

## การใช้กระบวนการเหนี่ยวนำเพื่อเป็นกลไกการรักษาในดนตรีบำบัด: การทบทวนแบบกำหนดขอบเขต ENTRAINMENT AS A THERAPEUTIC MECHANISM IN MUSIC THERAPY: A SCOPING REVIEW

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### บทคัดย่อ

กระบวนการเหนี่ยวนำเป็นหลักการสำคัญในการให้บริการดนตรีบำบัดซึ่งอาศัยจังหวะภายนอกร่างกายต่อการจัดระบบจังหวะภายในร่างกาย อีกทั้งยังเป็นกลไกสำคัญในการเปลี่ยนแปลงผลการรักษา การทบทวนวรรณกรรมเกี่ยวกับกระบวนการเหนี่ยวนำมีวัตถุประสงค์เพื่อศึกษาลักษณะสำคัญของกระบวนการเหนี่ยวนำรวมทั้งศึกษาผลลัพธ์ที่ปรากฏในวรรณกรรมที่ศึกษาจากทั้งหมด 167 รายการและคัดกรองผ่านเกณฑ์การศึกษาทบทวนวรรณกรรมแบบกำหนดขอบเขตทั้งสิ้น 10 รายการ ผลการศึกษาพบว่า กระบวนการเหนี่ยวนำมีวิธีการศึกษาที่หลากหลาย การศึกษาเหล่านี้มาจากสหรัฐอเมริกาและประเทศเยอรมนี มุ่งเน้นไปที่บริบททางการแพทย์หลายวิธีการและแสดงให้เห็นการประยุกต์ใช้กระบวนการทางดนตรีบำบัดในสภาพแวดล้อมทางการแพทย์ที่แตกต่างกัน การศึกษานี้ใช้กระบวนการทางดนตรีบำบัดแบบการใช้ทั้งดนตรีสดและใช้เปิดเพลงเครื่องบันทึกเสียงเพื่อกระตุ้นให้เกิดการเปลี่ยนแปลงทางกายภาพและจิตใจของผู้รับบริการ กระบวนการเหนี่ยวนำเป็นไปเพื่อการผ่อนคลาย การลดความเจ็บปวด และการบรรเทาความกังวล ใช้วิธีการประเมินเชิงอัตวิสัยและการตรวจสอบสัญญาณชีพพื้นฐาน ผลการศึกษาในปัจจุบันทำให้เกิดความเข้าใจมากยิ่งขึ้นเกี่ยวกับกระบวนการเหนี่ยวนำทางดนตรีบำบัด แต่ควรมีการศึกษาต่อเนื่องในกลุ่มประชากรที่หลากหลายมากยิ่งขึ้นเพื่อเพิ่มความละเอียดอ่อนทางบริบทวัฒนธรรม รวมทั้งผสมผสานนวัตกรรมเทคโนโลยีที่เกิดขึ้นใหม่ เสริมสร้างกระบวนการเหนี่ยวนำทางดนตรีบำบัดและขยายผลให้เกิดความเข้าใจเชิงลึกเพื่อประสิทธิผลในการบำบัด

**คำสำคัญ:** ดนตรีบำบัด/ กระบวนการเหนี่ยวนำ/ กลไกการรักษา/ กลไกการบำบัด/ การทบทวนขอบเขต

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## Abstract

Entrainment is a fundamental concept in music therapy, illustrating the profound influence of external rhythms on internal biological processes. It plays a pivotal role in music therapy as one of the key mechanisms for therapeutic change. Due to the wide variability in existing literature on the implementation of entrainment in music therapy, this scoping review aimed to summarize existing studies and identify key characteristics and outcomes addressed in this literature. Out of the 167 items identified from the initial database search, a total of 10 studies were selected for review, revealing a diverse range of methodologies and participant demographics. Predominantly conducted in the USA and Germany, these studies focused on various medical conditions, illustrating the diverse applications across different clinical settings. The reviewed studies primarily employed interventions involving receptive music therapy methods, utilizing live or recorded music to induce physiological and psychological changes in patients. These interventions targeted outcomes such as relaxation, pain reduction, and anxiety alleviation, measured through physiological markers and subjective assessments. Overall, while the existing literature provides valuable insights into the efficacy of music entrainment in therapeutic settings, there is a need for more rigorous research encompassing diverse methodologies, populations, and cultural contexts. Future studies should also explore the integration of new technologies to optimize music entrainment interventions and expand our understanding of its therapeutic potential.

**Keywords:** Music therapy/ Entrainment/ Healing mechanism/ Therapeutic mechanism/ Scoping review

## Introduction

Entrainment describes the process by which the internal biological rhythms of an organism synchronize with more pronounced external rhythms, such as the light-dark cycle. This concept is essential in fields like chronobiology and physics, illustrating how environmental rhythms influence biological processes across scales, from molecular interactions to whole organisms. For example, temporal locking allows one system's motion or signal frequency to align with another's, observable in both physical systems, like pendulum clocks, and biological ones, like fireflies. This phenomenon is also evident in human sensory and motor systems, underscoring its universality across different domains. (Thaut et al., 2015)

In the field of music therapy, the foundational premise posits that music can induce physiological and psychological changes in individuals. This is particularly significant due to the inherent rhythmic elements of music, which explains why entrainment is frequently cited as a key mechanism of change in music therapy. Entrainment, within this context, involves the automatic synchronization of a client's internal responses to the rhythmic components of music.

The discovery of entrainment fundamentally shifted and extended the view of the therapeutic properties of music, moving from a predominantly psychosocial perspective to one that utilizes the structural elements of music to retrain motor and brain function. (Thaut, 2015, p. 253-266.) Many clinicians and researchers focused on this as the therapeutic rationale and mechanism and further explained that music entrainment can induce changes in biological markers, brain waves, speech and language functions, and cognitive functions such as attention and memory. (Thaut, 2015, p. 253-266.) Additionally, it is postulated to also impact anxiety levels, (Jo Orr, 1998, p. 163-166.) brain connectivity, motor control and repetitive behaviors among persons with autism. (Bharathi et al., 2019, p. 180-186.)

Therefore, the concept of music entrainment has been implemented in clinical studies conducted with individuals with autism, (Azbell et al., 2006, p. 131-136.) post-operative pediatric patients, (Bradt, 2010, p. 150-157.) neuro-rehabilitational patients, (Galińska, 2015, p. 835-846.) patients with chronic pain, (Metzner, 2012, p. 163-170.) and patients with congenital heart disease, (Yurkovich et al., 2018, p. 62-82.) to name a few. With an increasing body of literature on utilizing entrainment as a key therapeutic mechanism, clinical applications vary widely in terms of clientele, settings, musical interventions, and descriptions of such mechanisms. A comprehensive synthesis and summary of the

available literature can better inform clinicians about the clinical applications of entrainment and offer a broader range of options considering the clinical needs and goals of different areas.

## **Objectives**

1. To investigate general characteristics of music therapy studies based on the entrainment mechanism
2. To explore the key intervention characteristics of studies that utilized entrainment as a therapeutic mechanism
3. To examine the goals/outcomes targeted in the entrainment studies in music therapy

## **Methodology**

In this study, the scoping review method was utilized to explore various applications of the entrainment mechanism. The literature search was conducted using the following databases: ERIC (EBSCOhost), PubMed, Academic Search Ultimate, and PsycARTICLES with hand searches of major music therapy journals. A specific boolean keyword search string used were: ‘Music therapy’ AND ‘Entrainment OR rhythmic entrainment OR music entrainment’

## **Inclusion Criteria**

For this paper, literature was selected based on the following inclusion criteria:

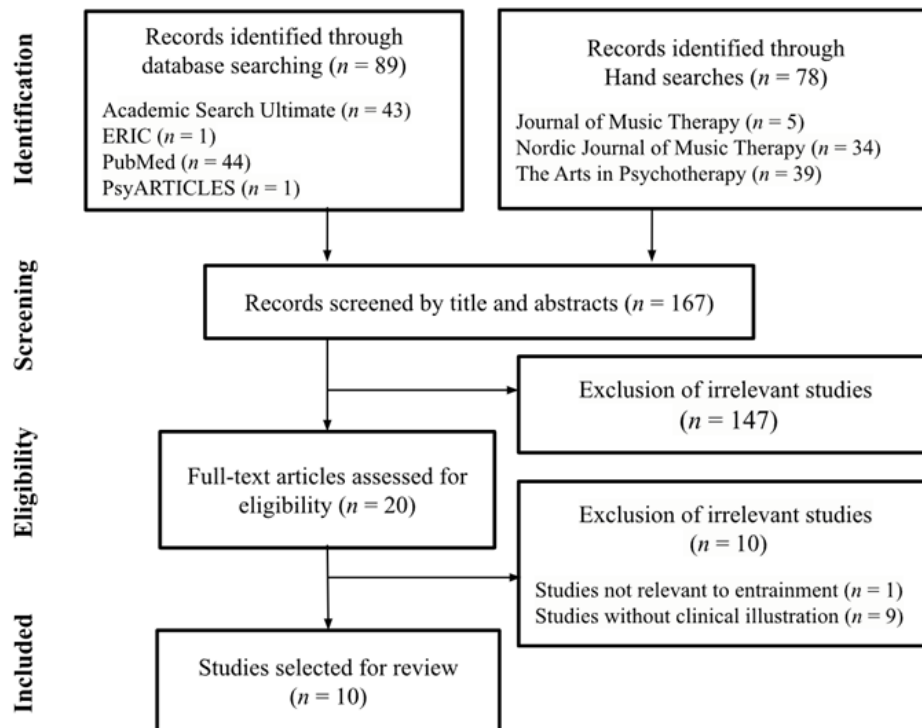
1. Studies with all types and designs;
2. Studies conducted with any population in various settings;
3. Studies that were published in English or Chinese languages;
4. Studies that applied the entrainment mechanism as a theoretical concept, therapeutic strategy, change mechanism or rationale for therapy.

## **Results**

### **Overview of the selection process**

Initial searches across four chosen electronic databases yielded 89 relevant studies identified through article title reviews. Additionally, a manual search of three music therapy journals identified 78 articles. In total, 167 studies were examined using the abstracts and assessed against predefined inclusion and exclusion criteria, resulting in the selection of 15 studies. Subsequently, the full texts of these studies were examined, leading to a final selection of 10 articles for review. The study selection process is illustrated in Figure 1 via a flow chart.

Figure 1 Flowchart of Literature Search Process



## Research Question 1

What are the general characteristics of music therapy studies based on the entrainment mechanism?

Selected studies were published between 1985 and 2018, with distribution as follows: before 2000 (n = 2), 2000-2009 (n = 4), and 2010-2019 (n = 4). These studies were conducted in two countries including Germany (n = 2), and the United States of America (n = 8), and all studies were published in English (n = 10). Among the 10 studies analyzed, 7 were published in music therapy-related journals, 2 in medical journals, and 1 in a general topic journal.

The research methodology implemented included randomized counterbalanced, repeated-measures design (n = 1), experimental study (n = 1), single-subject design (n = 1), pretest-posttest design (n = 1), within-subjects counterbalanced design (n = 1), case studies (n = 1), narrative literature review with case examples (n = 1), single case study design (n = 1), randomized controlled trial (RCT) (n = 1), and single case withdrawal (ABA) design (n = 1). The general characteristics of selected studies has been summarized in Table 1.

In terms of study participants, the average number per study was 11.7 (SD = 12.07), ranging from 1 to 32. Among the eight studies that specified patients' ages, one study targeted infants, two studies involved children, and the rest offered music entrainment to adults above 18 (n = 5). Seven of the ten articles involved patients with medical conditions, two with neurotypical individuals with no diagnoses, and one with a developmental condition. Participants with medical conditions included those with Acute Myeloid Leukemia (AML) (n = 1), Chronic pain (n = 1), Congenital heart disease (CHD) (n = 1), Pediatric postoperative pain (n = 1), Post-stroke rehabilitation (n = 1), and Spinal cord injury (n = 1). Two studies with neurotypical participants included nurses experiencing job stress (n = 1) and healthy university students (n = 1). The study participant with a developmental condition had Autism Spectrum Disorder (ASD) (n = 1). The information about participant characteristics of selected studies has been summarized in Table 2.

Table 1 General Characteristics of Included Studies

Source: by author

| Author<br>(Year)           | Country | Journal Title                                  | Type of study                                           |
|----------------------------|---------|------------------------------------------------|---------------------------------------------------------|
| Rider<br>(1985)            | USA     | Journal of Music Therapy                       | Randomized counterbalanced,<br>repeated-measures design |
| Rider et al.<br>(1985)     | USA     | Journal of Music Therapy                       | Experimental study                                      |
| Azbell et al.<br>(2006)    | USA     | UWL Journal of<br>Undergraduate Research       | Single-subject design                                   |
| Malcolm et al.<br>(2009)   | USA     | Topics in Stroke<br>Rehabilitation             | Pretest–posttest design                                 |
| Bradt<br>(2010)            | USA     | Music and Medicine                             | Within-subjects counterbalanced design                  |
| DiMaio<br>(2010)           | USA     | Music Therapy Perspectives                     | Case studies                                            |
| Metzer<br>(2012)           | Germany | Music and Medicine                             | Narrative literature review with<br>case examples       |
| Weaver et al.<br>(2015)    | USA     | Biology of Blood and<br>Marrow Transplantation | Single case study design                                |
| Kim et al.<br>(2018)       | Germany | The Arts in Psychotherapy                      | RCT                                                     |
| Yurkovich et<br>al. (2018) | USA     | Journal of Music Therapy                       | Single case withdrawal (ABA) design                     |

Table 2 Participant Characteristics of Included Studies

Source: by author

| Author                | N  | Gender (M/F) | Area               | Diagnosis                          | Targeted outcome                          | Outcome Measure                                                         |
|-----------------------|----|--------------|--------------------|------------------------------------|-------------------------------------------|-------------------------------------------------------------------------|
| Rider (1985)          | 23 | N/A          | Medical / Rehab    | Spinal cord injury                 | Promote relaxation; lower pain perception | Pain; EMG; VAS on imagery vividness; imagery activity; music preference |
| Rider et al. (1985)   | 12 | 0/12         | Neuro-typical      | None (Nurses with job stress)      | Promote relaxation; lower job stress      | Urine specimen; body temperature                                        |
| Azbell et al. (2006)  | 4  | 3/1          | Develo p- mental   | ASD                                | Reduce anxiety                            | Frequency of self-injurious and agitated disruptive behavior            |
| Malcolm et al. (2009) | 5  | 5/0          | Medical / Rehab    | Post-stroke rehabilitation         | Improve arm movement                      | Wolf Motor Function Test; Fugl-Meyer; MAL (how-well scale)              |
| Bradt (2010)          | 32 | 18/14        | Medical / Surgical | Pediatric postoperative pain       | Lower pain perception                     | VAS on pain intensity                                                   |
| DiMaio (2010)         | 4  | 2/2          | Medical / Hospice  | Various                            | Lower pain perception                     | Pain Assessment Scale                                                   |
| Metzer (2012)         | 1  | 0/1          | Medical / Pain     | Chronic pain                       | Lower pain perception                     | N/A                                                                     |
| Weaver et al. (2015)  | 1  | 0/1          | Medical / Oncology | Leukemia (AML)                     | Promote relaxation; lower anxiety         | Blood pressure; heart rate; State-Trait Anxiety; behavioral observation |
| Kim et al. (2018)     | 30 | 5/25         | Neuro-typical      | None (Healthy university students) | Promote relaxation                        | VAS on stress and general well-being; blood volume pulse (BVP)          |

| Author                  | N | Gender (M/F) | Area    | Diagnosis                      | Targeted outcome                 | Outcome Measure                                           |
|-------------------------|---|--------------|---------|--------------------------------|----------------------------------|-----------------------------------------------------------|
| Yurkovich et al. (2018) | 5 | 1/4          | Medical | Congenital heart disease (CHD) | Regulate physiological responses | Heart rate; respiratory rate; oxygenation saturation rate |

Note. VAS: Visual Analogue Scale

Table 3 Information about Intervention Characteristics

Source: by author

| Author (Year)         | Method                                                                                | Intervention provided by | Duration  | Frequency                         | Targeted outcome                          |
|-----------------------|---------------------------------------------------------------------------------------|--------------------------|-----------|-----------------------------------|-------------------------------------------|
| Rider (1985)          | Receptive, relaxation, and guided imagery                                             | Music Therapist          | 20 min    | N/A                               | Promote relaxation; lower pain perception |
| Rider et al. (1985)   | Receptive, progressive muscle relaxation and guided imagery                           | Music Therapist          | 20 min    | 5 days/week, for 3 weeks          | Promote relaxation; lower stress          |
| Azbell et al. (2006)  | Receptive (listened to 'specialized music' on tape)                                   | N/A                      | 20 min    | Total of 8 sessions over 2 weeks  | Reduce anxiety                            |
| Malcolm et al. (2009) | Receptive (listened to auditory cues during physical rehabilitation training)         | Occupational Therapist   | Various   | 3 days/week, total 2-week         | Improve arm movement                      |
| Bradt (2010)          | Receptive (listened to pain and healing music played on various instruments)          | Music Therapist          | 30-45 min | 2 session over 2 consecutive days | Lower pain perception                     |
| DiMaio (2010)         | Receptive (listen to pain and healing music created by voice and various instruments) | Music Therapist          | Various   | Various                           | Lower pain perception                     |

| Author (Year)           | Method                                                                      | Intervention provided by | Duration | Frequency | Targeted outcome                  |
|-------------------------|-----------------------------------------------------------------------------|--------------------------|----------|-----------|-----------------------------------|
| Metzer (2012)           | Receptive (listen to pain and healing music created on various instruments) | Music Therapist          | N/A      | N/A       | Lower pain perception             |
| Weaver et al. (2015)    | Receptive / relaxation                                                      | Music Therapist          | 30 min   | N/A       | Promote relaxation; lower anxiety |
| Kim et al. (2018)       | Receptive / relaxation with improvised body tambura and vocal improvisation | N/A                      | 10 min   | N/A       | Promote relaxation                |
| Yurkovich et al. (2018) | Receptive (listen to live music on voice and guitar)                        | Music Therapist          | 20 min   | Various   | Regulate physiological responses  |

Table 4 Information about Intervention and Specific Method / Strategy

Source: by author

| Author        | Year | Music     | Intervention                                                                                                                    | Specific Strategies                                                                                                                                                               |
|---------------|------|-----------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rider         | 1985 | Record ed | Listened to one of 7 <u>tape conditions</u> : Tapes for relaxation, imagery for pain relief, and relief from pain, and no music | Provide music via headphones; relaxation tape with guided relaxation with trans like minimalist music; entrainment condition with distinct mood shift from unpleasant to pleasant |
| Rider et al.  | 1985 | Record ed | Listened to recorded music program for music, guided imagery and Progressive muscle relaxation condition                        | Used specific pieces of music from earlier study to accompany the relaxation and guided imagery process                                                                           |
| Azbell et al. | 2006 | Record ed | Listened to recorded rhythmic entrainment music                                                                                 | Reduce anxiety-related behavior through rhythmic entrainment                                                                                                                      |

| Author           | Year | Music               | Intervention                                                                                                                           | Specific Strategies                                                                                                                                                                           |
|------------------|------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Malcolm et al.   | 2009 | Digitally generated | Provided RAS training coupled with auditory cues generated by a digital metronome                                                      | Initially move at a self-selected pace, then synchronize with the auditory cues in subsequent trials                                                                                          |
| Bradt            | 2010 | Live                | Listened to auditory image of pain and healing created on various musical instruments                                                  | Matched various musical parameters to match patients' descriptions of pain and healing auditory image, let patient direct the music                                                           |
| DiMaio           | 2010 | Live                | Listened to auditory image of pain and healing created on voice and various musical instruments                                        | Followed 5 stages entrainment (Dileo & Bradt, 1999); also matched various musical parameters to match patients' descriptions of pain and healing auditory image, let patient direct the music |
| Metzer           | 2012 | Live                | Music-imaginative pain treatment<br>(entrainment music played for pain and healing music)                                              | Synchronization on the neurophysiologic level                                                                                                                                                 |
| Weaver et al.    | 2015 | Live                | Use rhythmic entrainment live music to reduce anxiety and promote relaxation                                                           | Synchronize the physiological rhythms of patients such as heart and respiration rate to live music between the BPM of 66-72                                                                   |
| Kim et al.       | 2018 | Live                | Provided relaxation with entrainment music: live improvisation on body tambura and vocal improvisation (humming)                       | Synchronized exactly to the participant's physiological rhythm through musical beat                                                                                                           |
| Yurkovich et al. | 2018 | Live                | Provided live music selected based on the least-alerting music styles guidelines: voice alone or voice with instrumental accompaniment | Entrainment on physiologic responses matching the micro-beat of the guitar accompaniment to the infant's presenting heart rate                                                                |

## Research Question 2

### What are the key intervention characteristics of studies that utilized entrainment as a therapeutic mechanism?

All participants ( $n = 10$ ) used receptive methods such as active listening, relaxation, guided imagery, or physical rehabilitation. The authors aimed to synchronize with the current emotions, pain levels, or physiological states. Each session was conducted individually ( $n = 10$ ), lasting 10 to 45 minutes. Session frequencies varied: one study provided five sessions per week for three weeks (Rider et al., 1985), another offered four sessions per week for two weeks (Azbell et al., 2006), while another had sessions three days per week for two weeks (Malcolm et al., 2009). Additionally, one study scheduled two consecutive daily sessions (Bradt, 2010). Detailed intervention characteristics are in Table 3.

Among the reviewed studies, six employed live music, three utilized recorded music, and one featured digitally generated auditory stimulation using a digital metronome. (Malcolm et al., 2009, p. 69-79.) Recorded music was used in the three studies published on or before 2006, whereas the majority opted for live music. Most studies involving live music included various musical instruments. In contrast, Dimaio (2010) and Yukovich et al. (2018) provided improvised music using voice, while Kim et al. (2018) employed live improvisation with a body tambura and vocal techniques.

The strategy included providing music via headphones, relaxation tapes with guided relaxation and minimalist music, and an entrainment condition with a mood shift from unpleasant to pleasant ( $n = 1$ ). It used specific music pieces from earlier studies for relaxation and guided imagery ( $n = 1$ ), aimed to reduce anxiety-related behavior through rhythmic entrainment ( $n = 1$ ), involved initial self-paced movement followed by synchronization with auditory cues ( $n = 1$ ), and matched musical parameters to patients' pain and healing descriptions, allowing patient-directed music ( $n = 1$ ). It followed five stages of entrainment (Dileo & Bradt, 1999) and also included neurophysiological synchronization ( $n = 1$ ). The strategy synchronized physiological rhythms like heart and respiration rates to live music (BPM 66-72) ( $n = 1$ ), matched the patient's biorhythm using musical beats ( $n = 1$ ), and synchronized physiologic responses to the micro-beat of guitar accompaniment with the infant's heart rate ( $n = 1$ ). Detailed intervention characteristics are summarized in Table 4

### Research Question 3

#### What are the outcomes targeted in the entrainment studies in music therapy?

The targeted outcomes included promoting relaxation ( $n = 4$ ), decreasing pain perception ( $n = 4$ ), reducing anxiety ( $n = 2$ ), regulating physiological biorhythms ( $n = 1$ ), and decreasing stress ( $n = 1$ ). The measurement tools used included vital signs such as heart rate, blood pressure, respiratory rate and oxygen saturation rate ( $n = 2$ ), 10 point scale on pain intensity ( $n = 2$ ), EMG biofeedback ( $n = 1$ ), urine specimen collection; oral temperature recording ( $n = 1$ ), behavioral data ( $n = 1$ ), Wolf Motor Function Test, Motor Activity Log, and Fugl-Meyer Assessment ( $n = 1$ ), State-Trait Anxiety Inventory ( $n = 1$ ), visual analogue scale (VAS) on stress and general well-being, and blood volume pulse (BVP) ( $n = 1$ ). An overview of the targeted outcome of interventions were presented in Table 5.

### Conclusions

Seven of the ten reviewed articles indicated that entrainment-based music interventions were administered by music therapists. However, two studies did not state this information clearly. For example, Azbell et al. (2006) described the recorded music used in their study as ‘specialized music’ but did not provide comprehensive details about the intervention or interventionist. In a separate study, the intervention was conducted by an occupational therapist using a digital metronome for auditory stimulation. Due to the nature of the intervention itself, it did not necessitate an extensive description of the treatment condition. Nonetheless, for the purposes of enhancing research quality and ensuring rigor in clinical and ethical aspects, it is imperative that future studies explicitly outline the intervention procedures and details regarding the interventionists. (Dileo & Bradt, 2005)

Recorded music was exclusively used in studies conducted on or before 2006 ( $n = 3$ ) and in those published in 2010 and later ( $n = 6$ ). Notably, live music was employed to precisely match and shift the perceived levels of pain (Bradt, 2010; DiMaio, 2010; Metzger, 2012); to induce relaxation (Kim et al., 2018; Weaver et al., 2015; Yukovich et al., 2018), and to reduce anxiety (Weaver et al., 2015). Given that the principle of entrainment involves the meticulous synchronization of external stimuli with clients' internal biological rhythms, researchers have made deliberate adjustments to musical parameters to align with the patients' current conditions (Bradt, 2010; DiMaio, 2010; Metzger, 2012), including systematic modifications of tempo (Kim et al., 2018; Weaver et al., 2015) and even at the micro-beat level (Yukovich et al., 2018). This procedure is highly extemporaneous and requires vigilant observation by therapists to effectively match and entrain the desired responses (Dileo & Bradt, 1999)

Another notable aspect of the interventions is the presence of voice. Although the primary outcome targeted in all three studies was pain reduction, Bradt (2010) and Metzger (2012) provided instrumental improvised music, whereas DiMaio (2010) utilized both voice and instruments to create the entrainment music. DiMaio notably employed voice on multiple occasions, even to mimic patients' moans. One may suspect various reasons behind this clinical decision, yet, no additional rationale was provided by the author for the prominent use of voice compared to other studies. Similarly, two studies by Kim et al. (2018) and Yurkovich et al. (2018) also utilized vocal music without specifying the rationale behind this approach. Considering that the choice of instruments and the therapeutic methods can directly impact the type and level of patient experiences, a careful investigation of the differences between instrumental and vocal entrainment music could enhance the understanding of implementing music-based entrainment in music therapy.

Malcolm et al.'s study (2009) was the only study that utilized Rhythmic Auditory Stimulation (RAS) as an entrainment method to assist with physical rehabilitation. Given that RAS is an effective technique extensively used to address various physiological and rehabilitational needs of patients (Thaut et al., 2015), there appears to be a gap in research that illustrates the coupling of RAS with music entrainment approaches in music therapy.

Future research in music entrainment should focus on several key areas to deepen understanding and enhance effectiveness. Expanding methodological diversity is crucial; incorporating a broader range of study designs, including more randomized controlled trials and longitudinal studies, will help elucidate the long-term effects of music entrainment.

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