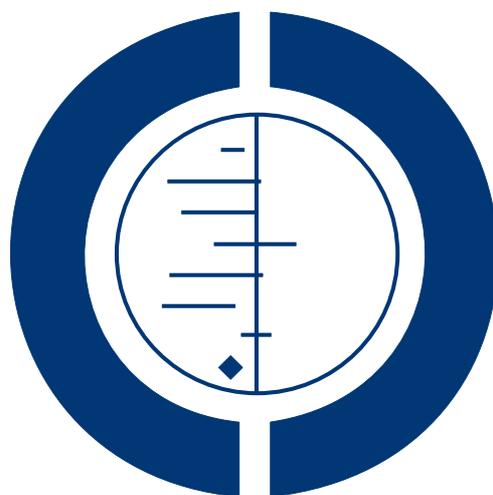


# Music interventions for mechanically ventilated patients (Review)

Bradt J, Dileo C, Grocke D



**THE COCHRANE  
COLLABORATION®**

This is a reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in *The Cochrane Library* 2010, Issue 12

<http://www.thecochranelibrary.com>



## TABLE OF CONTENTS

HEADER . . . . .	1
ABSTRACT . . . . .	1
PLAIN LANGUAGE SUMMARY . . . . .	2
SUMMARY OF FINDINGS FOR THE MAIN COMPARISON . . . . .	2
BACKGROUND . . . . .	6
OBJECTIVES . . . . .	7
METHODS . . . . .	7
RESULTS . . . . .	9
Figure 1. . . . .	10
Figure 2. . . . .	12
Figure 3. . . . .	13
DISCUSSION . . . . .	15
AUTHORS' CONCLUSIONS . . . . .	16
ACKNOWLEDGEMENTS . . . . .	18
REFERENCES . . . . .	18
CHARACTERISTICS OF STUDIES . . . . .	20
DATA AND ANALYSES . . . . .	32
Analysis 1.1. Comparison 1 Music versus standard care, Outcome 1 State Anxiety. . . . .	32
Analysis 1.2. Comparison 1 Music versus standard care, Outcome 2 Heart Rate. . . . .	33
Analysis 1.3. Comparison 1 Music versus standard care, Outcome 3 Respiratory Rate. . . . .	33
Analysis 1.4. Comparison 1 Music versus standard care, Outcome 4 Systolic Blood Pressure. . . . .	34
Analysis 1.5. Comparison 1 Music versus standard care, Outcome 5 Diastolic Blood Pressure. . . . .	34
Analysis 1.6. Comparison 1 Music versus standard care, Outcome 6 Oxygen Saturation Level. . . . .	35
APPENDICES . . . . .	35
HISTORY . . . . .	42
CONTRIBUTIONS OF AUTHORS . . . . .	42
DECLARATIONS OF INTEREST . . . . .	43
SOURCES OF SUPPORT . . . . .	43
DIFFERENCES BETWEEN PROTOCOL AND REVIEW . . . . .	44

[Intervention Review]

# Music interventions for mechanically ventilated patients

Joke Bradt<sup>1</sup>, Cheryl Dileo<sup>2</sup>, Denise Grocke<sup>3</sup>

<sup>1</sup>The Arts and Quality of Life Research Center, Boyer College of Music and Dance, Temple University, Philadelphia, PA, USA.

<sup>2</sup>Department of Music Therapy and The Arts and Quality of Life Research Center, Boyer College of Music and Dance, Temple University, Philadelphia, USA. <sup>3</sup>Melbourne Conservatorium of Music, University of Melbourne, Victoria, Australia

Contact address: Joke Bradt, Department of Creative Arts Therapies, College of Nursing and Health Professions, Drexel University, 1505 Race Street, rm 1041, Philadelphia, PA, 19102, USA. [jbradt@drexel.edu](mailto:jbradt@drexel.edu).

**Editorial group:** Cochrane Anaesthesia Group.

**Publication status and date:** New, published in Issue 12, 2010.

**Review content assessed as up-to-date:** 2 November 2010.

**Citation:** Bradt J, Dileo C, Grocke D. Music interventions for mechanically ventilated patients. *Cochrane Database of Systematic Reviews* 2010, Issue 12. Art. No.: CD006902. DOI: 10.1002/14651858.CD006902.pub2.

Copyright © 2010 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.

## ABSTRACT

### Background

Mechanical ventilation often causes major distress and anxiety in patients. Music interventions have been used to reduce anxiety and distress and improve physiological functioning in medical patients; however its efficacy for mechanically ventilated patients needs to be evaluated.

### Objectives

To examine the effects of music interventions with standard care versus standard care alone on anxiety and physiological responses in mechanically ventilated patients.

### Search strategy

We searched the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2010, Issue 1), MEDLINE, CINAHL, AMED, EMBASE, PsycINFO, LILACS, Science Citation Index, [www.musictherapyworld.net](http://www.musictherapyworld.net), CAIRSS for Music, Proquest Digital Dissertations, [ClinicalTrials.gov](http://ClinicalTrials.gov), Current Controlled Trials, the National Research Register, and NIH CRISP (all to January 2010). We handsearched music therapy journals and reference lists and contacted relevant experts to identify unpublished manuscripts. There was no language restriction.

### Selection criteria

We included all randomized and quasi-randomized controlled trials that compared music interventions and standard care with standard care alone for mechanically ventilated patients.

### Data collection and analysis

Two authors independently extracted the data and assessed the methodological quality. Additional information was sought from the trial researchers, when necessary. Results were presented using mean differences for outcomes measured by the same scale and standardized mean differences for outcomes measured by different scales. Post-test scores were used. In cases of significant baseline difference, we used change scores.

---

**Music interventions for mechanically ventilated patients (Review)**

Copyright © 2010 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.

1

## **Main results**

We included eight trials (213 participants). Music listening was the main intervention used, and seven of the studies did not include a trained music therapist. Results indicated that music listening may be beneficial for anxiety reduction in mechanically ventilated patients; however, these results need to be interpreted with caution due to the small sample size. Findings indicated that listening to music consistently reduced heart rate and respiratory rate, suggesting a relaxation response. No strong evidence was found for blood pressure reduction.

Music listening did not improve oxygen saturation level.

No studies could be found that examined the effects of music interventions on quality of life, patient satisfaction, post-discharge outcomes, mortality, or cost-effectiveness.

## **Authors' conclusions**

Music listening may have a beneficial effect on heart rate, respiratory rate, and anxiety in mechanically ventilated patients. However, the quality of the evidence is not strong. Most studies examined the effects of listening to pre-recorded music. More research is needed on the effects of music offered by a trained music therapist.

## **PLAIN LANGUAGE SUMMARY**

### **Music interventions for mechanically ventilated patients**

Mechanical ventilation often causes major distress and anxiety in patients, putting them at greater risk for complications. Side effects of analgesia and sedation may lead to the prolongation of mechanical ventilation and, subsequently, to a longer length of hospitalization and increased cost. Therefore, non-pharmacological interventions should be considered for anxiety and stress management. This review included eight randomized and quasi-randomized controlled trials with a total of 213 participants. The findings suggest that music listening may have a beneficial effect on heart rate, respiratory rate, and state anxiety in mechanically ventilated patients.

No evidence of effect was found for blood pressure or oxygen saturation level. However, only a small number of trials investigated the effects of music on these outcomes. More research is needed.

The vast majority of the studies examined the effects of patients' listening to pre-recorded music. More research is needed on the effects of music offered by a trained music therapist.

## SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Music interventions compared to Standard treatment for mechanically ventilated patients						
<b>Patient or population:</b> mechanically ventilated patients <b>Settings:</b> Critical care unit <b>Intervention:</b> Music interventions <b>Comparison:</b> Standard treatment						
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Standard treatment	Music interventions				
<b>State Anxiety</b> STAI - short form		The mean State Anxiety in the intervention groups was <b>1.06 standard deviations lower</b> (2.09 to 0.04 lower)		135 (3 studies)	⊕○○○ <b>very low</b> <sup>1,2,3</sup>	SMD -1.06 (-2.09 to -0.04)
<b>Heart Rate</b>		The mean Heart Rate in the intervention groups was <b>4.75 lower</b> (6.98 to 2.51 lower)		167 (5 studies)	⊕○○○ <b>very low</b> <sup>4,5</sup>	
<b>Respiratory Rate</b>		The mean Respiratory Rate in the intervention groups was <b>3.18 lower</b> (4.41 to 1.95 lower)		187 (6 studies)	⊕⊕○○ <b>low</b> <sup>4,6</sup>	

<b>Systolic Blood Pressure</b>	The mean Systolic Blood Pressure in the intervention groups was <b>2.7 lower</b> (6.84 lower to 1.45 higher)	98 (3 studies)	⊕⊕○○ <b>low</b> <sup>5,7</sup>
<b>Diastolic Blood Pressure</b>	The mean Diastolic Blood Pressure in the intervention groups was <b>4.51 lower</b> (11.13 lower to 2.1 higher)	98 (3 studies)	⊕⊕○○ <b>low</b> <sup>5,7</sup>
<b>Oxygen Saturation Level</b>	The mean Oxygen Saturation Level in the intervention groups was <b>0.71 lower</b> (3.08 lower to 1.66 higher)	40 (2 studies)	⊕○○○ <b>very low</b> <sup>3,5,8,9</sup>

\*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

**CI:** Confidence interval;

GRADE Working Group grades of evidence

**High quality:** Further research is very unlikely to change our confidence in the estimate of effect.

**Moderate quality:** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

**Low quality:** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

**Very low quality:** We are very uncertain about the estimate.

<sup>1</sup> 1 of these studies received a high risk of bias b/c of lack of blinding for physiological outcome assessment. However, anxiety was measured by means of self-report (STAI) - therefore, blinding was not possible.

<sup>2</sup> Results were inconsistent across studies as evidenced by I square = 85%

<sup>3</sup> Small total sample size

<sup>4</sup> 3 studies received high risk of bias rating

<sup>5</sup> wide confidence interval

- <sup>6</sup> small cumulative sample size
- <sup>7</sup> 1 study received high risk of bias rating
- <sup>8</sup> Two studies had high risk of bias
- <sup>9</sup> Confidence interval includes no effect

## BACKGROUND

Mechanical ventilation often causes major distress and anxiety in patients. The sensation of breathlessness, frequent suctioning, inability to talk, uncertainty regarding surroundings or condition, discomfort, isolation from others, and fear contribute to high levels of anxiety (Lindgren 2005; Wong 2001). Increased anxiety may in turn lead to breathing difficulty and greater distress during weaning attempts, that is, the process of liberating the patient from mechanical support and from the tracheal tube (Boles 2007; Lindgren 2005). Moreover, mechanically ventilated patients often experience adverse events, including constriction of arteries and the airways in the lungs, caused by this anxiety (Ledingham 1988). Therefore, analgesia and sedation are considered important in the management of patients who require mechanical ventilation.

However, complications related to the use of analgesic and sedative agents are common. The immobility resulting from sedation may contribute to venous thrombosis or pressure damage to the nerves and skin. Furthermore, immune responses may be weakened from extensive use of sedative medications (Suter 2002). These side effects may lead to the prolongation of mechanical ventilation and, subsequently, to a longer length of hospitalization and increased costs (Bobek 2001; Egerod 2002; Kollef 1998). Additionally, an increase in morbidity and mortality has been found in anxious, critically ill patients (Moser 1996).

A review of the literature on treatment interventions for mechanically ventilated patients (Thomas 2003) indicated that the four most frequently perceived stressors for mechanically ventilated patients are dyspnoea or difficulty breathing, anxiety, fear, and pain. Few non-pharmacological interventional studies to reduce these stressors were found. Four interventions, that is, hypnosis and relaxation, patient education and information sharing, music therapy, and supportive touch have been investigated and results indicate that they may be helpful in reducing patient stress (Thomas 2003).

Music has been used in different medical fields to meet physiological, psychological, and spiritual needs of patients. Research on the effects of music or music therapy for medical patients has burgeoned during the past 20 years and has included a variety of outcome measures in a wide range of specialty areas (Dileo 2005). Specifically, the anxiolytic effects of music have been studied in a variety of medical patients including surgical (Daub 1988; Kaempff 1989; Koch 1998; Mok 2003); cardiac (Bolwerk 1990; Hamel 2001; White 1999); and oncology (Frank 1985; Pfaff 1989) patients. The efficacy of music therapy as a non-pharmacological intervention for the reduction of pain and anxiety, and for the enhancement of feelings of control and well being, has been demonstrated in mechanically ventilated patients (Chlan 1995; Wong 2001). However, it is important to note that there are a number of individual factors that influence responses to music. These include, but are not limited to, age, gender, cognitive function, severity of stress, anxiety, discomfort and pain, training in music,

familiarity with and preference for the music, culture, and personal associations with the music (Pelletier 2004; Standley 1986; Standley 2000). Music also evokes various types of imagery in many individuals. Thus, the individual's unique imagery experience will influence his or her responses to the music. Therefore, it cannot be assumed that sedative music will always have positive effects on individuals; careful monitoring of individual effects is needed.

It is important to make a clear distinction between music interventions administered by medical or healthcare professionals (music medicine) and those implemented by trained music therapists (music therapy). A substantive set of data (Dileo 2005) indicates that music therapy interventions with medical populations are significantly more effective than music medicine interventions for a wide variety of outcomes. This difference might be attributed to the fact that music therapists individualize their interventions to meet patients' specific needs; more actively engage the patients in the music making; and employ a systematic therapeutic process, including assessment, treatment, and evaluation. As defined by Dileo (Dileo 1999), interventions are categorized as 'music medicine' when passive listening to pre-recorded music is offered by medical personnel. In contrast, music therapy requires the implementation of a music intervention by a trained music therapist, the presence of a therapeutic process, and the use of personally tailored music experiences. These music experiences include:

1. listening to live, improvised or pre-recorded music;
2. performing music on an instrument;
3. improvising music spontaneously using voice or instruments, or both;
4. composing music; and
5. music combined with other modalities (e.g., movement, imagery, art) (Dileo 2007).

Furthermore, it is important to distinguish the use of patient-preferred music from the use of researcher-selected music. In the case of mechanically ventilated patients, assessment of music preference may be challenging. If the patient is not alert, input from the patient's family or friends may provide some indication of music preference. In addition, the patient's reactions to different music stimuli can be observed to watch for contraindications such as increased heart rate, breathing rate, or any physical changes that might indicate a negative reaction. If the patient is alert but cannot speak, music preferences can be indicated by head nodding or by actually playing excerpts of the music and having the patient nod or shake his or her head in terms of preference for the music.

Several research studies on the effects of music on mechanically ventilated patients have reported positive results. Several of these studies, however, have suffered from small sample size (Almerud

2003; Besel 2006; Chlan 1995; Wong 2001). In addition, differences in factors such as study design, methods of interventions, and types of music have led to varying results. A systematic review is needed to more accurately gauge the efficacy of music medicine or music therapy as anxiety-reducing interventions with mechanically ventilated patients, as well as to identify variables that may moderate the effects.

## OBJECTIVES

1. To identify randomized controlled trials examining the effects of music therapy or music medicine interventions (as defined by the authors) on anxiety and other outcomes in mechanically ventilated patients.
2. To conduct a meta-analysis to compare the effects of participation in standard care combined with music therapy or music medicine interventions with standard care alone.
3. To compare the effects of patient-selected music with researcher-selected music.
4. To compare the effects of different types of music interventions (e.g., music therapy versus music medicine).

## METHODS

### Criteria for considering studies for this review

#### Types of studies

We included all randomized controlled trials (RCT) and controlled clinical trials (CCTs) with quasi-randomized or systematic methods of treatment allocation in any language, published and unpublished.

#### Types of participants

The review included studies of mechanically ventilated patients in an intensive or critical care unit, long term acute care hospital (LCAT), or 'step-down' unit. We imposed no restrictions as to age, gender, or ethnicity. We included both patients undergoing ongoing ventilation and patients who were being weaned after prolonged mechanical ventilation. The most frequently used modes of ventilatory support included synchronized intermittent mandatory ventilation and pressure support mode. Types of airway included oral endotracheal tube, nasal endotracheal tube, and tracheostomy tube.

#### Types of interventions

We included all studies in which standard treatment combined with music therapy or music medicine interventions (as defined by the authors) were compared with:

1. standard care alone;
2. standard care combined with other therapies; or
3. standard care with placebo. Placebo treatment involved the use of headphones for the patients wherein no music stimuli were provided or another type of auditory stimulus was provided (e.g., white noise (hiss), pink noise (sound of ocean waves), or nature sounds).

#### Types of outcome measures

##### Primary outcomes

1. State anxiety (defined as a temporary unpleasant emotional arousal in the face of threatening demands or dangers; this is in contrast with trait anxiety, which reflects the existence of stable individual differences in reactions (Spielberger 1983)) - as reported by the study authors

##### Secondary outcomes

1. Sedative drug intake
2. Physiological outcomes (e.g., heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, oxygen saturation, airway pressure)
3. Quality of life - as reported by the study authors
4. Patient satisfaction - as reported by the study authors
5. Post-discharge patient outcomes (e.g., functional status, post-discharge quality of life) - as reported by the study authors
6. Mortality
7. Cost-effectiveness

#### Search methods for identification of studies

##### Electronic searches

We searched the following electronic databases and trials registers:

1. Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2010, Issue 1);
2. MEDLINE (1966 to January 2010);
3. EMBASE (1980 to January 2010);
4. CINAHL (1982 to January 2010);
5. PsycINFO (1967 to January 2010);
6. LILACS (1982 to January 2010);
7. AMED (1985 to January 2010);
8. The Science Citation Index (to January 2010);

9. The specialist music therapy research database at [www.musictherapyworld.net](http://www.musictherapyworld.net) (database is no longer functional) (March 1 2008);

10. CAIRSS for Music (January 2010);

11. Proquest Digital Dissertations (January 2010)

12. ClinicalTrials.gov ([www.clinicaltrials.gov/](http://www.clinicaltrials.gov/)) (January 2010);

13. Current Controlled Trials ([www.controlled-trials.com/](http://www.controlled-trials.com/)) (January 2010);

14. National Research Register ([www.update-software.com/National/](http://www.update-software.com/National/)) (January 2010);

15. NIH CRISP (January 2010).

We used the search strategy for MEDLINE as was listed in the protocol ([Appendix 1](#)) and adapted it for the other databases.

### Searching other resources

We handsearched the following journals, from the first available date:

1. *Australian Journal of Music Therapy* (October 2010);
2. *Canadian Journal of Music Therapy* (January 2010);
3. *The International Journal of the Arts in Medicine* (December 2007, latest issue was published in 1999);
4. *Journal of Music Therapy* (October 2010);
5. *Musik-, Tanz-, und Kunsttherapie* (Journal for Art Therapies in Education, Welfare and Health Care) (April 2010);
6. *Musiktherapeutische Umschau* (April 2010);
7. *Music Therapy* (December 2007, latest issue published in 1996);
8. *Music Therapy Perspectives* (October 2010);
9. *Nordic Journal of Music Therapy* (October 2010);
10. *Music Therapy Today* (online journal of music therapy) (December 2007; latest issue published December 2007);
11. *Voices* (online international journal of music therapy) (October 2010);
12. *New Zealand Journal of Music Therapy* (October 2010) (latest index available online: 2009);
13. *British Journal of Music Therapy* (October 2010).

We checked the bibliographies of relevant studies or reviews. We contacted relevant experts for the identification of unpublished trials.

We imposed no language restrictions for either searching or trial inclusion.

### Data collection and analysis

#### Selection of studies

One author (JB) scanned the titles and abstracts of each record retrieved from the search. If information in the abstract clearly indicated that the trial did not meet the inclusion criteria, we rejected the trial. When a title or abstract could not be rejected

with certainty, two authors (CD and JB) independently inspected the full-text article. Both authors used an inclusion criteria form to assess the trial's eligibility for inclusion. We checked the inter-rater reliability for trial selection. The third author (DG) was available to settle any disagreement. If a trial was excluded, we kept a record of both the article and the reason for exclusion.

#### Data extraction and management

The lead author (JB) and a research assistant independently extracted data from the selected trials using a standardized coding form. We discussed any differences in data extraction and sought the input of the third author (DG) when needed.

#### Assessment of risk of bias in included studies

One author and a research assistant, blinded to each other's assessment, assessed all included trials for trial quality. We resolved any disagreements by discussion. We used the following criteria for quality assessment.

##### 1. Method of randomization.

- Was the trial reported as randomized? Yes or no.
- Was the method of randomization appropriate? Yes, no, or unclear.

We rated the randomization as appropriate if every participant had an equal chance of being selected for either group and if the investigator was unable to predict the treatment to which the participant would be assigned. We regarded the use of date of birth, date of admission, or alternation as inappropriate.

##### 2. Allocation concealment was rated in accordance with section 6.3 of the Cochrane Handbook for Systematic Reviews of Interventions ([Higgins 2005](#)).

Adequate: methods to conceal allocation included 1. central randomization; 2. serially numbered, opaque, sealed envelopes; or 3. other descriptions with convincing concealment.

Unclear: authors did not adequately report on method of concealment.

Inadequate: allocation was not adequately concealed (e.g. alteration methods were used).

##### 3. Blinding: yes, no, or unclear.

With music and music therapy studies it is not possible to blind either the participants or those providing the music or music therapy interventions. However, outcome assessors can be blinded. In this review we marked blinding as yes, no, or unclear as it pertained to blinding of outcome assessors.

##### 4. Intention-to-treat analysis: adequate, inadequate, or unclear.

We considered an intention-to-treat analysis adequate when numbers of drop-outs and reasons for dropping out were reported. If there were no withdrawals and this was indicated in the article, we assigned the article a rating of adequate.

We used the above four criteria to give each article an overall quality rating (based on section 6.7.1 of the Cochrane Handbook for Systematic Reviews of Interventions ([Higgins 2005](#))).

- Low risk of bias: all four criteria met.
- Moderate risk of bias: one or more of the criteria only partly met.
- High risk of bias: one or more criteria not met.

### Dealing with missing data

We analysed data on an endpoint basis, including only participants for whom final data point measurement was obtained (available case analysis). We did not assume that participants who dropped out after randomization had a negative outcome.

### Assessment of heterogeneity

We investigated heterogeneity using the  $I^2$  statistic, with  $I^2 > 50\%$  indicating significant heterogeneity.

### Assessment of reporting biases

We had planned to create funnel plots to check for publication bias but the small number of studies did not allow for a meaningful analysis.

### Data synthesis

We entered all trials included in the systematic review into Review Manager (RevMan 5.0). All outcomes in this review were presented as continuous variables. We calculated standardized mean differences for outcome measures using results from different scales. We used mean differences (MD) for results using the same scales. We anticipated that some individual studies would have used final scores and others change scores and even ANCOVA in their statistical analyses of the results. We combined these different types of analyses as MD. We determined not to pool the results in case of significant clinical heterogeneity. We calculated pooled estimates using the fixed-effect model unless there was significant heterogeneity, in which case we used the random-effects model. We determined the levels of heterogeneity by the  $I^2$  statistic (Higgins 2002). We used a random-effects model when the  $I^2$  statistic was more than 50%. We calculated 95% confidence intervals (CI) for each effect size estimate.

The following treatment comparison was made: music versus standard care alone.

### Subgroup analysis and investigation of heterogeneity

The following subgroup analyses were determined a priori, but these could not be carried out because of insufficient numbers of studies:

- a. type of intervention (music therapy or music medicine);
- b. dosage of music therapy or music medicine; and
- c. music preference.

Subgroup analyses would have been conducted as described by Deeks et al (Deeks 2001) and as recommended in section 8.8 of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2005).

### Sensitivity analysis

The influence of study quality was examined using a sensitivity analysis wherein the results of including and excluding lower quality studies in the analysis were compared. Specifically, we assessed the impact of studies that used alternate group assignment as a randomization method.

Although we had planned to perform a sensitivity analysis to reveal the impact of type of analysis on the results, this was not possible because of the small number of studies.

## RESULTS

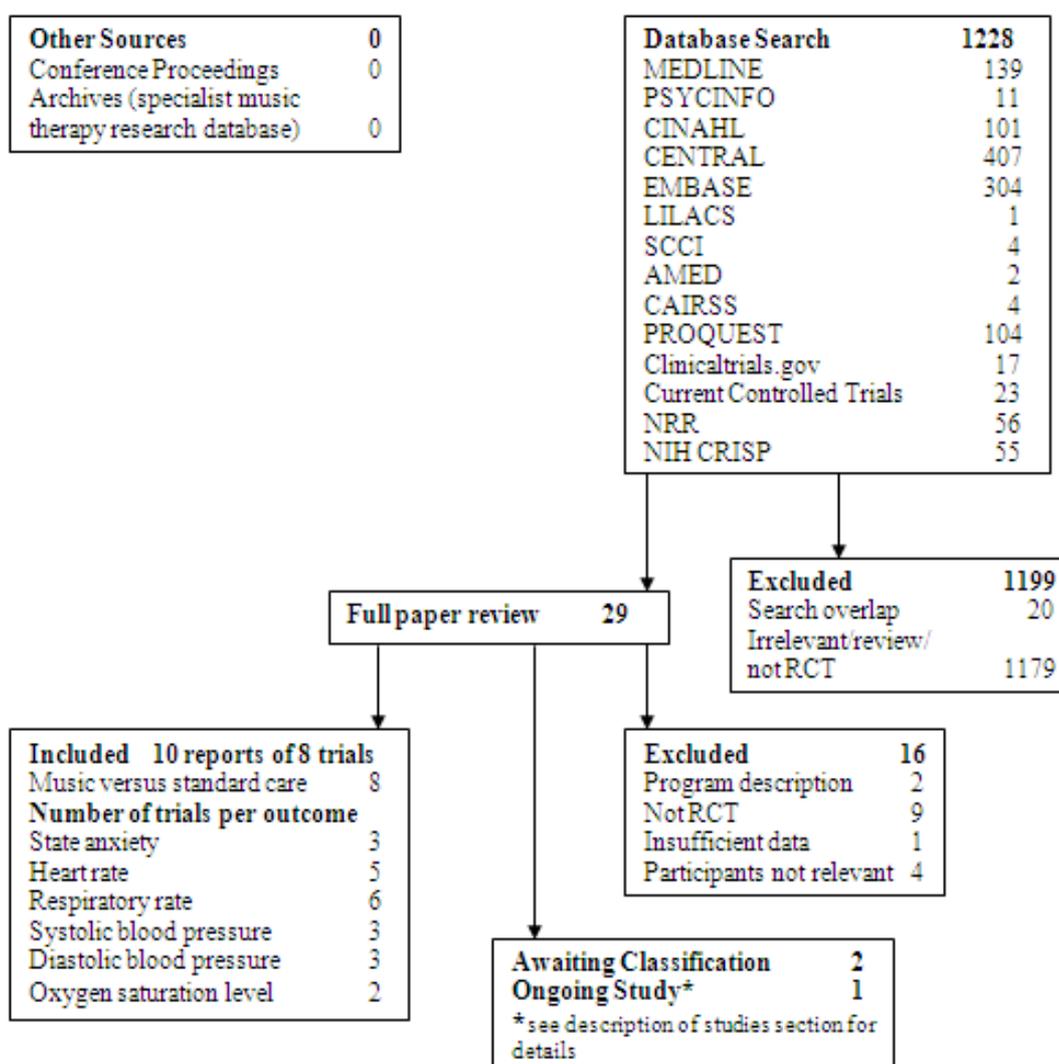
### Description of studies

See: [Characteristics of included studies](#); [Characteristics of excluded studies](#); [Characteristics of studies awaiting classification](#).

### Results of the search

The database searches and handsearching of conference proceedings, journals, and reference lists resulted in 1228 citations (see Figure 1). One author (JB) examined the titles and abstracts and identified 29 studies as potentially relevant, which were retrieved for further assessment. These were then independently screened by the two authors.

Figure 1. Searching results



In spite of many attempts, we were unable to locate a study (Bauer 2002) that appeared eligible for this review because of an incorrect citation. This study (Bauer 2002) has been listed in the [Characteristics of studies awaiting classification](#). The study by Wu (Wu 2008) was recently published and is currently awaiting classification (see [Characteristics of studies awaiting classification](#)). Finally, the lead author of one ongoing study requested that this study not be listed in the current review under 'ongoing studies' to avoid jeopardizing the blinding used in the trial. This study will be assessed for inclusion in future updates of this review. Ten references reporting eight trials were included in this review (see [Characteristics of included studies](#)) (Chlan 1995; Chlan 1997;

Chlan 2007a; Conrad 2007; Jaber 2007; Lee 2005; Phillips 2007; Wong 2001). Where necessary, we contacted chief investigators to obtain additional information on study details and data.

#### Included studies

We included eight studies with a total of 213 patients in this review. These studies examined the effects of music on physiological and psychological outcomes in mechanically ventilated patients. The majority of the patients included in these studies were male (60%). Only two studies provided details on ethnicity (Chlan 1997; Chlan

2007a). Four studies were conducted in the USA (Chlan 1995; Chlan 1997; Chlan 2007a; Phillips 2007); two in China (Lee 2005; Wong 2001); one in Germany (Conrad 2007); and one in France (Jaber 2007). Trial sample size ranged from 10 to 64 participants.

Only four studies (Chlan 1997; Chlan 2007a; Lee 2005; Wong 2001) included details on the ventilatory support modes used. Synchronized intermittent mandatory ventilation and pressure support mode were most frequently used. Only three studies (Jaber 2007; Lee 2005; Wong 2001) detailed the type of airway. The majority of the patients had an oral endotracheal tube or a tracheostomy tube. Few patients had a nasal endotracheal tube. Five studies (Chlan 1995; Chlan 1997; Chlan 2007a; Lee 2005; Wong 2001) provided information related to the average length of stay of the participants before the onset of the study. The average ranged from 2.5 days to 14 days.

A variety of medical diagnoses were included in each study, except for Conrad (Conrad 2007), with the primary diagnoses being pulmonary-related problems in most studies. Other medical problems included post-surgical complications, cardiac disease, trauma injuries, cancer, and sepsis. Conrad's study only included post-operative patients.

Not all studies measured all outcomes identified for this review. Details of the studies included in the review are shown in the table [Characteristics of included studies](#).

Seven studies were categorized as music medicine studies (as defined by the review authors in the background section). One study (Phillips 2007) was categorized as music therapy. All music medicine studies used music listening as the main intervention. The music therapy study used live music selected by the patient. The music therapist initially matched the music to the respiratory rate of the patient. The tempo of the music was then gradually decelerated to decrease the rate of vital signs to ranges suitable for extubation.

Most studies offered one 20 to 30-minute music session to the patients. One study offered one 60-minute session. In most clinical settings that serve patients on mechanical ventilation, listening to pre-recorded music can be easily implemented at low cost. However, studies are needed that compare the effect of different frequencies, durations, and timing of music sessions. Offering multiple music listening sessions allows for the patient to give feedback about the music, select different music if needed, and become more skilled in using music for relaxation purposes. In the case of music therapy interventions, multiple sessions allow for the development of a therapeutic relationship and deepening of the therapeutic process through the music. This may lead to greater health benefits.

Except for one study (Conrad 2007), none of the music medicine studies provided detailed information about the music that was used. The authors only reported the different styles of music that were offered to the participants (for example, jazz, easy listening, country and western, classical music) without any composition-

specific or performance-specific information. Conrad provided information about the specific compositions that were used (see Characteristics of included studies table). Only one study (Chlan 1997) provided tempo information.

Seven studies used patient-selected music, whereas one study (Conrad 2007) used researcher-selected music. In some trials, only classical music choices were offered without a good rationale for this music selection. In several trials, participants were allowed to select the music from a variety that was offered. This decision was based on the assumption that music preference plays an important part in the effectiveness of music relaxation. However, it needs to be noted that participants could only select from a limited number of music styles presented by the researcher. It is likely that the preferred music of some of the participants was not included in the music selection offered and, even if it were, that they may not have liked the specific compositions or songs being played. Lee explicitly stated that four participants disliked the music (Lee 2005). Another researcher reported that five patients refused to participate because they disliked the music selections that were being offered, whereas five other participants expressed a dislike for the music after they completed participation in the music intervention (Wong 2001). As stated in the background section of this review, assessment of music preference may be challenging when working with mechanically ventilated patients. If the patient is not alert, input from the patient's family or friends may provide some indication of music preference. In addition, the patient's reactions to different music stimuli can be monitored for contraindications such as increased heart rate, respiratory rate, or any physical changes that might indicate a negative reaction. If the patient is alert but cannot speak, musical preferences can be indicated by head nodding, or by actually playing excerpts of the music and having the patient nod or shake his head to indicate his or her preference for the music. It is highly recommended that the effect of the music be monitored during the intervention to ascertain that physiological responses are being regulated by the music.

The data of one study (Chlan 2007a) could not be pooled with the other studies because of severe validity issues. The lead author expressed the following concerns: there was wide variability in mean levels of biomarkers, a very small sample size, and several confounding factors (for example, administration of intravenous morphine sulphate to two control patients; and two experimental patients needed endotracheal suctioning during the intervention). The data of one additional study (Conrad 2007) were only provided in narrative form in this review because of insufficient data reporting.

### Excluded studies

We excluded a total of 16 studies for the following reasons: (a) programme descriptions (Chlan 2000; Fontaine 1994); (b) studies were not randomized controlled trials or controlled clinical trials

(Besel 2006; Burke 1995; Chlan 2001; Chlan 2006; Chou 2003; Hansen-Flachen 1994; Hunter 2010; Iriarte 2003; Twiss 2006); (c) study participants did not meet inclusion criteria (Caine 1991; Lorch 1994; Standley 1995; Wiens 1995), and (d) insufficient data reporting (Almerud 2003).

The reasons for exclusion are listed in the table [Characteristics of excluded studies](#).

### Risk of bias in included studies

We included studies that used appropriate methods of randomization (for example, computer-generated table of random numbers, drawing of lots, flip of coins) (six studies) as well as studies that used non-random methods of allocation (for example, alternate

group assignment) (two studies). The impact of method of randomization was examined by sensitivity analyses. Sixty-two percent of the studies (five studies) used allocation concealment. In 62% (five studies) of the trials, blinding of the outcome assessors was not used and this inevitably introduced the potential for biased assessment. Blinding of intervention allocation is not possible in music interventions, adding another layer of possible bias. The drop-out rate was 0% for five of the trials and between 8% and 14% for the other trials.

As a result, five studies (62%) received a high risk of bias rating, two (25%) a moderate risk, and one (12.5%) a low risk. Risk of bias is detailed for each study in the risk of bias tables included with the [Characteristics of included studies](#) table (see [Figure 2](#); [Figure 3](#)).

**Figure 2. Methodological quality graph: review authors' judgements about each methodological quality item presented as percentages across all included studies.**

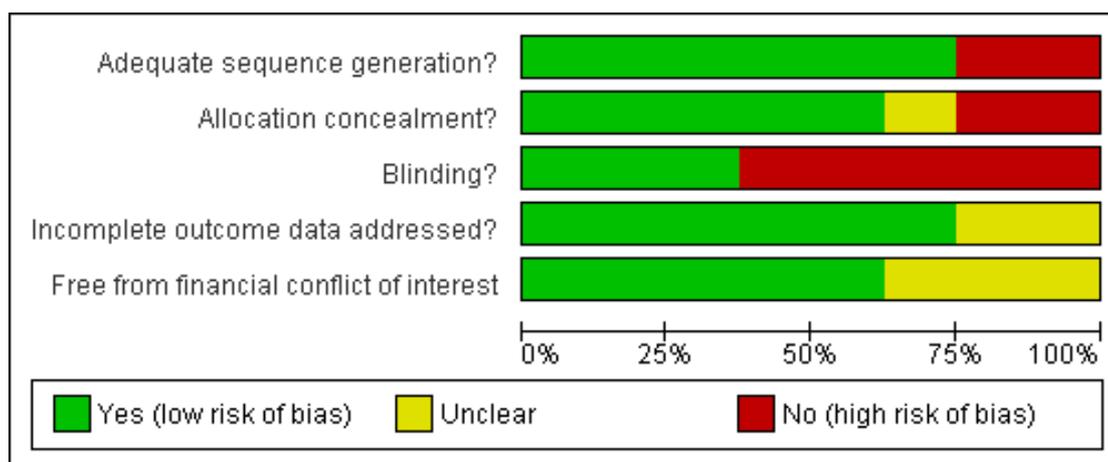


Figure 3. Methodological quality summary: review authors' judgements about each methodological quality item for each included study.

	Adequate sequence generation?	Allocation concealment?	Blinding?	Incomplete outcome data addressed?	Free from financial conflict of interest?
Chlan 1995	+	+	-	+	+
Chlan 1997	+	+	-	+	+
Chlan 2007a	+	+	-	+	+
Conrad 2007	-	-	+	+	+
Jaber 2007	+	?	+	+	?
Lee 2005	+	+	+	?	?
Phillips 2007	-	-	-	+	+
Wong 2001	+	+	-	?	?

## Effects of interventions

See: [Summary of findings for the main comparison Music interventions compared to standard treatment for mechanically ventilated patients](#)

### Primary outcomes

#### State anxiety

Three studies (Chlan 1997; Lee 2005; Wong 2001) examined the effects of music listening on state anxiety in mechanically ventilated patients. All three studies used the Spielberger State and Trait Anxiety Inventory (STAI), State Anxiety Short Form. However, Wong converted the scores back to full-form scores and only reported data on the converted scores (Wong 2001). Therefore, the standardized mean difference (SMD) was used for this outcome. The pooled estimate of these studies indicated that music listening may have a beneficial effect on anxiety (SMD -1.06, 95% confidence interval (CI) -2.09 to -0.04,  $P = 0.04$ ). However, the results were not consistent across the studies ( $I^2 = 85%$ ) (Analysis 1.1). Because of the high heterogeneity, a random-effects model was used for this analysis.

### Secondary outcomes

#### Sedative drug intake

None of the studies provided data on the effect of music on sedative drug intake, although some studies provided a narrative statement. Conrad (Conrad 2007) reported that “patients in the music group did not require additional sedation by propofol, whereas among patients in the control group, propofol was occasionally necessary to allow sufficient patient-ventilator coordination” (p2710). Other authors reported that, as part of the protocol, no medication was provided to the participants for the duration of the intervention (Chlan 1995; Jaber 2007).

#### Heart rate

The pooled estimate of five studies (Chlan 1995; Chlan 1997; Jaber 2007; Lee 2005; Phillips 2007) indicated that listening to music significantly reduced heart rate (MD -4.75, 95% CI -6.98 to -2.51,  $P = 0.001$ ;  $I^2 = 0%$ ). The results were consistent across studies (Analysis 1.2). A sensitivity analysis examining the impact of randomization methods revealed that inclusion of an alternate assignment study (Phillips 2007) did not inflate the effect size. In contrast, excluding this study led to a higher pooled estimate (MD -4.80, 95% CI -7.05 to -2.55,  $P < 0.001$ ) and did not influence the homogeneity of the results across studies.

Conrad (Conrad 2007) reported that the heart rate in the control group increased from 120 beats per minute (BPM) (SD = 9) to 125 bpm (SD = 7) whereas it remained the same in the music group. However, no significant differences between the groups were found. Because no means and standard deviations were reported for the music group, these data could not be included in the meta-analysis. Conrad was unable to provide the original data.

#### Respiratory rate

Listening to music also had a significant effect on respiratory rate (6 studies: MD -3.18, 95% CI -4.41 to -1.95,  $P < 0.001$ ) and the results were consistent across studies (Analysis 1.3) (Chlan 1995; Chlan 1997; Jaber 2007; Lee 2005; Phillips 2007; Wong 2001). A sensitivity analysis excluding the Phillips study (Phillips 2007), because of its inadequate randomization method, revealed a negligible change in the pooled estimate (MD -3.19, 95% CI -4.44 to -1.94,  $P < 0.00001$ ).

#### Blood pressure

Three studies (Chlan 1995; Jaber 2007; Lee 2005) examined the effects of music listening on systolic blood pressure (SBP). Their pooled estimate indicated no strong evidence of effect for the music intervention (MD -2.70, 95% CI -6.84 to 1.45,  $P = 0.20$ ) (Analysis 1.4). A pooled estimate of -4.51 mm Hg (95% CI -11.13 to 2.10; 3 studies) was found for diastolic blood pressure (DBP), however this effect was not statistically significant ( $P = 0.18$ ) (Chlan 1995; Jaber 2007; Lee 2005). A random-effects model was applied for DBP because of significant heterogeneity of the results ( $I^2 = 67%$ ) (Analysis 1.5).

Wong (Wong 2001) reported a greater reduction in mean arterial pressure in the music group (post-test mean 76.15 mm Hg, SD = 15.37) than the control group (post-test mean 80.90 mm Hg, SD = 14.41), but the difference between the two groups was not statistically significant. In contrast, Conrad (Conrad 2007) reported a significant difference ( $P = 0.014$ ) between the intervention group ( $N = 5$ ) and the control group ( $N = 5$ ) but no means and standard deviations were provided and, therefore, these study results could not be pooled with the results of the Wong study.

#### Oxygen saturation levels

Two studies examined the effects of music listening on oxygen saturation levels (Chlan 1995; Phillips 2007). In their pooled estimate they did not find support for an effect of music (MD -0.71, 95% CI -3.08 to 1.66,  $P = 0.56$ ). Chlan (Chlan 1995) commented that the lack of improvement in oxygen saturation level may be due to the fact that when a patient is already 100% saturated, there

would be no increase in oxygen saturation level. She suggested that mixed venous oxygen saturation monitoring may be a more sensitive measure for oxygen consumption.

### Hormone levels

Conrad (Conrad 2007) obtained blood levels for the participants before and after the intervention to measure concentrations of dehydroepiandrosterone (DHEAS), growth hormone, epinephrine, norepinephrine, ACTH, cortisol, interleukin-6 (IL-6), prolactin, and prolactin monomer. Conrad examined the effects of music listening on these hormone levels in an attempt to elucidate the physiological mechanisms by which music may have a stress-reducing effect. The specific neuroendocrine outcomes were selected based on current literature on the human neurohormonal stress response (Conrad 2007). Significant differences were found between the music and the control groups for DHEAS ( $P = 0.011$ ), growth hormone ( $P = 0.032$ ), IL-6 ( $P = 0.028$ ), and epinephrine ( $P = 0.014$ ). No significant between-group differences were found for prolactin ( $P = 0.27$ ), prolactin monomer ( $P = 0.08$ ), norepinephrine ( $P = 0.22$ ), ACTH ( $P = 0.36$ ), or cortisol ( $P = 0.92$ ). The sample size in this study was very small ( $N = 10$ ) and no means and standard deviations were reported. However, these results are encouraging and provide pilot data for future studies.

Chlan (Chlan 2007a) also obtained serum levels of stress hormones, including epinephrine, norepinephrine, corticotropin, and cortisol, but found no significant differences between the music group ( $N = 5$ ) and the control group ( $N = 5$ ). Chlan suspected that the results were influenced by the fact that two participants in the music group needed endotracheal suctioning before the blood sample was obtained. In addition, five participants in the rest group received intravenous morphine sulfate immediately prior to or during the implementation of the protocol, potentially influencing the epinephrine and norepinephrine levels.

No studies were identified that addressed the other secondary outcomes listed in the protocol, namely quality of life, patient satisfaction, post-discharge patient outcomes, mortality, and cost-effectiveness.

## DISCUSSION

### Summary of main results

#### State anxiety

The results of three studies suggest that music listening may have a beneficial effect on anxiety in mechanically ventilated patients. However, this evidence is not strong because of several reasons.

First, Chlan and Lee (Chlan 1995; Lee 2005) questioned the reliability of the STAI Short Form (Marteau 1992) to measure state anxiety in mechanically ventilated patients. Second, results were inconsistent across studies. Finally, the small number of studies warrants a cautious interpretation of these results (Chlan 1997; Lee 2005; Wong 2001). More studies are needed examining the effects of music interventions on anxiety levels in mechanically ventilated patients.

### Physiological outcomes

The results of this review indicate that listening to music reduces heart rate and respiratory rate consistently across studies. Reduction in these physiological responses is considered indicative of a relaxation response.

No strong evidence was found for the effect of music on systolic or diastolic blood pressure. However, the physiology underlying haemodynamic responses in mechanically ventilated patients is complicated and confounded by ventilator settings as well as medications.

Music listening did not improve oxygen saturation levels according to two studies (Chlan 1995; Phillips 2007). However, one could question the usefulness of oxygen saturation as an indicator of a relaxation response in mechanically ventilated patients as this outcome is greatly influenced by ventilator settings.

No studies could be found that examined the effects of music interventions on quality of life, patient satisfaction, post-discharge outcomes, mortality, and cost-effectiveness in mechanically ventilated patients.

### Overall completeness and applicability of evidence

This review included eight trials. The strength of our review is that we searched all available databases and a large number of music therapy journals (English, German, and French language), checked reference lists of all relevant trials, contacted relevant experts for identification of unpublished trials, and included publications without restricting language. In spite of such a comprehensive search, it is still possible we missed some published and unpublished trials. We requested additional data, where necessary, for all trials we considered for inclusion. This allowed us to get accurate information on the trial quality and data for most trials and helped us make well-informed trial selection decisions.

Results of this review indicated that a single music listening session consistently reduces heart rate by an average of 5 bpm in mechanically ventilated patients. In the case of a resting heart rate within normal range, a reduction of 5 bpm may not be clinically significant. However, in case of a tachycardiac rate, this reduction may be important. In a study examining the quantitative relationship between resting heart rate reduction and clinical benefit, it was found that each 10 bpm reduction in heart rate is estimated to

reduce the relative risk of cardiac death by 30% (Cucherat 2007). The results of this review also suggested a reduction in respiratory rate following a single music listening session. A reduction in heart rate and respiratory rate are generally viewed as indicative of a relaxation response. Given the high risk of agitation in mechanically ventilated patients, we believe that even a small relaxation response can be beneficial. Three studies suggested that music may be beneficial for anxiety reduction but more research is needed. No strong evidence was found for the reduction of blood pressure. It is unclear, at this time, whether this was due to the intervention or to the potential confounding effects of positive pressure support and medication.

All but one trial (Phillips 2007) used listening to pre-recorded music as the clinical intervention. All trials used one music intervention session. This clinical uniformity adds to the strength of this review but also leaves several questions unanswered. First, the relationship between the frequency and duration of treatment and treatment effect remains unclear. Further investigation into the optimal frequency and duration of music interventions for critically ill patients is needed. In addition, it is unclear whether music therapy interventions, using live music to meet specific in-the-moment needs of the patients, are more effective than listening to pre-recorded music.

Presently, no data can be provided regarding costs or cost-effectiveness of music medicine applications in the care of mechanically ventilated patients as these data were not included in the studies reviewed. Furthermore, no data were provided regarding costs for music therapy interventions, therefore, no comparisons can be conducted between these two types of treatments. It is recommended that future research include cost-effectiveness measures of these two interventions as well as cost comparisons between them. The trials, in general, included very limited information about the music selections used, except for mentioning general music styles (for example, classical, easy listening, jazz, country). Needless to say, music within each of these styles can vary widely and more detailed information would help clinicians make well-informed decisions regarding music selections. More research is needed to evaluate the effect of music that is truly patient-preferred, as well as the effect of music with different characteristics (tempo, timbre, harmony, emotional intensity, etc.).

Because little information was provided in these studies about the ethnic make-up of the patient samples, one can question the generalizability of these results to various ethnic groups. Persons' cultures may influence their music preferences and their potential acceptance and use of music as a therapeutic agent, especially during high-stress medical situations such as mechanical ventilation. This in turn may influence the anxiety-reducing potential of music, in greater or lesser degree.

## Quality of the evidence

In general the quality of reporting was poor, with only three studies detailing the methods of randomization and allocation concealment, and level of blinding (Jaber 2007; Lee 2005; Wong 2001). The chief investigators of most studies needed to be contacted to provide additional methodological and statistical information. Five studies received a high risk of bias rating (Chlan 1995; Chlan 1997; Chlan 2007a; Conrad 2007; Phillips 2007).

For heart rate and respiratory rate, consistent effects were obtained across studies. For the other outcomes included in the protocol, inconsistent results were obtained or not enough studies were available. The trials included were generally small ( $n = 213$ ; range of sample size 10 to 64) resulting in a lack of precision of treatment effects as evidenced by the rather large confidence intervals. This, combined with the high risk of bias, requires that the results of this review be interpreted with caution.

We are confident that our detailed search strategy combined with extensive handsearching of journals and some conference proceedings identified all relevant trials. It is possible that we did not identify some grey literature; however, it is doubtful that this would have had a significant impact on our results. Grey literature tends to include trials with relatively small numbers of participants and inconclusive results (McAuley 2000).

## AUTHORS' CONCLUSIONS

### Implications for practice

This systematic review indicates that music listening may have beneficial effects on state anxiety in mechanically ventilated patients in critical care units. The findings of this meta-analysis further indicate that music listening may reduce heart rate and respiratory rate. Because of these results, and because music listening is an easy intervention to implement, it is recommended that music listening be offered as a stress management intervention to these critically ill patients.

All studies in this review used sedative music or music that is calming. However, there are many styles of sedative music (for example, new age, classical, country and western, easy listening, etc.) and at this time it is unclear which type of music is most effective. The music therapy literature recommends that patients select music that is characterized by a slow tempo and lacks abrupt changes and sharp timbres. In addition, music that evokes strong emotional reactions, which may be caused by memories associated with the music, should be avoided when used for stress and anxiety reduction purposes (Dileo 2007). These recommendations stem from the clinical experience and knowledge of music therapists as well as experimental research in the field of music psychology. More controlled trials are needed with medical patients to further examine which musical characteristics enhance the psychological and physiological benefits from music listening.

We did not find evidence for reduction of blood pressure. It is unclear at this time whether this is due to ineffectiveness of the intervention, the possible confounding effect of medication intake, or the complex physiology underlying haemodynamic responses in critically ill patients requiring ventilator support.

It is important to note that only one study in this review used a trained music therapist (Phillips 2007). Music therapists in medical settings do not limit their interventions to offering music listening for relaxation purposes. Music therapists are specially trained both clinically and academically to carefully assess individual patients' needs, select from a range of music interventions, and use both music and their relationship with patients to offer emotional and spiritual support, enhance sense of control, improve physical well being, and provide moment-to-moment interactions based on patients' physiological and emotional responses. Because of the lack of randomized controlled trials examining the effect of music therapy interventions on mechanically ventilated patients, it is impossible to establish at this time whether these interventions are more effective than listening to pre-recorded music.

It is recommended that music therapists collaborate with medical personnel in this setting to carefully assess and evaluate the complexity of physiological responses in these patients. Vice versa, it is important that medical personnel providing music experiences to ICU patients consult with a music therapist to understand the differential impact of specific music parameters on relaxation responses as well as to perform an accurate assessment of patients' musical preferences.

### Implications for research

This systematic review provides evidence that listening to music may have beneficial effects on anxiety in mechanically ventilated patients. All studies but one (Phillips 2007) used pre-recorded music and were carried out by medical professionals. Randomized controlled trials on the use of music therapy (provided by a trained music therapist) with this population are urgently needed. Although the use of pre-recorded music may be preferred as a standardized stimulus by researchers, it is possible to develop music therapy protocols that will allow for individualization according to patient needs while still adhering to randomized controlled trial research standards. Music therapists are urged to formalize protocols to test the effectiveness of their interventions through randomized controlled trials (RCTs).

One should also not ignore the importance of qualitative research and non-RCT research to gain a better understanding of the qualitative aspects of the patient's experience and to identify factors that may contribute to or limit the effectiveness of music medicine and music therapy interventions.

The selection of music needs to be carefully considered in future trials. In particular, studies that use music that truly reflects patient preference are needed. Several studies in this review reported that

some participants disliked the music, even though various music styles had been offered to the patients (Lee 2005; Wong 2001). Dislike for the music may agitate the patient and result in an increased stress response.

More information is needed about dosages as well as timing of music interventions. Future studies need to examine the relationship between the frequency, duration, and timing of music interventions and treatment effects. Are there optimal lengths of music interventions? Do multiple sessions lead to better results? Are there preferred times during the day to optimize the benefits of music listening? To answer many of these questions, comparative studies are needed. Furthermore, several authors recommended that future studies exert better control over the confounding effects of medication intake on physiological responses (Chlan 1995; Chlan 1997; Chlan 2007a; Lee 2005). When researching critically ill patients, it is not possible to exclude the use of cardiovascular, sedative, and other medications. However, medication intake can be carefully monitored and included as a covariate in the analyses. In addition, future studies should specifically examine the effects of music listening on medication intake. Only one study (Conrad 2007) reported that less pharmacological sedation was required in the music group versus the control group. Finally, Chlan (Chlan 1997) recommended that future research explore possible interaction effects between music interventions and certain types of medication (for example, sedatives).

One author (Lee 2005) recommended that future studies exclude patients that are on the synchronized intermittent mandatory ventilation (SIMV) ventilator mode. In this mode, the ventilator delivers a mandatory breath to patients when their respiration becomes too slow. Therefore, the breath rate may not accurately reflect the effects of the music when this ventilator mode is used.

Selection of an appropriate measurement tool for anxiety is a major challenge in research studies with mechanically ventilated patients because these patients easily fatigue and have communication limitations. In addition, existing instruments may contain items that lack relevance for this particular population (Chlan 2003). Two authors (Chlan 1997; Lee 2005) reported difficulties with the use of the STAI Short Form (Marteanu 1992). Chlan reported a low internal consistency ( $\alpha = 0.67$ ) and questioned the reliability of this instrument to measure state anxiety in mechanically ventilated patients. Lee, on the other hand, reported that several of the participants had trouble understanding and answering some of the items of the Chinese version of this STAI Short Form. Chlan pointed out that the 6-item STAI scale (Marteanu 1992) had not been tested previously with critically ill patients. In 2003, Chlan and colleagues developed a 6-item short form from the STAI with mechanically ventilated patients. This shortened version had good psychometric properties but additional research is needed to further validate this scale (Chlan 2003).

Several studies in this review used a very small sample size (10 to

20). Future studies need to include power analyses so that sufficiently large samples are used. Future studies need to include important outcomes such as quality of life, patient satisfaction, time-compression, number of ventilator-dependent days, length of ICU stay, post-discharge outcomes, mortality, and cost-effectiveness assessments. In addition, future studies need to include stress hormone levels as these may provide more sensitive measures of effect and may provide insight into the underlying physiology of anxiety and stress reduction.

## ACKNOWLEDGEMENTS

We would like to thank Karen Hovhannisyan (Trials Search Co-

ordinator Cochrane Anaesthesia Review Group (CARG)) for his help with the development of the search strategy and Jane Cracknell (Managing Editor, CARG), Prof Harald Herkner (content editor), Dr Marialena Trivella (statistical editor), Dr Megan Pricor (peer reviewer), Yusra Badr and Ann Fonfa (Cochrane Consumer Network) for their help and editorial advice during the preparation of this review. We would like to thank Dr Linda Chlan (peer reviewer), Clare Jeffrey (consumer), Janet Wale (consumer), Anne Lyddiatt (consumer), and Naseem Akhtar Qureshi (consumer) for their help and editorial advice during the preparation of the protocol of the review. We would also like to acknowledge Mike Viega, research assistant, for his help in the data extraction and data input, and Patricia Gonzalez and Cassandra Mulcahey, graduate assistants, for their help with handsearching and article retrieval.

## REFERENCES

### References to studies included in this review

#### Chlan 1995 *{published and unpublished data}*

\* Chlan LL. Psychophysiological responses of mechanically ventilated patients to music: A pilot study. *American Journal of Critical Care* 1995;4(3):233–8. [MEDLINE: 18836973]

#### Chlan 1997 *{published and unpublished data}*

Chlan LL. Effectiveness of a music therapy intervention on relaxation and anxiety for patients receiving ventilatory assistance. *Heart and Lung* 1998;27(3):169–76. [MEDLINE: 9622403]

Chlan LL. Effect of a single music therapy session on anxiety and relaxation for critically ill mechanically ventilated patients. *Alternative Therapies in Health and Medicine* 1998;4(2):91–2.

\* Chlan LL. The relationship of absorption to the effects of music therapy on anxiety and relaxation for mechanically ventilated patients. Unpublished dissertation, University of Minnesota. Minnesota: University of Minnesota, 1997.

#### Chlan 2007a *{published and unpublished data}*

\* Chlan LL, Engeland WC, Anthony A, Guttormson J. Influence of music on the stress response in patients receiving mechanical ventilatory support: A pilot study. *American Journal of Critical Care* 2007;16(2):141–5. [MEDLINE: 17322014]

#### Conrad 2007 *{published and unpublished data}*

\* Conrad C, Niess H, Jauch KW, Bruns CJ, Hartl W, Welker L. Overture for growth hormone: requiem for interleukin-6?. *Critical Care Medicine* 2007;35(12):2709–13. [MEDLINE: 18074473]

#### Jaber 2007 *{published and unpublished data}*

\* Jaber S, Bahloul H, Guetin S, Chanques G, Sebbane M, Eledjam JJ. Effects of music therapy in intensive care unit without sedation in weaning patients versus non-ventilated patients [Effets de la musicothérapie en réanimation hors sédation chez des patients en cours de sevrage ventilatoire versus des patients non ventilés]. *Annales Françaises d'Anesthésie et de Réanimation* 2007;26:30–8. [MEDLINE: 17085009]

#### Lee 2005 *{published data only}*

\* Lee OKA, Chung YFL, Chan MF, Chan WM. Music and its effect on the physiological responses and anxiety levels of patients receiving mechanical ventilation: A pilot study. *Journal of Clinical Nursing* 2005;14:609–20. [MEDLINE: 15840076]

#### Phillips 2007 *{unpublished data only}*

\* Phillips SD. The effect of music entrainment on respiration of patients on mechanical ventilation in the intensive care unit. Master's thesis, Florida State University. Florida, 2007.

#### Wong 2001 *{published data only}*

\* Wong HLC, Lopez-Nahas V, Molassiotis A. Effects of music therapy on anxiety in ventilator dependent patients. *Heart and Lung* 2001;30(5):376–87. [MEDLINE: 11604980]

### References to studies excluded from this review

#### Almerud 2003 *{published data only}*

\* Almerud S. Music therapy—a complementary treatment: for mechanically ventilated intensive care patients. *Intensive and Critical Care Nursing* 2003;19(1):21–30. [MEDLINE: 12590891]

#### Besel 2006 *{published data only}*

\* Besel JM. The effects of music therapy on comfort in the mechanically ventilated patients in the intensive care unit. Unpublished Master's Thesis, Montana State University 2006.

#### Burke 1995 *{published data only}*

\* Burke M, Walsh J, Oehler J, Gingras J. Music therapy following suctioning: four case studies. *Neonatal Network* 1995;14:41–9. [MEDLINE: 7565526]

#### Caine 1991 *{published data only}*

Caine J. The effects of music on the selected stress behaviors, weight, caloric and formula intake, and length of hospital stay of premature and low birth weight neonates in a newborn intensive care unit. *Journal of Music Therapy* 1991;28(4):180–92. [MEDLINE: 10160836]

**Chlan 2000** *{published data only}*

\* Chlan LL. Music therapy as a nursing intervention for patient supported by mechanical ventilation. *AACN Clinical Issues* 2000;**11**(1):128–38. [MEDLINE: 11040559]

**Chlan 2001** *{published data only}*

\* Chlan L, Tracy MF, Nelson B, Walker J. Feasibility of a music intervention protocol for patients receiving mechanical ventilatory support. *Alternative Therapies in Health & Medicine* 2001;**7**:80–3. [MEDLINE: 11712475]

**Chlan 2006** *{published data only}*

\* Chlan LL. Acute effects of music on stress in patients receiving mechanical ventilatory support. *American Journal of Critical Care* 2006;**15**(3):324–46.

**Chou 2003** *{published data only}*

\* Chou L, Wang R, Chen S, Pai L. Effects of music therapy on oxygen saturation in premature infants receiving endotracheal suctioning. *Journal of Nursing Research* 2003;**11**(3):209–15. [MEDLINE: 14579198]

**Fontaine 1994** *{published data only}*

\* Fontaine DK. Nonpharmacologic management of patient distress during mechanical ventilation. *Critical Care Clinics* 1994;**10**(4):695–708. [MEDLINE: 8000922]

**Hansen-Flachen 1994** *{published data only}*

\* Hansen-Flachen J. Improving patient tolerance of mechanical ventilation. *Critical Care Clinics* 1994;**10**(4):659–71. [MEDLINE: 8000919]

**Hunter 2010** *{unpublished data only}*

\* Hunter BC, Oliva R, Sahler OJZ, Gaisser D, Salipante DM, Arezina CH. Music therapy as an adjunctive treatment in the management of stress for patients being weaned from mechanical ventilation. *Journal of Music Therapy* 2010; Vol. 47, issue 3: 198–220.

**Iriarte 2003** *{published data only}*

\* Iriarte RA. Music therapy effectiveness to decrease anxiety in mechanically ventilated patients [Efectividad de la musicoterapia para promover la relajacion en pacientes sometidos a ventilacion mecanica]. *Enfermeria Intensiva* 2003;**14**(2):43–8. [MEDLINE: 12952774]

**Lorch 1994** *{published data only}*

\* Lorch CA, Lorch V, Diefendorf AO, Earl PW. Effect of stimulative and sedative music on systolic blood pressure, heart rate, and respiratory rate in premature infants. *Journal of Music Therapy* 1994;**31**(2):105–18.

**Standley 1995** *{published data only}*

\* Standley JM, Moore, RS. Therapeutic effects of music and mother's voice on premature infants. *Pediatric Nursing* 1995;**21**(6): 509–12. [MEDLINE: 8700604]

**Twiss 2006** *{published and unpublished data}*

Twiss E. The effect of music listening on older adults undergoing cardiovascular surgery. Unpublished Master's thesis. Florida: Florida Atlantic University, 2003.

\* Twiss E, Seaver J, McCaffrey R. The effect of music listening on older adults undergoing cardiovascular surgery. *Nursing in Critical Care* 2006;**11**(5):224–31. [MEDLINE: 16983853]

**Wiens 1995** *{published data only}*

\* Wiens ME, Reimer MA, Guyn HL. Music therapy as a treatment method for improving respiratory muscle strength in patients with advanced multiple sclerosis: a pilot study. *Rehabilitation Nursing* 1995;**24**(2):74–80. [MEDLINE: 10410058]

**References to studies awaiting assessment****Bauer 2002** *{published data only}*

\* Bauer J. Music therapy reduces anxiety in ventilator patients. *Montvale* 2002;**65**(1):22.

**Wu 2008** *{published data only}*

\* Wu SJ, Chou FH. The effectiveness of music therapy in reducing physiological and psychological anxiety in mechanically ventilated patients [Chinese]. *Hu Li Za Zhi* 2008;**55**(5):35–44. [MEDLINE: 18836973]

**Additional references****Bobek 2001**

Bobek MB, Hoffman-Hogg L, Bair N, Slomka J, Mion L, Arroliga AC. Utilization patterns, relative costs, and length of stay following adoption of MICU sedation guidelines. *Formulary* 2001;**36**: 664–73.

**Boles 2007**

Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, et al. Weaning from mechanical ventilation. *European Respiratory Journal* 2007;**29**:1033–56.

**Bolwerk 1990**

Bolwerk C. Effects of relaxing music on state anxiety in myocardial infarction patients. *Critical Nurse Quarterly* 1990;**13**:63–72. [MEDLINE: 2383784]

**Chlan 2003**

Chlan L, Savik K, Weinert C. Development of a shortened state anxiety scale from the Spielberger State-Trait Anxiety Inventory (STAI) for patients receiving mechanical ventilatory support. *Journal of Nursing Measurement* 2003;**11**(3):283–93.

**Cucherat 2007**

Cucherat M. Quantitative relationship between resting heart rate reduction and magnitude of clinical benefits in post-myocardial infarction: a meta-regression of randomized clinical trials. *European Heart Journal* 2007;**28**(24):3012–9.

**Daub 1988**

Daub D, Kirschner-Hermanns R. Reduction of pre-operative anxiety [Verminderung der preoperative angst]. *Anaesthetist* 1988; **37**:594–7. [MEDLINE: 3056086]

**Deeks 2001**

Deeks JJ, Altman DG, Bradburn MJ. Statistical methods for examining heterogeneity and combining results from several studies in meta-analysis. In: Egger M, Davey Smith G, Altman DG editor (s). *Systematic Reviews in Health Care: Meta-Analysis in Context*. 2nd Edition. London: BMJ Publication Group, 2001.

**Dileo 1999**

Dileo C. A classification model for music and medicine. *Applications of Music in Medicine* 1999;**1**:1–6.

**Dileo 2005**

Dileo CD, Bradt J. *Medical music therapy: A meta-analysis & agenda for future research*. Jeffrey Books, 2005.

**Dileo 2007**

Dileo C, Bradt J. Music therapy: Applications to Stress Management. In: Lehrer P, Woolfolk R editor(s). *Principles and Practice of Stress Management*. 3rd Edition. New York: Guilford Press, in press.

**Egerod 2002**

Egerod I. Uncertain terms of sedation in ICU. How nurses and physicians manage and describe sedation for mechanically ventilated patients. *Journal of Clinical Nursing* 2002;**11**:831–40. [MEDLINE: 12427190]

**Frank 1985**

Frank JM. The effects of music therapy and guided visual imagery on chemotherapy-induced nausea and vomiting. *Oncology Nursing Forum* 1985;**12**(5):47–52. [MEDLINE: 3898031]

**Hamel 2001**

Hamel WJ. The effects of music intervention on anxiety in patients waiting for cardiac catheterization. *Intensive & Critical Care Nursing: The Official Journal of the British Association of Critical Care Nurses* 2001;**17**:279–85. [MEDLINE: 11866419]

**Higgins 2002**

Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Statistic in Medicine* 2002;**21**:1539–58.

**Higgins 2005**

Higgins JPT, Green S, editors. Cochrane Handbook for Systematic Reviews of Interventions 4.2.5 [updated May 2005]. In: The Cochrane Library, Issue 3, 2005. Chichester, UK: John Wiley & Sons, Ltd.

**Kaempf 1989**

Kaempf G, Amodie ME. The effect of music on anxiety. A research study. *AORN Journal* 1989;**50**(1):112–8. [MEDLINE: 2751292]

**Koch 1998**

Koch ME, Kain ZN, Ayoub C, Rosenbaum SH. The sedative and analgesic sparing effect of music. *Anesthesiology* 1998;**89**(2):300–6. [MEDLINE: 9710387]

**Kollef 1998**

Kollef MH, Levy NT, Ahrens TS, Schaiff R, Prentice D, Sherman G. The use of continuous IV sedation is associated with prolongation of mechanical ventilation. *Chest* 1998;**114**(2):541–8. [MEDLINE: 9726743]

**Ledingham 1988**

Ledingham IM, Bion JF, Newman LH, McDonald JC, Wallace PGM. Mortality and morbidity amongst sedated intensive care patients. *Resuscitation* 1988;**16**:69–77. [MEDLINE: 2849180]

**Lindgren 2005**

Lindgren V, Ames N. Caring for patients on mechanical ventilation: What research indicates is best practice. *American Journal of Nursing* 2005;**105**(5):50–60.

**Marteau 1992**

Marteau T, Bekker H. The development of a 6-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology* 1992;**31**(3):301–6.

**McAuley 2000**

McAuley L, Pham B, Tugwell P, Moher D. Does the inclusion of grey literature influence estimates of intervention effectiveness reported in meta-analyses?. *Lancet* 2000;**356**:1228–31.

**Mok 2003**

Mok E, Wong KY. Effects of music on patient anxiety. *AORN Journal* 2003;**77**(2):396–9. [MEDLINE: 12619853]

**Moser 1996**

Moser DK, Dracup K. Is anxiety early after myocardial infarction associated with subsequent ischemic and arrhythmic events?. *Psychosomatic Medicine* 1996;**58**(5):395–401. [MEDLINE: 8902890]

**Pelletier 2004**

Pelletier CL. The effect of music on decreasing arousal due to stress: A meta-analysis. *Journal of Music Therapy* 2004;**41**(3):192–214.

**Pfaff 1989**

Pfaff VK, Smith KE, Gowan D. The effects of music assisted relaxation on the distress of pediatric cancer patients undergoing bone marrow aspiration. *Children's Health Care* 1989;**18**:232–6.

**RevMan 5.0**

The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan)[Computer program]. Version 5.0 for Windows.. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008.

**Spielberger 1983**

Spielberger CD. *Manual for the State-Trait Anxiety Inventory (STAI)*. PaloAlto: Consulting Psychologists Press, 1983.

**Standley 1986**

Standley JM. Music research in medical/dental treatment: Meta-analysis and clinical implications. *Journal of Music Therapy* 1986;**23**(2):50–5.

**Standley 2000**

Standley JM. Music research in medical/dental treatment. In: Smith DS editor(s). *Effectiveness of music therapy procedures: Documentation of research and clinical practice*. Silver Spring: American Music Therapy Association, 2000:1–64.

**Suter 2002**

Suter PM. MV causes lung inflammation and systematic immune depression. *Intensive Care Medicine* 2002;**28**(4):383–5.

**Thomas 2003**

Thomas. Clinical management of stressors perceived by patients on mechanical ventilation. *AACN Clinical Issues* 2003;**14**(1):73–81. [MEDLINE: 12574705]

**White 1999**

White JM. Effects of relaxing music on cardiac autonomic balance and anxiety after acute myocardial infarction. *American Journal of Critical Care* 1999;**8**(4):220–30. [MEDLINE: 10392221]

\* Indicates the major publication for the study

## CHARACTERISTICS OF STUDIES

### Characteristics of included studies [ordered by study ID]

Chlan 1995

Methods	Randomized controlled trial Randomization method: Flip of coin Allocation concealment: Yes (personal communication with author) Blinding: No Design: Repeated measures control group design	
Participants	Adults with various diagnoses on mechanical ventilation: pulmonary related (80%), miscellaneous (20%) (e.g. cancer and kidney transplant) Average length of mechanical ventilation before onset of study: control group: 5.4 days; music group 14.5 days (due to one patient in music group with a ventilator length of 72 days) Ventilator mode: not reported Type of airway: not reported N music group: 11 N control group: 9 Sex: 7 F, 13 M Age in music group: 55.7; control group: 64.2 Setting: critical care units, USA	
Interventions	Two study groups: 1. music-listening via headphones 2. non-music, headphone only control group Music selections provided: classical selections from Music for Relaxation (Helen Bonny) Number of sessions: 1 Length of session: 30 minutes Categorized as music medicine study	
Outcomes	Mood (Profile or Mood States): post-test scores Heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, oxygen saturation, airway pressure: change scores from pre-test to post-test	
Notes	No standard deviations were reported for post-test scores. Additional data was obtained from the lead author. Change scores were computed by JB.	
<b><i>Risk of bias</i></b>		
<b>Item</b>	<b>Authors' judgement</b>	<b>Description</b>
Adequate sequence generation?	Yes	Flip of coin
Allocation concealment?	Yes	Achieved through use of flip of coin for each patient after consent was obtained

**Chlan 1995** (Continued)

Blinding? Objective outcomes	No	
Incomplete outcome data addressed? All outcomes	Yes	No subject loss
Free from financial conflict of interest?	Yes	

**Chlan 1997**

Methods	Randomized controlled trial Randomization method: Table of random numbers Allocation concealment: Yes (personal communication with author) Blinding: No Design: Repeated measures control group design	
Participants	Adults with various diagnoses on mechanical ventilation: pulmonary related (68%), cancer (4%), heart transplant (4%), trauma (5%), miscellaneous (19%) Average length of mechanical ventilation before onset of study: 7.39 days (SD 10.39) Most common ventilator mode: Synchronized Intermittent Mandatory Ventilation (SIMV) (70%). Other ventilator modes: Pressure support (PS), Positive and expiratory pressure (PEEP), Continuous positive airway pressure (CPAP), Assist/Control (A/C) Type of airway: not reported N music group: 27 N control group: 27 Sex: 59% F, 41% M Age: 57.1y Setting: critical care units, USA	
Interventions	Two study groups: 1. music-listening via headphones 2. rest period (no music) Music selections provided: classical, new age, country/western, religious, and easy listening. Number of sessions: 1 Length of session: 30 minutes Categorized as music medicine study	
Outcomes	State anxiety: post-test scores on the Spielberger State Anxiety Inventory (6-item version) Heart rate: post-test scores (at 30 minutes) Respiratory rate: post-test scores (at 30 minutes)	
Notes		
<b>Risk of bias</b>		
<b>Item</b>	<b>Authors' judgement</b>	<b>Description</b>

**Chlan 1997** (Continued)

Adequate sequence generation?	Yes	Table of random numbers
Allocation concealment?	Yes	Confirmed through personal communication with author
Blinding? Objective outcomes	No	
Incomplete outcome data addressed? All outcomes	Yes	Authors described number of subject withdrawals and reasons for withdrawal
Free from financial conflict of interest?	Yes	

**Chlan 2007a**

Methods	<p>Randomized controlled trial          Randomization method: Flip of coin          Allocation concealment: Yes (personal communication with author)          Blinding: No          Design: Repeated measures control group design</p>
Participants	<p>Adults receiving mechanical ventilation in critical care unit: pneumonia (5), respiratory failure (2), shortness of breath (1), ventricular tachycardia (1), and ischaemic bowel (1)          Average length of mechanical ventilation before onset of study: 14.2 (15) days          Ventilator modes: A/C (6), SIMV (2), and Pressure-release (2)          Type of airway: not reported          N music group: 5          N control group: 5          Age: 64.9 (7.8) y          Sex: 6 F, 4M          Setting: critical care unit, USA</p>
Interventions	<p>Two study groups:          1. music listening to patient-selected music via headphone          2. rest quietly without headphones          Number of sessions: 1          Length of session: 60 minutes          Categorized as music medicine study</p>
Outcomes	<p>Corticotropin, cortisol, epinephrine and norepinephrine blood samples were obtained from central venous catheter at 4 intervals: baseline, 15 minutes after baseline, 30 minutes after baseline, and 60 minutes after baseline          Heart rate: at baseline, 15 minutes after baseline, 30 minutes after baseline, and 60 minutes after baseline</p>
Notes	<p>The data of this study cannot be pooled with data from other studies in this review because of several confounding variables that likely impacted the outcomes at post-test: wide variability in mean levels of biomarkers, a very small sample size, administration of</p>

**Chlan 2007a** (Continued)

	intravenous morphine sulphate to 2 control subjects immediately prior to intervention, and 2 subjects in the experimental group needed endotracheal suctioning during the intervention.	
<b>Risk of bias</b>		
<b>Item</b>	<b>Authors' judgement</b>	<b>Description</b>
Adequate sequence generation?	Yes	Flip of coin
Allocation concealment?	Yes	Achieved through use of flip of coin
Blinding? Objective outcomes	No	
Incomplete outcome data addressed? All outcomes	Yes	No subject loss
Free from financial conflict of interest?	Yes	

**Conrad 2007**

Methods	Randomized controlled trial Randomization method: Alternate assignment (personal communication with author) Allocation concealment: Inadequate Blinding: Yes (personal communication with author) Design: Repeated measures control group design
Participants	Critically ill adults on mechanical ventilation Average length of mechanical ventilation before onset of study: not reported Ventilator modes: not reported Type of airway: not reported N music group: 5 N control group: 5 Sex: 1 F, 9 M Age M: 59.9 y Setting: critical care unit
Interventions	Two study groups: 1. music-listening via headphones 2. no music with headphones Music selection: "slow-moving" Mozart piano sonatas selected based on compositional elements of relaxation, according to the author: KV283, Andante; KV311, Andantino con espressione; KV330, Andante cantabile; KV332, Adagio; KV333, Andante cantabile; KV545, Andante; KV570, Adagio; and KV576, Adagio Number of sessions: 1 Length of session: 60 min

Conrad 2007 (Continued)

Outcomes	<p>Sedative drug intake, heart rate variability, arterial pressure, serum level of dehydroepiandrosterone (DHEAS), serum concentrations of growth hormone, interleukin-6: for these variables, means and standard error of the mean (SEM) are given for the control group but not for the music group. Only general statements such as “serum levels of dehydroepiandrosterone remained unchanged during the music intervention” are provided for the music group. Exact P levels of between-group changes are given for mean arterial pressure, growth hormone, interleukin-6, epinephrine, and DHEAS, but no mean differences are reported.</p> <p>Prolactin, norepinephrine, adrenocorticotrophic hormone (ACTH), cortisol, prolactin monomer: only P values are given.</p> <p>Because of the limited data reporting, results of this study are only discussed in narrative form in this review.</p>
----------	---

Notes

**Risk of bias**

Item	Authors' judgement	Description
Adequate sequence generation?	No	Alternate assignment
Allocation concealment?	No	
Blinding? Objective outcomes	Yes	Nursing staff who performed outcome assessments were blinded as to whether the patient received music via the headphones
Incomplete outcome data addressed? All outcomes	Yes	No subject loss
Free from financial conflict of interest?	Yes	

**Jaber 2007**

Methods	<p>Randomized controlled trial          Randomization method: Table of random numbers          Allocation concealment: Unclear          Blinding: Yes          Design: Cross-over trial</p>
Participants	<p>Adults with various diagnoses on mechanical ventilation: postsurgical (9), pancreatitis (2), respiratory issues (2), sepsis (2)          Average length of mechanical ventilation before onset of study: not reported          Ventilator mode: not reported          Type of airway: oral endotracheal tube (87%), tracheostomy (13%)          N music condition: 15 (ventilated patients only - see notes)          N control condition: 15 (ventilated patients only - see notes)          Age: 58 (7.8) y</p>

	Sex: 7 F, 8 M Setting: critical care unit, France
Interventions	Two conditions: 1. music listening to patient-selected music via headphone 2. uninterrupted rest Music selection used: a compilation of patient-preferred music was made by a music therapist according to the following tempo guidelines: the music started at 90-100 beats per minute (bpm), then slowed down to 60-60 bpm. The last 5 minutes, the tempo was increased to 70-80 bpm to re-energize the patient. The music therapist did not implement the music intervention sessions. Number of sessions: 1 Length of session: 20 minutes Categorized as music medicine study
Outcomes	Heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure: at 15 minute intervals. Because the music selections followed a U-curve (decreasing the tempo and then increasing during the last 5 minutes to re-energize the patient), the data of the 15-minute interval was used. The study report does not include standard deviations and precise data for each group. This information was obtained from the lead author.
Notes	This study compared ventilated patients (n=15) with non-ventilated patients (n=15). All patients were randomized to receive music listening followed by a period of rest or to first receive a period of rest followed by a period of music. Only data of the ventilated patients were used in this review. Group-specific data was obtained from the author.

**Risk of bias**

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Table of random numbers
Allocation concealment?	Unclear	Not stated
Blinding? Objective outcomes	Yes	Outcome assessors were blinded to treatment (personal communication with author)
Incomplete outcome data addressed? All outcomes	Yes	Subject loss is described in detail
Free from financial conflict of interest?	Unclear	Funding information is not provided. Conflict of interest statement is lacking.

**Lee 2005**

Methods	Randomized controlled trial Randomization method used: Draw of lots Allocation of concealment: Yes Blinding: Yes Design: Repeated measures control group design	
Participants	Adults, 39% respiratory problems and 34.3% postoperative surgical problems Average length of mechanical ventilation before onset of study: 2.5 (3.3) days Most frequently used ventilator mode: Pressure Support (PS) (89%) Most common type of airway: oral endotracheal tube (91%). Other: nasal (4%) and tracheostomy (4%) Ethnicity: Chinese N music group: 32 N control group: 32 Sex: 18 F, 46 M Age: 69.4 y Setting: critical care unit, China	
Interventions	Two study groups: 1. listening to patient-selected music via headphones 2. rest period with headphones Music selections provided: Chinese classical music, religious music (Buddhist and Christian), Western classical music and music with "natural sounds" Number of sessions: 1 Length of session: 30 minutes Categorized as music medicine study	
Outcomes	State anxiety: change scores from pretest to post test on the Spielberger State Anxiety Inventory (6-item version) Heart rate: change scores from pre-test to post-test Respiratory rate: change scores from pre-test to post-test Systolic blood pressure: change scores from pre-test to post-test Diastolic blood pressure: change scores from pre-test to post-test	
Notes		
<b><i>Risk of bias</i></b>		
<b>Item</b>	<b>Authors' judgement</b>	<b>Description</b>
Adequate sequence generation?	Yes	Draw of lots
Allocation concealment?	Yes	Achieved through use of draw of lots by independent group assigner after consent was obtained
Blinding? Objective outcomes	Yes	Researcher who completed outcome assessments was unaware of group assignment

Lee 2005 (Continued)

Incomplete outcome data addressed? All outcomes	Unclear	It is unclear whether number of participants analysed equals the number of participants recruited
Free from financial conflict of interest?	Unclear	Funding information is not provided. Conflict of interest statement is lacking.

Phillips 2007

Methods	Randomized controlled trial Randomization method: Alternate assignment Allocation concealment: Inadequate Blinding: Unclear Design: Repeated measures control group design Intention to treat: Adequate
Participants	Adults with various diagnoses on mechanical ventilation: cardiac problems (56%), pulmonary issues (21%), traumatic injury (8%), other (15%) Average length of mechanical ventilation before onset of study: not reported Ventilator mode: not reported Type of airway: no tracheostomy N music group (medical): 10 N music group (cardiac): 9 (not included in this review) N control group (medical): 10 N control group (cardiac): 10 (not included in this review) Sex: 10 F, 10 M (for medical, non-cardiac patients) Age: 57.5 y Setting: critical care unit, USA
Interventions	Two study groups: 1. experimental group: music therapy entrainment intervention, matching live music to respiratory rate of patients and 2. rest only Patient-selected live music used. Music therapist used guitar and voice Number of sessions: 1 Length of session: 25 minutes Categorized as music therapy study
Outcomes	Hear rate: change scores from pre-test to post-test Respiratory rate: change scores from pre-test to post-test Oxygen saturation level: change scores from pre-test to post-test Rapid shallow breathing: change scores from pre-test to post-test
Notes	Only the data of the medical, non-cardiac patients are included in this review. The cardiac patients were treated immediately following cardiac artery bypass grafting surgery and their physiological responses were still suppressed by the anaesthesia.

Phillips 2007 (Continued)

<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	No	Alternate group assignment
Allocation concealment?	No	
Blinding? Objective outcomes	No	
Incomplete outcome data addressed? All outcomes	Yes	subject loss is described
Free from financial conflict of interest?	Yes	

Wong 2001

Methods	Randomized controlled trial Randomization method: Draw of lots Allocation of concealment: Adequate Blinding: Unclear Design: Cross-over trial
Participants	Adults receiving mechanical ventilation in critical care unit. Most frequent primary diagnosis: pulmonary disease (no further details reported) Average length of mechanical ventilation before onset of study: 6.05 (3.65) days Ventilator mode: PS (80%), SIMV + PS (20%) Type of airway: tracheostomy (60%), oral endotracheal tube (40%) Ethnicity: Chinese Diagnosis: Pulmonary diseases N music condition: 20 N control condition: 20 Age: 58.25 y Sex: 5 F, 15 M Setting: inpatient critical care unit
Interventions	Two study groups: 1. music listening to patient-selected music via headphone or 2. uninterrupted rest Music selection used: Chinese music (Chinese folk song, music played by Chinese instruments, Chinese music played by Western instruments, Buddhist music) and various Western music (classical, soundtrack, piano). Number of sessions: each subject participated in one music condition and one rest condition. Length of condition: 30 minutes Categorized as music medicine study

**Wong 2001** (Continued)

Outcomes	State anxiety (short form; data was converted to full score): post-test score on the Spielberger State Anxiety Inventory (6-item version) Respiratory rate: post-test score Mean blood pressure: post-test score	
Notes		
<b><i>Risk of bias</i></b>		
<b>Item</b>	<b>Authors' judgement</b>	<b>Description</b>
Adequate sequence generation?	Yes	Draw of lots
Allocation concealment?	Yes	Achieved through use of draw of lots for each patient after consent was obtained
Blinding? Objective outcomes	No	
Incomplete outcome data addressed? All outcomes	Unclear	It is unclear whether number of participants analysed equals the number of participants recruited
Free from financial conflict of interest?	Unclear	Funding information is not provided. Conflict of interest statement is lacking.

**Characteristics of excluded studies** [ordered by study ID]

Study	Reason for exclusion
Almerud 2003	Insufficient data reporting
Besel 2006	Not randomized controlled trial
Burke 1995	Not randomized controlled trial
Caine 1991	Not population of interest
Chlan 2000	Programme description
Chlan 2001	Not randomized controlled trial
Chlan 2006	Not randomized controlled trial
Chou 2003	Not randomized controlled trial

(Continued)

Fontaine 1994	Programme description
Hansen-Flachen 1994	Not randomized controlled trial
Hunter 2010	Not randomized controlled trial
Iriarte 2003	Not randomized controlled trial
Lorch 1994	Not population of interest
Standley 1995	Not population of interest
Twiss 2006	Not randomized controlled trial. In the thesis author explicitly states that only 4 CD players were available. If all CD players were in use, the next group of patients were placed in the control group
Wiens 1995	Not population of interest

### Characteristics of studies awaiting assessment [ordered by study ID]

#### Bauer 2002

Methods	Unknown
Participants	Mechanically ventilated patients
Interventions	Music therapy or music medicine (unclear)
Outcomes	Unknown
Notes	Study could not be obtained because of incorrect citation.

#### Wu 2008

Methods	Randomized controlled trial
Participants	Mechanically ventilated patients
Interventions	Music therapy or music medicine (unclear)
Outcomes	Anxiety, heart rate, respiratory rate, blood pressure and oxygen saturation
Notes	

## DATA AND ANALYSES

### Comparison 1. Music versus standard care

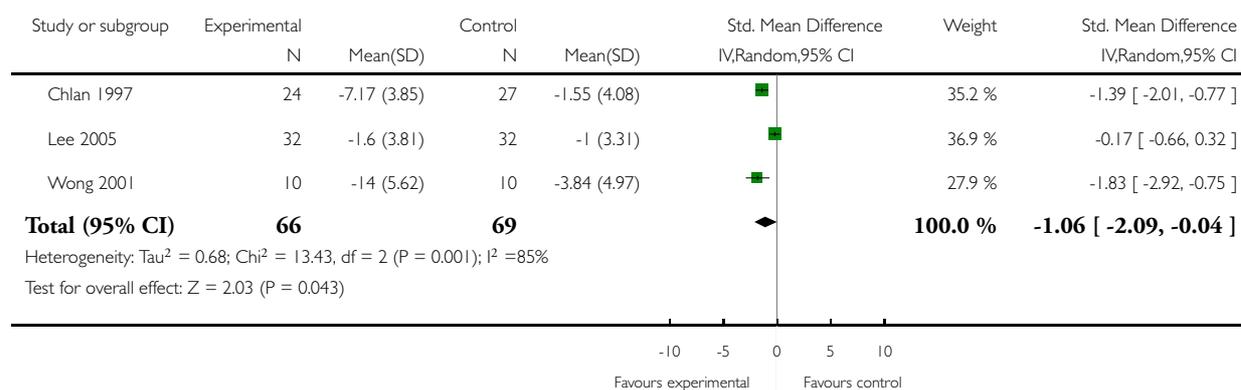
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 State Anxiety	3	135	Std. Mean Difference (IV, Random, 95% CI)	-1.06 [-2.09, -0.04]
2 Heart Rate	5	167	Mean Difference (IV, Fixed, 95% CI)	-4.75 [-6.98, -2.51]
3 Respiratory Rate	6	187	Mean Difference (IV, Fixed, 95% CI)	-3.18 [-4.41, -1.95]
4 Systolic Blood Pressure	3	98	Mean Difference (IV, Fixed, 95% CI)	-2.70 [-6.84, 1.45]
5 Diastolic Blood Pressure	3	98	Mean Difference (IV, Random, 95% CI)	-4.51 [-11.13, 2.10]
6 Oxygen Saturation Level	2	40	Mean Difference (IV, Fixed, 95% CI)	-0.71 [-3.08, 1.66]

#### Analysis 1.1. Comparison 1 Music versus standard care, Outcome 1 State Anxiety.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 1 State Anxiety

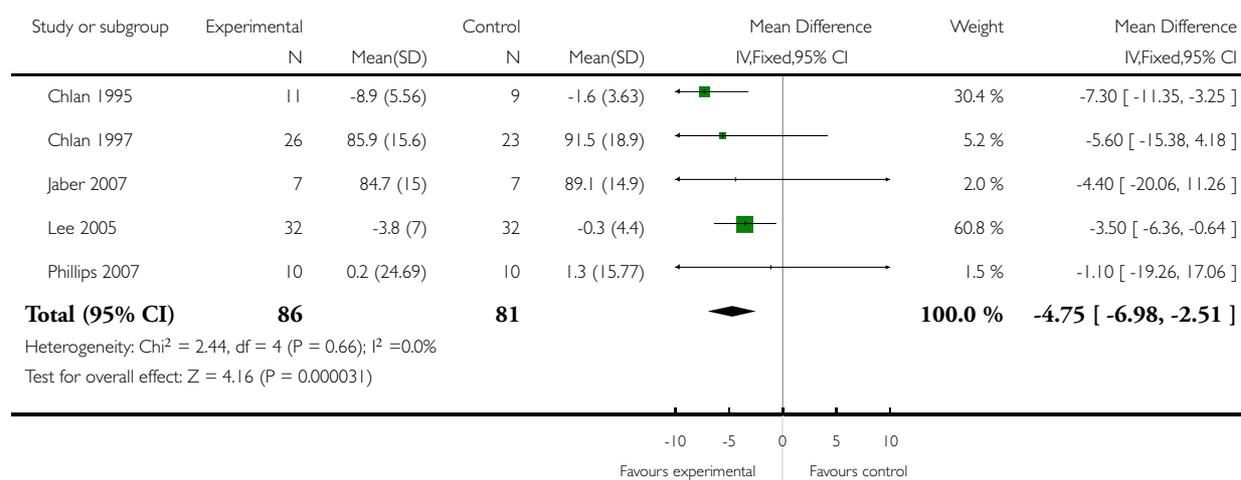


### Analysis 1.2. Comparison 1 Music versus standard care, Outcome 2 Heart Rate.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 2 Heart Rate

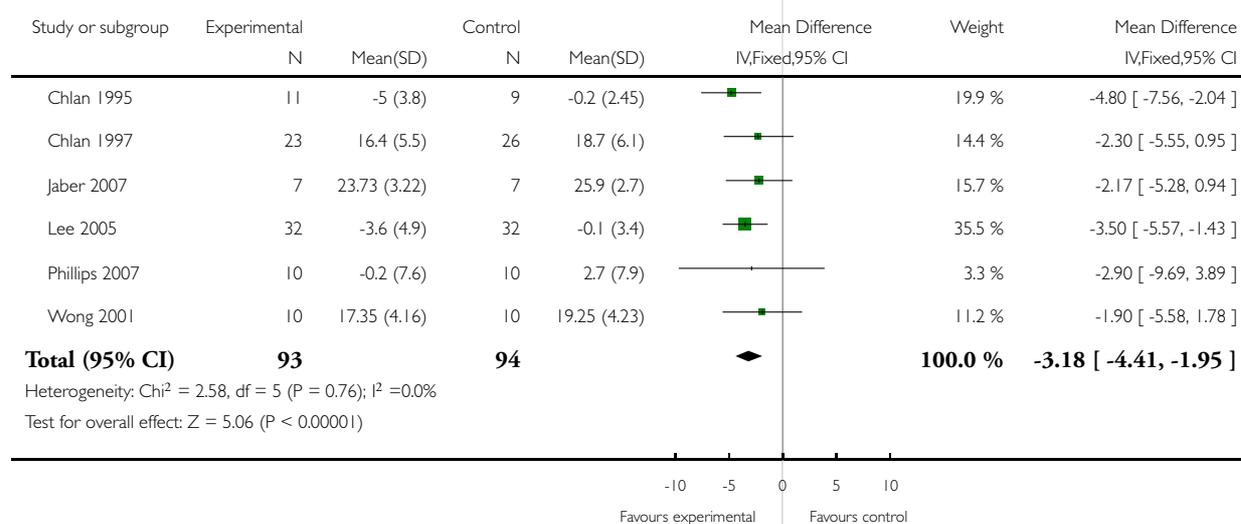


### Analysis 1.3. Comparison 1 Music versus standard care, Outcome 3 Respiratory Rate.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 3 Respiratory Rate

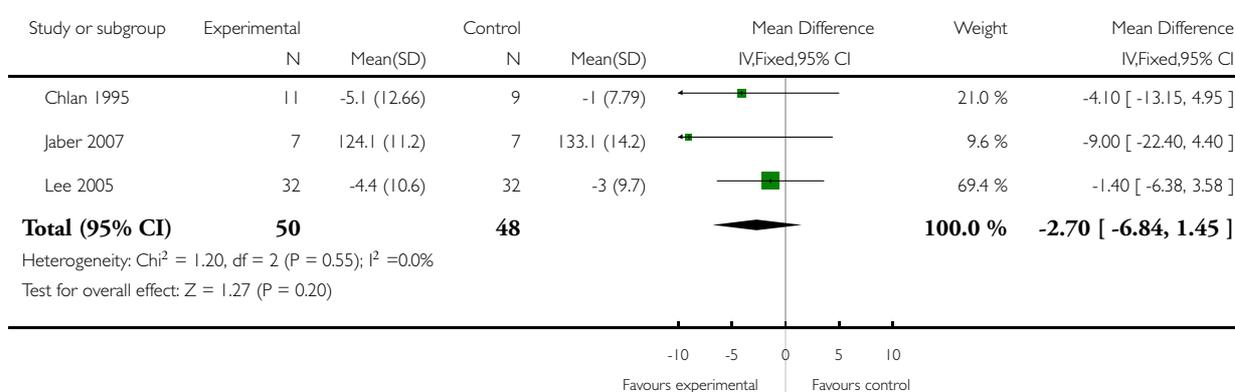


### Analysis 1.4. Comparison 1 Music versus standard care, Outcome 4 Systolic Blood Pressure.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 4 Systolic Blood Pressure

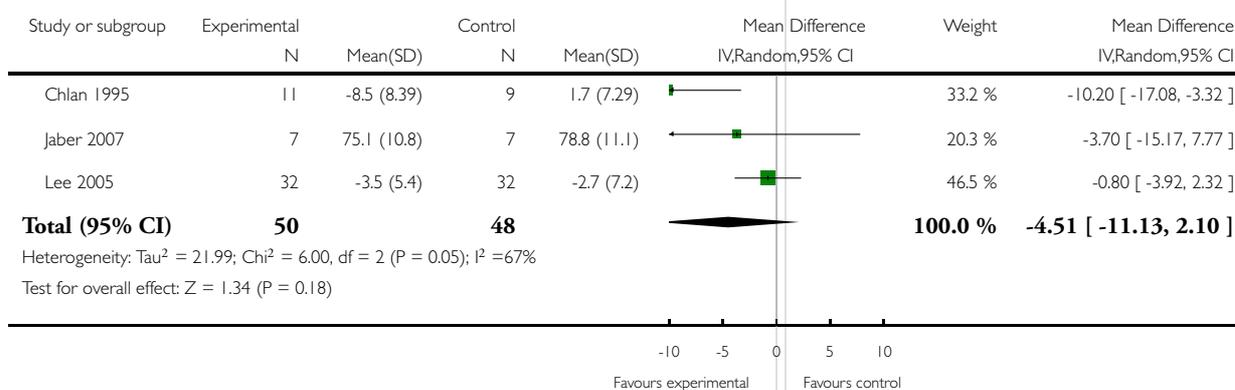


### Analysis 1.5. Comparison 1 Music versus standard care, Outcome 5 Diastolic Blood Pressure.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 5 Diastolic Blood Pressure

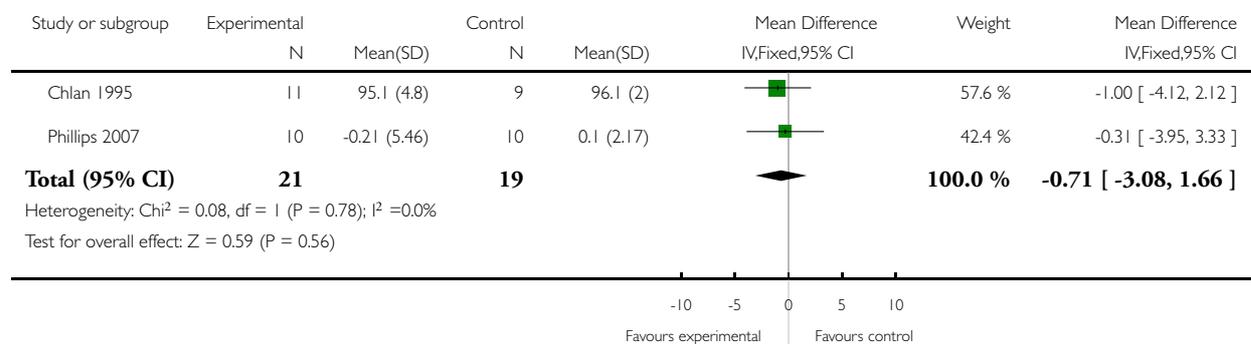


### Analysis 1.6. Comparison 1 Music versus standard care, Outcome 6 Oxygen Saturation Level.

Review: Music interventions for mechanically ventilated patients

Comparison: 1 Music versus standard care

Outcome: 6 Oxygen Saturation Level



## APPENDICES

### Appendix 1. MEDLINE search strategy (OvidSP)

- 1 music/
- 2 music therapy/
- 3 (music\$ or rhythm\$ or melod\$).tw.
- 4 (singing or sing or song\$ or compos\$ or improvis\$).tw.
- 5 or/1-4
- 6 Respiration artificial/
- 7 (artificial adj5 ventil\$).tw.
- 8 (Ventilat\$ adj5 mechanical).tw.
- 9 Intubation, intratracheal/
- 10 exp respiratory insufficiency/
- 11 (respiratory failure or (respiratory adj5 failure)).tw.
- 12 Suction/
- 13 or/6-12
- 14 randomized controlled trial.pt.
- 15 controlled clinical trial.pt.

16 randomized controlled trial.sh.  
17 random allocation.sh.  
18 double blind method.sh.  
19 single blind method.sh.  
20 or/14-19  
21 (animals not human).sh.  
22 20 not 21  
23 clinical trial.pt.  
24 exp clinical trial/  
25 (clin\$ adj25 trial\$).ti,ab.  
26 ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj25 (blind\$ or mask\$)).ti,ab.  
27 placebos.sh.  
28 placebo\$.ti,ab.  
29 random\$.ti,ab.  
30 research design.sh.  
31 or/23-30  
32 31 not 21  
33 22 or 32  
34 5 and 13  
35 33 and 34

## Appendix 2. PsycInfo search strategy (OvidSP)

```
1 Music/
2 Music therapy/)
3 (music$ or rhythm$ or melod$).tw.
4 (singing or sing or song$ or compos$ or listening or improvis$).tw.
5 or/1-4
6 artificial respiration/
7 artificial near ventil$.tw.
8 Ventilat$ near mechanical.tw.
9 exp Trachea/
10 intubation.tw.
11 respiratory failure.mp. or respiratory failure.tw.
12 suction.mp.
13 or/6-12
14 5 and 13
15 empirical study.md.
16 followup study.md.
17 longitudinal study.md.
18 prospective study.md.
19 quantitative study.md.
20 "2000".md.
21 treatment effectiveness evaluation/
22 exp hypothesis testing/
23 repeated measures/
24 exp experimental design/
25 placebo$.ti,ab.
26 random$.ti,ab.
27 (clin$ adj25 trial$).ti,ab.
28 ((sing$ or doubl$ or trebl$ or tripl$) adj (blind$ or mask$)).ti,ab.
29 or/15-28
30 14 and 29
31 limit 30 to human
```

## Appendix 3. CENTRAL search strategy

```
#1 MeSH descriptor Music, this term only
#2 MeSH descriptor Music Therapy explode all trees
#3 music* or rhythm* or melod*
#4 singing or sing or song* or compos* or listening or improvis*
#5 (#1 OR #2 OR #3 OR #4)
#6 MeSH descriptor Respiration, Artificial, this term only
#7 artificial near ventil*
#8 Ventilat* near mechanical
#9 MeSH descriptor Intubation, Intratracheal, this term only
#10 MeSH descriptor Respiratory Insufficiency explode all trees
#11 (respiratory failure) or (respiratory near failure)
#12 MeSH descriptor Suction explode all trees
#13 (#6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12)
#14 (#5 AND #13)
```

#### Appendix 4. EMBASE search strategy (OvidSP)

1 exp MUSIC THERAPY/ or exp MUSIC/  
2 (music\$ or rhythm\$ or melod\$).tw.  
3 (singing or sing or song\$ or compos\$ or listening or improvis\$).tw.  
4 or/1-3  
5 Respiration artificial/  
6 (artificial adj10 ventilat\$).mp.  
7 (Ventilat\$ adj10 mechanical).tw.  
8 exp Endotracheal Intubation/  
9 exp Respiratory Failure/  
10 respiratory failure.mp. or (respiratory adj10 failure).tw.  
11 Suction.mp. or SUCTION/  
12 or/5-11  
13 4 and 12  
14 Randomized Controlled Trial/  
15 RANDOMIZATION/  
16 Controlled Study/  
17 Multicenter Study/  
18 Phase 3 Clinical Trial/  
19 Phase 4 Clinical Trial/  
20 Double Blind Procedure/  
21 Single Blind Procedure/  
22 (RANDOM\* or CROSS?OVER\* or FACTORIAL\* or PLACEBO\* or VOLUNTEER\*).ti,ab.  
23 ((SINGL\* or DOUBL\* or TREBL\* or TRIPL\*) adj5 (BLIND\* or MASK\*)).ti,ab.  
24 or/14-23  
25 HUMAN.sh,hw.  
26 25 and 24  
27 26 and 13

#### Appendix 5. CINAHL search strategy (EBSCOhost)

#	Query
S19	S16 NOT S17
S18	S16 NOT S17
S17	(MH "Animals") or (MH "Animals, Laboratory") or (MH "Animal Studies")
S16	S15 and S5
S15	S14 or S13 or S12 or S11 or S10 or S9 or S8 or S7 or S6
S14	(MH "Intubation, Intratracheal") or (MH "Extubation")
S13	(MH "Suction") or (MH "Suctioning, Endotracheal") or (MH "Airway Suctioning")
S12	TX ventilator N5 weaning

(Continued)

S11	TX respiratory N5 failure
S10	(respiratory failure) or (MH "Respiratory Failure") or (MH "Ventilator Weaning")
S9	TX Ventilator* N5 mechanical
S8	TX artificial N5 ventilator*
S7	respiratory insufficiency
S6	(artificial respiration) or (MH "Ventilation, Mechanical+") or (MH "Ventilators, Mechanical")
S5	(S4 or S3 or S2 or S1)
S4	TX compos* or TX *
S3	TX singing or TX sing or TX song*
S2	TX music* or TX rhythm* or TX melod*
S1	MH music or MH music therapy

### Appendix 6. LILACS search strategy (Virtual Health Library)

((music\$) and ((mechanical and ventilation) or (intratracheal and intubation) or (respiratory and failure) or ([MH]"RESPIRATORY FAILURE") or (artificial and respiration) or (suction) or ([MH]"SUCTION" ))) AND Group=Humans [1]

### Appendix 7. AMED search strategy (OvidSP)

	Searches
1	Music/
2	Music Therapy/
3	(music\$ or rhythm\$ or melod\$).tw.
4	(singing or sing or song\$ or compos\$ or listening or improvis\$).tw.
5	or/1-4
6	Respiration artificial/
7	artificial near ventil\$.tw.

(Continued)

8	Ventilat\$ near mechanical.tw.
9	exp respiratory insufficiency/
10	respiratory failure.mp. or respiratory near failure.tw. [mp=abstract, heading words, title]
11	exp Intubation/
12	or/6-11
13	5 and 12

## Appendix 8. The Science Citation Index search strategy (ISI)

```
# 27 #26 AND #12 AND #4
# 26 #25 OR #24 OR #23 OR #22 OR #21 OR #20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 OR #13
# 25 TS=(control$ or prospectiv$ or volunteer$)
# 24 TS=(prospective studies)
# 23 TS=(follow up studies)
# 22 TS=(evaluation studies)
# 21 TS=(comparative study)
# 20 TS=random$
# 19 TS=placebo$
# 18 TS=(Clinical trial$)
# 17 TS=(single-blind method$)
# 16 TS=(double blind method$)
# 15 TS=(randomized controlled trial$)
# 14 TS=(controlled clinical trial$)
# 13 TS=(random allocation)
# 12 #11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5
# 11 TS=(suction)
# 10 TS=((respiratory failure) or (respiratory adj failure))
# 9 TS=(respiratory insufficiency)
# 8 TS=(Intubation, intratracheal)
# 7 TS=(Ventilat* adj mechanical)
# 6 TS=(artificial adj ventil*)
# 5 TS = Respiration artificial
# 4 #1 or #2 or #3
# 3 TS=(singing OR song or song* or compos* or improvis* or rhythm* or melod*)
# 2 TS=(music therapy)
# 1 TS=music*
```

## Appendix 9. The specialist music therapy research database search strategy

Research database is no longer functional. Archives of research reports, dissertations and conference proceedings were handsearched.

## Appendix 10. CAIRSS for Music search strategy (Webvoyage)

```
("mechanical ventilation")[in Keyword Anywhere] OR ("artificial ventilation")[in Keyword Anywhere] OR
("artificial respiration")[in Keyword Anywhere]
(intubation)[in Keyword Anywhere] OR ("suction")[in Keyword Anywhere]
("respiratory failure" [in Keyword Anywhere] OR ("respiratory insufficiency")[in Keyword Anywhere]
```

## Appendix I I. Proquest Digital Dissertations search strategy (Proquest)

```
((artificial ) W/3 (respir*)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
((artificial ) W/3 (ventilation)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
((mechanical) W/3 (ventilation)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
((intubation or suction)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
((respirat*) w/3 (insufficien*)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
((respirat*) w/3 (failure*)) AND ((Singing or sing or song* or compos* or improvis* or music* or rhythm* or melod*))
```

## Appendix I 2. Clinical trials.gov search strategy

```
(music or "music therapy")
```

## Appendix I 3. Current Controlled Trials search strategy

```
music
music therapy
```

## Appendix I 4. National Research Registry search strategy

```
music
```

## Appendix I 5. NIH CRISP search strategy

```
music
```

## HISTORY

Protocol first published: Issue 1, 2008

Review first published: Issue 12, 2010

Date	Event	Description
13 June 2008	Amended	Converted to new review format.

## **CONTRIBUTIONS OF AUTHORS**

Conceiving the review: Cheryl Dileo (CD)

Co-ordinating the review: JB

Undertaking manual searches: Joke Bradt (JB), Denise Grocke (DG), and graduate assistants

Screening search results: CD and JB

Organizing retrieval of papers: JB

Screening retrieved papers against inclusion criteria: JB

Appraising quality of papers: CD and JB

Abstracting data from papers: JB and research assistant

Writing to authors of papers for additional information: JB

Providing additional data about papers: JB

Obtaining and screening data on unpublished studies: CD

Data management for the review: JB

Entering data into Review Manager ([RevMan 5.0](#)): JB and research assistant

RevMan statistical data: JB

Other statistical analysis not using RevMan: JB

Double entry of data: (data entered by person one JB; data entered by person two: research assistant)

Interpretation of data: CD, JB, DG

Statistical inferences: JB

Writing the review: CD, JB, DG

Securing funding for the review: CD

Guarantor for the review (one author): JB

Person responsible for reading and checking review before submission: JB

## **DECLARATIONS OF INTEREST**

All authors are music therapists

## **SOURCES OF SUPPORT**

### **Internal sources**

- No sources of support supplied

### **External sources**

- State of Pennsylvania Formula Fund, USA.

## **DIFFERENCES BETWEEN PROTOCOL AND REVIEW**

In the protocol, we stated that we would exclude studies that used systematic methods of randomization. However, because only a small number of studies met all inclusion criteria, we decided to include studies that used systematic randomization (for example alternate assignment). We analysed the impact of these studies by means of sensitivity analysis.

The Specialist Music Therapy Research database is no longer a functional database. However, archives of research reports, dissertations, and conference proceedings are still available for handsearching. The authors handsearched these files.