety and Depression Scale ($n = 2$; Zigmond & Snaith, 1983), Depression Anxiety Stress Scales ($n = 2$; Lovibond & Lovibond, 1995), Geriatric Anxiety Scale ($n = 1$; Segal et al., 2010), Four Factor Anxiety Inventory ($n = 1$; Gupta & Gupta, 1998), Beck Anxiety Inventory ($n = 1$; Beck et al., 1988), Visual Analogue Scale Anxiety ($n = 1$; Bassett et al., 1977). Some studies included more than one measure of anxiety.

The main focus of this review was the immediate effects of ML on anxiety outcomes. However, there was some variation across studies on the time that the post-intervention outcome measures were collected. For the majority of studies ($n = 18$), authors did not specify the specific time that the post-intervention anxiety measure was collected beyond 'post-intervention'. A further three studies stated that the post-test measure of anxiety was collected the day after the intervention. The authors of one study stated that the measure was collected on the same day (Bekiroglu et al., 2013). For one online study, participants were given up to five days to provide their response, post-intervention (Nwebube et al., 2017).

In addition, a total of five studies collected further follow-up measurements post-intervention. The follow-up time periods were as follows: one week post-intervention ($n = 1$), six weeks post-intervention ($n = 1$), eight weeks post-intervention ($n = 1$) and three months post-intervention ($n = 2$). Results were mixed for follow-up measurements. Significantly lower anxiety scores were seen at follow-up in ML conditions compared to control in two studies (one-week follow-up, Bensimon et al., 2015, and eight-week follow-up, Guétin et al., 2009). Two studies found a non-significant difference between intervention and control conditions at follow-up (six-week follow-up, Cheung et al., 2018, and three-month follow-up, Burrai et al., 2020). Baylan et al. (2020) did not conduct a statistical analysis to compare anxiety scores at three months follow-up, although mean differences were in favour of the control condition.

Quality of reporting

In line with Robb et al. (2018), the presence of a theoretical rationale was sparse across studies. Three of the 24 studies referred to a specific theory in the introduction. In terms of intervention information, most studies included details on the music used in the study. Eight studies did not provide evidence to support the choice of musical stimuli. In terms of setting, six of the included studies provided no information on the environment in which participants listened to music. A number of studies provided information on attempts to create a relaxing environment (such as reclining chairs, beds and dimmed lights). Two studies included a face mask for individuals to use in order to reduce visual distractions.

Volume regulation varied across studies, with the majority of studies ($n = 13$) not including any information on volume. Five studies allowed participants to control volume levels. In addition to this, two studies involved controlled-U sequences of gradual volume increase then decrease and finally, in two studies, the volume was set at 50–60 db. The materials included in the studies were rarely stated. Eight studies included information on the device used to play music.

Risk of bias across studies

Risk of bias was assessed using the Cochrane risk of bias tool 2.0 (Higgins et al., 2019).

Overall, of the 24 included studies, 10 were deemed low risk of bias. A further eight were deemed to have “some concerns” and six were rated as having a high risk of bias. The “Reported result” item of the RoB 2.0 had the highest amount of studies deemed as having “some concerns,” due to the majority of studies not including a detailed intention of analysis or protocol prior to presenting results. The outcome measure item was the lowest risk of bias across studies, due to the use of standardised measures of anxiety.

Meta-analysis

Overall, ML had a significant (p =.002) large effect on anxiety outcomes ($d = -0.77$ [95% CI = −1.26, −0.28-->, $\kappa = 21$). The forest plot for the main meta-analysis can be found in Figure 2. The heterogeneity of studies in the main meta-analysis was $Q(20) = 379.49$, $p < .001$; $I^2 = 94.73\%$, which is deemed as considerable heterogeneity according to the Cochrane guidelines (Higgins et al., 2012).

Sensitivity analysis

After the removal of the high risk of bias studies, the effect of ML on anxiety remained significant (p =.009), $d = -0.97$ [95% CI = −1.70, −0.24], $k = 10$, and the size of the effect increased in magnitude (Higgins et al., 2012). Heterogeneity was significant, $Q(9) = 219.10$, $p < .001$; $I^2 = 95.89\%$, and still deemed considerable.

Publication bias

A funnel plot was carried out for the main meta-analysis to assess publication bias, which showed slight asymmetry, indicating some publication bias. However, it does not follow the typical pattern of publication bias as studies are missing on the left, where successful ML interventions are depicted. Additionally, Egger et al.'s (1997) regression test was nonsignificant, which indicates no publication bias ($t = -1.07$, $p = .296$). The funnel plot for publication bias can be found in Figure 3.

Group versus individual ML, music selection, control condition, setting and dosage comparisons

Categorical moderation was justified due to the considerable significant heterogeneity. According to Fu et al. (2011), a minimum of four studies per sub-group is required for categorical moderation and 10 studies are required for subgroup analysis (Higgins et al., 2012). There was an insufficient number of studies for the group ML subgroup ($n = 3$) for moderation or subgroup analysis to be conducted between group ML and individual ML interventions.

For other comparisons (music selection, control condition, setting and single session dosage), there were sufficient studies to run subgroup analyses.

There was not a significant moderating effect ($p > .05$) for setting (health and social care, including care homes, and non-healthcare settings). Health and social care settings yielded a larger effect size ($k = 15$; $d = -0.95$) compared to non-healthcare settings ($k = 6$; $d = -0.32$). This is illustrated in Figure 1 in the supplementary material.

For control condition (which included silence control and other control conditions), there was not a significant moderating effect ($p > .05$). The "other control condition" subgroup yielded a larger effect size ($k = 12$; $d = -1.11$) compared to Silence control ($k = 9$; $d = -0.35$). This is shown in Figure 2 in the supplementary material.

For music selection, the moderating effect was also not significant ($p > .05$), with studies involving participant or combination of participant and experimenter selected music generating a larger effect ($k = 7$; −1.01) than experimenter selected music ($k = 14$; −0.65). This is shown in Figure 3 in the supplementary material.

For intervention dosage, there was no significant moderating effect ($p > .05$), with very similar effect sizes for studies involving up to 30 minutes per session ($k = 6$; −0.61) and studies involving ML of 30 minutes and above ($k = 13$; −0.63). This is shown in Figure 4 in the supplementary material.

Discussion

This review and meta-analysis were the first to test ML interventions for reducing naturally occurring state anxiety. Overall, the findings suggested that ML interventions reduced anxiety with a large effect size. These findings were robust and remained significant when only studies at low risk of bias were included in the analysis. Additionally, there was no evidence of publication

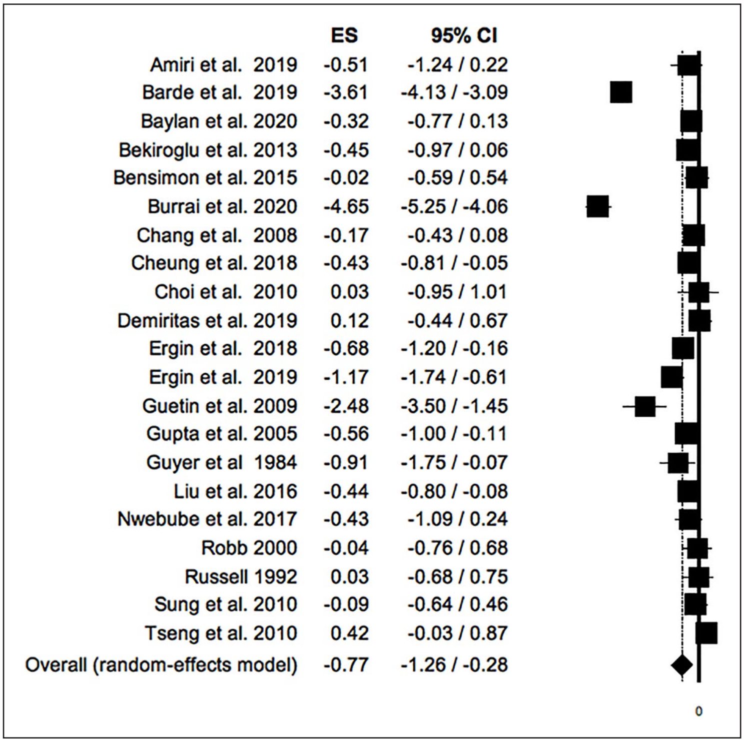

Figure 2. Main meta-analysis forest plot for ML on anxiety outcomes.

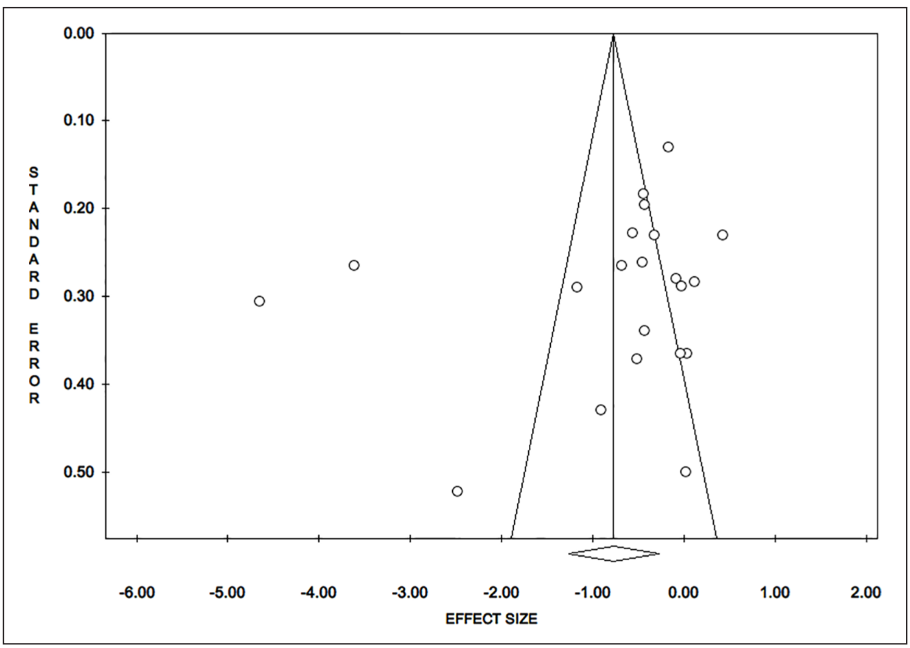

Figure 3. Funnel plot to assess publication bias using Prometa.

bias. There were no significant moderating effects found for setting, control condition, music selection and single-session dosage, with interventions found to be more effective when involving health and social care settings, participant/combination of participant and experimenter selected music, and other control conditions. Both groups ($<$ 30 minutes and $\geqslant$ 30 minutes) were not significant for single-session dosage of ML. A wide range of populations were investigated in the studies included in the review that could be expected to be experiencing heightened anxiety, such as prison populations, those with significant health concerns and those with dementia. As such, these review findings suggest that ML interventions appear to be widely acceptable and offer benefits across groups and settings.

The findings could be explained by the extensive literature on the adaptive functions of ML. The significant reductions in anxiety could be linked to its emotional regulatory effects. Emotional regulation is commonly cited in the literature as the main function of ML (Groarke & Hogan, 2018; Saarikallio, 2008). None of the included studies tested the underlying mechanisms of ML so without this we can only speculate such links. Future consideration of underlying mechanisms would be beneficial when developing interventions for anxiety; this could be achieved by including measures such as the Adaptive Functions of Music Listening scale (AFML; Groarke & Hogan, 2018) and the Music in Mood Regulation scale (B-MMR; Saarkallio, 2008, 2012).

Discussion of the findings in relation to previous reviews

Findings were in line with similar reviews investigating ML and anxiety (Panteleeva et al., 2017); music interventions for stress and anxiety (de Witte et al., 2019); and ML on biological parameters associated with stress and anxiety (Finn & Fancourt, 2018). The current review did not include experimentally manipulated anxiety, which means that it provides a more ecological evaluation of ML interventions than previous reviews. The contribution of studies involving secondary outcome measures of anxiety added nine studies to the review. This represents an advance upon the Panteleeva et al. (2017) review, which did not include studies where anxiety was a secondary outcome measure, meaning that several relevant studies were excluded.

Prior meta-analytic work assessing ML for anxiety (Panteleeva et al., 2017) did not include further analysis of effect sizes. There was not a significant moderating effect for setting. However, health and social care settings yielded a larger overall effect size. The greater effect size for health and social care settings may be due to the fact that studies conducted in clinical settings are often of better quality compared with non-clinical settings (Finn & Fancourt, 2018). It may also be explained by the possibility that participants in these settings have higher baseline levels of anxiety, thereby enhancing the scope for anxiety reduction, although it must be noted that this difference was not statistically significant.

Additionally, there was not a moderating effect for control condition. This finding is in line with de Witte et al. (2019), who did not find a moderating effect of control condition. However, their review compared active controls with care as usual. For the current review, there were insufficient studies involving active control conditions to run this comparison. Rather, the majority of control conditions involved sitting in silence, which was also seen in Panteleeva et al. (2017). More research involving active controls should be conducted in this area to allow for comparisons to be made.

There was also no significant moderating effect of music selection. Studies involving participant or combination of participant and experimenter selected music yielded higher effect sizes, but this difference was not significant. This is in contrast with previous research indicating that self-selected music maximises the stress-reducing response (Jiang et al., 2016; Juslin et al., 2008).

For single-session dosage, both groups (< 30 minutes and $\geqslant 30$ minutes) yielded similar effect sizes. A session time of 30 minutes has been recommended previously (Nilsson, 2008) and this was the most common duration among the included studies. Future research comparing different durations would be useful for the purposes of drawing further conclusions.

Strengths and limitations

A strength of the review was that it was pre-registered on PROSPERO and followed the Cochrane guidelines (Higgins et al., 2012; Higgins et al., 2019) closely to ensure a stringent, standardised summary of the research area. Furthermore, risk of bias across studies was in line with previous ML reviews (see Finn & Fancourt, 2018; Panteleeva et al., 2017). Additionally, the review findings were strengthened by including only RCTs and CBAs.

A limitation of the review was significant high heterogeneity across studies, which was probably due to differences between interventions. One example of this is the total dosage of ML, ranging between 15 minutes and 3360 minutes across studies. However, this is a common challenge, seen consistently across reviews in this area (Robb et al., 2018). This was managed via the use of a random-effects model within the meta-analysis and through conducting moderation analyses. Considering the ubiquitous nature of ML, it is a constant challenge to distinguish it as a therapeutic intervention, which should be noted when drawing conclusions. In addition, the scope of our review was limited by its inclusion only of studies written in English.

Implications for clinicians and researchers

The review found that ML interventions were effective for reducing anxiety. A key benefit of such interventions is that, unlike interventions involving the creation of music, they do not require any specialist knowledge, equipment, or ability. Furthermore, they can be self-administered, either in conjunction with a practitioner-delivered intervention or in isolation. These findings come at a time when such interventions are sorely needed: Covid-19 pressures have increased anxiety levels, with 24.4% of 90,000 participants demonstrating moderate-severe anxiety in a recent survey (Fancourt et al., 2020), and have simultaneously reduced individuals' abilities to interact with healthcare professionals or receive traditional psychological interventions. As such, psychological therapists could consider using ML as an adjunct to other interventions they are delivering to clients who are experiencing anxiety, and policymakers could consider recommending ML as one of a range of strategies for managing anxiety.

Importantly, it appears that ML may have utility across a wide range of groups and settings. Studies included in the review included the participation of groups of patients with dementia and prisoners. Overall, studies involving the dementia group found a reduction in anxiety (Cheung et al., 2018; Guétin et al., 2009; Sung et al., 2010). Additionally, decreased anxiety was found in the prisoner group post ML compared with controls (Bensimon et al., 2015). Research indicates elevated levels of anxiety in the dementia group (38–72% prevalence rate; Kwak et al., 2017) and in prisoners (Malik et al., 2019) compared to the general population. This highlights the effectiveness of ML on elevated anxiety levels and in institutional settings such as prisons and care homes, where access to psychological interventions is limited.

Future research should focus on groups diagnosed with clinical levels of anxiety. This group was under-represented in the present review. Further, more research is needed involving group ML interventions as in the present review, as only four studies were found that investigated ML interventions delivered in this format. Considering the plethora of research on the functions of

ML emphasizing in particular its social function (Schäfer et al., 2013), the lack of group ML interventions for anxiety is surprising. Additionally, Groarke and Hogan (2016) discuss the potential improvements to wellbeing attributable to the facilitation of social connection and bonding associated with ML. Due to both the lack of group ML interventions for anxiety and the research indicating the links between social functions of ML and wellbeing, investigating the effects of group ML on anxiety further would be a worthwhile area to explore. Considering the current Coronavirus outbreak and associated social-distancing measures, it is important to understand whether ML is more effective in group settings.

Specific recommendations

Researchers may want to consider the following recommended intervention characteristics, as collated from the review findings. Firstly, in terms of music it appears that participant involvement in selection is important. However, if music is to be selected by experimenters, it appears that instrumental classical music is most commonly used in this area. Further research should look into comparing the effectiveness of different types of music in ML interventions for anxiety. In terms of intervention dosage, 30 minutes was used most frequently across studies. The subgroup analysis suggested that both groups (< 30 minutes and ≥ 30 minutes) had similar effects on reducing anxiety. More research is needed to compare different single-session dosages. Additionally, more research involving the specific timing of post-intervention outcome measurement (i.e., more detail beyond "post-intervention") would be useful, as well as studies involving follow-up measurements post-intervention to gain further insight into long-term effects, as the evidence for these was mixed. Overall, we strongly recommend that researchers provide adequate justification for all their methodological choices, where possible.

Summary

This is the first systematic review and meta-analysis investigating the effectiveness of ML interventions for reducing naturally occurring state anxiety. Findings indicate that ML is a useful resource for reducing anxiety in a range of settings, in both clinical and nonclinical groups. As such, ML may represent a cost-effective anxiety-reduction intervention that can be delivered by practitioners as an adjunct to other anxiety interventions or self-administered by individuals.

Acknowledgements

Thanks to Michelle Ulor, Anita Balcer-Whittle and Alice Dunning for their contributions to this review.

Declaration of conflicting interests

No potential conflict of interest was reported by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Supplemental material

Supplemental material for this article is available online.

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