








# A Systematic Review of the Technology Available for Data Collection and Assessment in Music Therapy

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**Abstract.** The lack of standardized tools for assessment in music therapy is a reality that has concerned music therapists for years. Considering technology as one of the advances that have most modified our lives in recent years, this study carries out a systematic review to analyze the technology available for data collection and assessment in music therapy. The databases analyzed were PubMed and Scopus, from 2013 to June 2023. Out of 370 records, only 8 records met the inclusion criteria, showing a strong prevalence in publications in 2022. This review suggests that the technology is increasingly present in music therapy sessions and it is also growing the number of studies worried to find more accurate solutions for data collection and assessment in music therapy. Taking advantage of technological resources for this process seems to be a great opportunity, but the research in this context is insufficient for this moment, so there remains too much work to do.

**Keywords:** Music therapy · Technology · Data collection · Assessment

## 1 Introduction

In the past decades much music therapy research has focused on clinical practice and the experiences of therapeutic projects based on music therapy. Led by some of the best-known names in music therapy development, many of these investigations have focused on clarifying the benefits obtained from clinical work in cases of treatment of autistic spectrum disorder [1], for acquired brain injury [2], to slow the effects of dementia [3], among many others; either individually or for groups [4]. These studies are of vital importance to support the use of music as therapy, to continue growing in the discipline and to inspire other potential music therapy projects. For this aim, it is also important to ensure accurate tools that reflect the results of these practices [5] and this is an issue that has been worrying many of the music therapy studies, especially in the last years. Nevertheless, an evident lack has been identified in the music therapy research on music therapy data collection and assessment.

In their proposal of a taxonomy of the qualities of music therapy interactions in cancer care, Magee, Davidson, and Hwang [6] especially emphasize the importance of accurately defining and measuring the qualities of music therapy interactions to better understand the outcomes of music therapy. Mössler, Chen, Heldal, and Gold [7] stress the rigorous use of precise measurement tools to assess outcomes after conducting a systematic review examining the efficacy of music therapy in people with schizophrenia and schizophrenia-like disorders. And, in the same way [8], insist during their meta-analysis on the importance of using precise research tools, such as activation probability estimation analysis, to better understand the neurological processes involved in musical improvisation in therapeutic contexts. Magree [9] further adds how data collection and assessment tools should reflect the artistic and unique nature of music therapy, being essential to find the accurate method.

We certainly need to be concerned about the importance of evidence-based practice in music therapy and how data collection and assessment tools need to be updated to reflect these advances in research and clinical practice [10], so we should aim to integrate contemporary perspectives in this process [11].

The most used tools are mainly inspired by the proposals of the first referents of music therapy, which established the working bases in the second half of the 21st century and which, therefore, have become obsolete with the passage of time, especially because they are not taking advantage of all the opportunities that technology offers us. It is true that data collection tools and assessment in music therapy have evolved in the past decades, trying to adapt to the advances in music therapy as analyzed by Schmid and Elefant [12], but observation is still used as the main method, and data collection is usually done with a paper and a pen [13].

We must develop standardized assessment tools to specific populations or needs to guarantee the quality and comparability of music therapy studies [14]. It is not essential to have the same assessment, because not all practices are the same, but it is essential to have standardized tools [15]. Another important point is to standardize the terminology used [16] and establish a common vocabulary to avoid mismatches in the interpretation of data.

In his systematic review, Gattino [13] registered a strong tendency to study assessment practices in children, possibly justified by the large number of music therapists who attend or investigate within this population or context, but he stated that there are no specific studies of how to use technology in a practical way in the context of the data collection and assessment in music therapy. And this article aims to shed some light in this regard.

## 2 Literature Review

The assessment in music therapy is an essential process, both to ensure the quality of work and to achieve a qualitative increase in the recognition of the discipline [17]. It is considered that data collection is the initial step of gathering information and assessment is a broader process that may involve data collection and evaluation but also encompasses making informed judgments and decisions in context. On the one hand, the assessment in music therapy allows the music therapist to know in detail the needs, abilities and goals

of the people with whom they work, giving them some essential keys to be able to design an appropriate therapeutic process. On the other hand, it allows the results obtained with clinical practice to be endorsed, for which it is essential that there be rigor and adequate and objective evaluation bases. Whenever something is evaluated, it is necessary to use an appropriate evaluation method and, especially, one that allows us to measure what we want to measure. Sotelo [18] reflects that we cannot measure the temperature with a tape measure or the distance with a thermometer, although both are valid tools and the concepts are measurable. That is why it is important to choose well what you work with. The main challenge is to translate into words or data what happens in the sessions with music, especially with objectivity and rigor [19].

Despite this, university training programs often focus on practice and the fundamentals of practice and do not devote the necessary time to research, data collection and assessment. Almost 10 years ago, Benenson [20] identified this lack in the training of music therapy students, highlighting a greater need to integrate research and assessment skills into university training programs; and it seems that reality has not changed as much as expected, following the criticism of Magee and Byrland [21] where they emphasize this same idea and the need for more comprehensive training that includes data collection and evaluation to support the effectiveness of music therapy, especially in medical contexts where these methodologies are frequently used.

It's very important to lay the knowledge foundations of music therapy data collection and assessment, to determine what is to be measured and how, but then it is essential that there be flexibility, because not all therapeutic processes are the same [22]. Since the use of music therapy was standardized, there have been a variety of evaluation methods and tools that seek to measure in the most reliable way the items on which work is done in the sessions of the discipline [23].

For this purpose, music therapy has frequently used some of the foundations and tools used for evaluation in other disciplines, combining some of these tools with its main method of data collection: the phenomenological observation. We know from Wigram and Wosch [24] how the phenomenological observation can provide valuable insight into the therapeutic process and in multiple clinical contexts. In their book *Microanalysis in Music Therapy: Methods, Techniques and Applications for Clinicians, Researchers, Educators and Students* they offer a “wide range of instruments, analysis tools, and aids for systematically supporting these perceptions through a multitude of microanalysis methods in music therapy for different problems in clinical practice, different client populations, and different approaches of music therapy”. Within the 20 methods of microanalysis in music therapy thoroughly analyzed in this book, we see that there are different tools that stand out for data collection:

- Video recording: analyzing the video recording and later transforming it into a music notation and comments in the score [25], with a coding system that leads to graphic representation [26], in an excel sheet with established descriptions [27], standard items for behavior analysis [28] or in responses for a form analysis based on events [29], among others.
- Audio recording: analyzing the audio recording and building with it a graphical representation of the waveform [30], a two-dimensional spatial diagram generated with PrinGrid [31], among others.

- Written descriptions: text descriptions of the musical experience [32] or narratives about the experience and its reflections [33], among others.
- Scales: transformation of the sessions into qualitative scales with different levels of compliance with the analyzed behaviors [34], Likert scales or scales of musical parameters [35], among others.

Although most of the cases previously exposed focus on individual clinical work, in the case of community music therapy, Stige, Ansdell, Elefant and Pavlicevic [36] also explore phenomenological observation as a valid tool to understand the musical experience in this context.

Parallel to the establishment of these tools for data collection and microanalysis, technology has evolved immensely, offering new possibilities for music therapy. It has been 13 years since Ruud announced a new direction for music therapy, reflecting on how the everyday musicking through smartphones and mp3-technology may initiate a new area in the use of music as self-caring technology [37]. Furthermore, as indicated by Andrew Knight [38]: “since the release of the first iPad in 2010, development of software applications (apps) with uses for music therapists has increased dramatically. Apps for musical instruments, notation/composition, and recording/playback range from easy-to-use interfaces to highly technical apps for industry professionals”. Ten years have passed since this affirmation and now some music therapists have also seen the possibility of taking advantage of this technology to improve assessment in music therapy, recently creating the following tools [23]:

- IMTAP (Individualized Music Therapy Assessment Profile) is an assessment protocol developed by a team of six experienced music therapists [39]. Now it is digitized and allows an automated process in music therapy. This tool, available in Portuguese now, has the following sections: admission form, planning and implementation, initial assessment, completion/discharge and data collection. The admission form allows to collect general information about the patient and information about sensory, communicative, cognitive, perceptive, emotional, and social skills. The initial evaluation is divided into an initial evaluation sheet, potentialities and challenges, and goals and objectives. And the data collection section is divided into gross motor skills, fine motor skills, oral motor skills, sensory, receptive communication, expressive communication, cognitive, emotional, social and musicality; and each section is valued with a scoring scale.
- MITM (Meet In The Music) by Esther Thane (n.d.), is a music therapy curriculum for autism and diverse needs that offers enormous resources for the music therapist: a music therapy goal bank, examples of interventions - with songs, audio files, picture cards, sheet music, training videos of music therapy strategies, parent programs to do at home...-, a method of qualitative and quantitative data collection for analysis, templates for treatment plans, among others. MITM even proposes to the music therapist activities and objectives, personalized for each patient by adding information about this person. Currently this tool is only available in English, but it is expected that a Spanish version will also be available soon and the author herself will provide training for music therapists to learn how to use it.

On the other hand, the technology applied both to music production and to the recording of patient responses plays an increasingly important role in the clinical context of music therapy. There are digital applications that support the sessions by generating music, making it possible for users who have certain physical or cognitive difficulties to participate. Among the multiple tools identified in this sense, two stand out that have been considered the most useful for the authors of this article:

- Virtual Musical Instrument (VMI): this digital program “allows the slightest of movements to produce music on a computer - bringing the empowerment of making music to those for whom picking up a guitar or sitting at a piano are activities inaccessible due to disability” [40]. It has been designed for therapists and educators and is customizable according to the preferences and needs of the user. It has been invented in Professor Tom Chau’s Pediatric Rehabilitation Intelligent Systems Multidisciplinary (PRISM) lab at Holland Bloorview Kids Rehabilitation Hospital.
- SoundBeam: this tool is “a ‘touch-free’ musical device that turns physical movements into sounds and music. Using cutting-edge sensor technology, Soundbeam translates any physical gestures into musical notes, enabling people of all abilities to create music” [41]. This digital musical instrument also allows combining various sensors and configuring the sound sets and musical parameters to adapt them to the person’s needs.

All these previously mentioned resources are considered of great value for the music therapist, but a greater knowledge about the technology available for data collection and assessment in music therapy could be of even greater value for the discipline. That is what this systematic review promotes.

### 3 Methodology

This report aimed to clarify the current technology available for data collection and assessment in music therapy. The research question is: how could take advantage of the use of advanced technology for data collection and assessment in terms of assessing the effectiveness, efficiency, and accuracy of practice in music therapists’ sessions? To identify all potential tools, we screened the literature with a systematic review in PubMed and Scopus. A first systematic literature search was conducted on 30/06/2023 in the two databases selected, the systematic search was limited to systematic reviews in English or Spanish, published from 2013 to 2023.

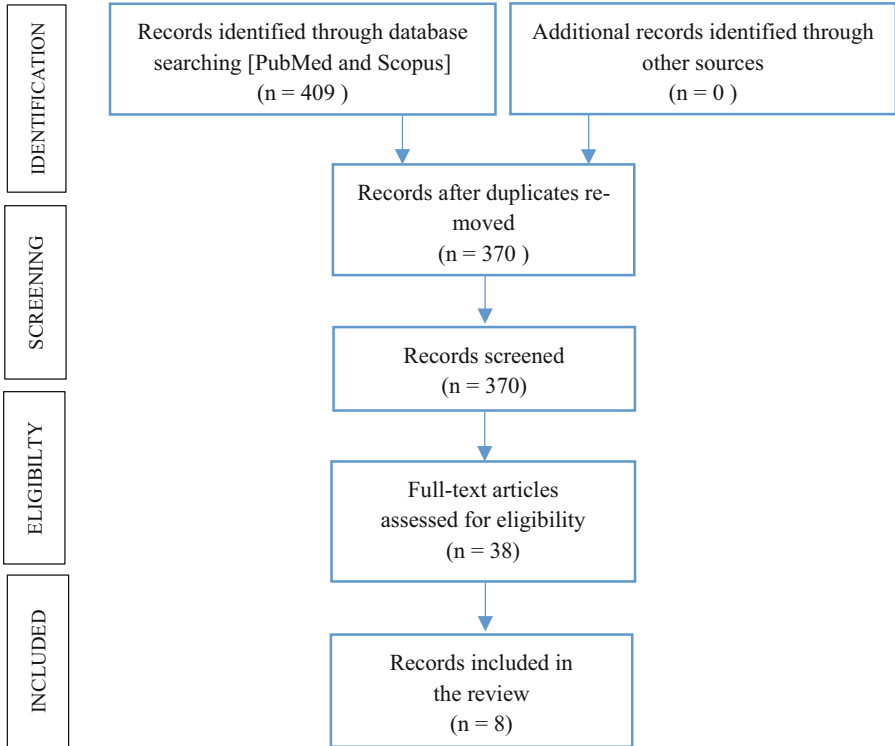
We initially used the terms “music therapy” AND “technology” OR “virtual” OR “digital” - in English or Spanish - and we attained 821 results. Then we decided to narrow the search further and we added the terms “data collection” and “assessment”. The inclusion criteria for relevant studies are summarized in Table 1.

**Table 1.** Inclusion criteria.

Heading level	PubMed and Scopus
Languages	English and Spanish
Date	30/06/2023
Publication period	2013 – June 2023
Search	<p><b>(music therapy OR musicoterapia) AND ((technology) OR (technological) OR (virtual) OR (digital) OR (tecnología) OR (tecnológico)) AND ((data collection) OR (assessment) OR (toma de datos) OR (registro de datos) OR (recopilación de datos) OR (evaluación))</b>  ("music therapy"[MeSH Terms] OR ("music" [All Fields] AND "therapy" [All Fields]) OR "music therapy"[All Fields] OR "musicoterapia" [All Fields]) AND ("technology" [MeSH Terms] OR "technology" [All Fields] OR "technologies" [All Fields] OR "technology s" [All Fields] OR "technologic" [All Fields] OR "technological" [All Fields] OR "technologically" [All Fields]) OR ("virtual" [All Fields] OR "virtuality" [All Fields] OR "virtualization" [All Fields] OR "virtualized" [All Fields] OR "virtualizing" [All Fields] OR "virtuals" [All Fields]) OR ("digital" [All Fields] OR "digitalisation" [All Fields] OR "digitalised" [All Fields] OR "digitalization" [All Fields] OR "digitalize" [All Fields] OR "digitalized" [All Fields] OR "digitalizer" [All Fields] OR "digitalizing" [All Fields] OR "digitally" [All Fields] OR "digitals" [All Fields] OR "digitization" [All Fields] OR "digitizations" [All Fields] OR "digitize" [All Fields] OR "digitized" [All Fields] OR "digitizer" [All Fields] OR "digitizers" [All Fields] OR "digitizes" [All Fields] OR "digitizing" [All Fields]) OR "tecnología" [All Fields] OR "tecnologías" [All Fields] OR "tecnológico" [All Fields]) AND ("data collection" [MeSH Terms] OR "data" [All Fields] AND "collection" [All Fields]) OR "data collection" [All Fields] OR ("assess" [All Fields] OR "assessed" [All Fields] OR "assessment" [All Fields] OR "assesses" [All Fields] OR "assessing" [All Fields] OR "assessment s" [All Fields] OR "assessments" [All Fields]) OR ("toma" [All Fields] AND ("drug effects" [MeSH Subheading] OR ("drug" [All Fields] AND "effects" [All Fields]) OR "drug effects" [All Fields] OR "de" [All Fields]) AND "datos" [All Fields]) OR (("registro" [All Fields] OR "registros" [All Fields]) AND ("drug effects" [MeSH Subheading] OR ("drug" [All Fields] AND "effects" [All Fields]) OR "drug effects" [All Fields] OR "de" [All Fields]) AND "datos" [All Fields]) OR ("recopilacion" [All Fields] AND ("drug effects" [MeSH Subheading] OR ("drug" [All Fields] AND "effects" [All Fields]) OR "drug effects" [All Fields]) OR "de" [All Fields]) AND "datos" [All Fields]) OR "evaluacion" [All Fields])</p> <p><b>Translations</b>  <b>music therapy:</b> "music therapy" [MeSH Terms] OR ("music" [All Fields] AND "therapy" [All Fields]) OR "music therapy" [All Fields]  <b>technology:</b> "technology" [MeSH Terms] OR "technology" [All Fields] OR "technologies" [All Fields] OR "technology's" [All Fields]  <b>technological:</b> "technologic" [All Fields] OR "technological" [All Fields] OR "technologically" [All Fields]  <b>virtual:</b> "virtual" [All Fields] OR "virtuality" [All Fields] OR "virtualization" [All Fields] OR "virtualized" [All Fields] OR "virtualizing" [All Fields] OR "virtuals" [All Fields]  <b>digital:</b> "digital" [All Fields] OR "digitalisation" [All Fields] OR "digitalised" [All Fields] OR "digitalization" [All Fields] OR "digitalize" [All Fields] OR "digitalized" [All Fields] OR "digitalizer" [All Fields] OR "digitalizing" [All Fields] OR "digitally" [All Fields] OR "digitals" [All Fields] OR "digitization" [All Fields] OR "digitizations" [All Fields] OR "digitize" [All Fields] OR "digitized" [All Fields] OR "digitizer" [All Fields] OR "digitizers" [All Fields] OR "digitizes" [All Fields] OR "digitizing" [All Fields]  <b>tecnología:</b> "tecnología" [All Fields] OR "tecnologías" [All Fields]  <b>data collection:</b> "data collection" [MeSH Terms] OR "data" [All Fields] AND "collection" [All Fields] OR "data collection" [All Fields]  <b>assessment:</b> "assess" [All Fields] OR "assessed" [All Fields] OR "assessment" [All Fields] OR "assesses" [All Fields] OR "assessing" [All Fields] OR "assessment" [All Fields] OR "assessment's" [All Fields] OR "assessments" [All Fields]  <b>registro:</b> "registro" [All Fields] OR "registros" [All Fields]</p>

The update search yielded 252 articles from PubMed and 157 results from Scopus – 409 in total. After removing duplicate results – 39 articles – and collating the update search in both databases, 370 references remained.

After screening the 370 abstracts, 332 studies were excluded because they clearly reflected not using technology for data collection or assessment in music therapy. 38 studies appeared to fit these criteria through their abstract, so all these studies were read in full to check their suitability. Finally, 30 full-text articles were excluded, resulting in 8 included studies (see Fig. 1).



**Fig. 1.** Study selection (PRISMA flow diagram)

## 4 Results

Out of 370 studies, only 8 studies qualified our inclusion criteria: use technology for data collection or evaluation in music therapy. A detailed search criterion has been demonstrated in Fig. 1 and the details of the 8 articles are summarized in Table 2.

**Table 2.** Final selection.

Author/s	Research	Year of publication	Use of technology	Tools	Category
Lu D	Evaluation Model of Music Therapy's Auxiliary Effect on Mental Health Based on Artificial Intelligence Technology	2022	Assessment	Artificial Intelligence	Mental Health
Xu W	Response of music therapy to body mechanism and automatic efficacy evaluation system based on artificial intelligence technology	2022	Data collection and assessment	Artificial Intelligence	Emotions
Faramarzi A., Sharini H., Shanbehzadeh M., Pour MY., Fooladi M., Jalalvandi M., Amiri S., Kazemi-Arpanahi H	Anhedonia symptoms: The assessment of brain functional mechanism following music stimuli using functional magnetic resonance imaging	2022	Data collection	Magnetic resonance imaging SPM Toolbox in MATLAB software	Anhedonia and depression
Pascual-Vallejo C. D., Casillas-Martín, S., Cabezas-González, M	Una propuesta alternativa de evaluación en el diseño de las interacciones e interfaces tecnológicas musicales: en la búsqueda de nuevos paradigmas	2022	Assessment	IMTAP software	Music therapy
Alneyadi M., Drissi N., Almeqbaali M., Ouhbi S	Biofeedback-Based Connected Mental Health Interventions for Anxiety: Systematic Literature Review	2022	Data collection	Biofeedback devices	Anxiety

*(continued)*

**Table 2.** (continued)

Author/s	Research	Year of publication	Use of technology	Tools	Category
Luo Z., Durairaj P., Lau C.M., Katsumoto Y., Do E.Y.-L., Zainuddin A.S.B., Kawauchi K	Gamification of Upper Limb Virtual Rehabilitation in Post Stroke Elderly Using Silver Tune - A Multi-sensory Tactile Musical Assistive System	2021	Data collection and assessment	SilverTune	Rehabilitation in Post Stroke Elderly
Hatwar N. R., Gawande U. H	Can music therapy reduce human psychological stress: A review	2019	Data collection	Electroencephalogram (EEG)	Stress
Magrini M., Pieri G	Real time system for gesture tracking in psycho-motorial rehabilitation	2014	Data collection	Real-time gesture tracking	Psycho-motorial rehabilitation

## 5 Discussion

The 8 records included in this review show different ways of using technology for data collection and assessment in music therapy:

- Lu in 2022 [42] proposes an evaluation model of the auxiliary effect of music therapy on mental health based on artificial intelligence technology. For this, the research delves into big data mining theory and proposes a statistical data model, showing the applied formulas in the evaluation model and the rules for updating the information of the statistical data. The research uses an experimental group and a control group to evaluate its effectiveness and parameters such as pressure or stress are measured. The author concludes that “this model can effectively improve the accuracy of the evaluation of music therapy’s auxiliary effect on mental health, and the evaluation results are accurate and reliable, with low error and good confidence” [42].
- A new system based on artificial intelligence is proposed in 2022 to evaluate the efficacy of music therapy. Xu [43] seeks to create a tool capable of monitoring the physical condition of subjects in real time and adjusting the type of treatment music according to this information. The proposal is mainly focused on the emotional aspect of people during music therapy sessions.
- Another recent study [44] used magnetic resonance imaging technology (fMRI) to determine the effect of music on depression and anhedonia. Three groups of people-healthy patients, patients with depression, and patients with depression and anhedonia-participated in the music therapy sessions, based on the stimulation with popular and traditional Iranian music. Then the data were analyzed using SPM Tool-box in MATLAB software. The authors highlight in conclusions that fMRI has been shown to be an effective tool in evaluating anhedonia symptoms by detecting the

hemodynamic changes in the cerebral cortex in response to appropriate musical stimuli [44].

- A research group in Spain has taken the tool IMTAP (The Individualized Music Therapy Assessment Profile) as a reference and they present in their article an alternative assessment proposal, highlighting the need to explore creative approaches to assessment in the design of cognitive, creative, and expressive technology [45]. It proposes an audiovisual record of the sessions - at least four cameras - and subsequent manual transcription of the data. In this way, the data is included manually, completing the categories established in the program form, and then an automatic analysis of the patient's evolution is made. In this way, the digital tool facilitates the assessment of the music therapy process.
- A 2022 systematic review by Alneyadi, Drissi, Almeqbaali and Ouhbi [46] evaluated interventions using technology for mental health care and biofeedback technology as a part of their process for anxiety management. The study reflects that biofeedback was used to better understand both psychological and physiological patient information - as well as the association between the two - during the intervention, but it also allows data collection that could be valuable for therapists to analyze the patient assessment.
- Luo, Durairaj, Lau, Katsumoto, Do, Zainuddin and Kawauchi [47] develop SilverTune, a smart multi-sensory musical assistive system to promote the rehabilitation outcomes of elderly post-stroke patients. The app allows users to work on their skills but also the app can record the user's profile and the data input from SilverTune for future analysis by the therapist. This automatic data collection - through app technology - facilitates a more accurate assessment of the patient's progress.
- Another project that uses technology to collect data on the effect of music on the brain of people with stress is the one developed by Hatear and Gawande [48]. They use electroencephalogram technology (EEG) as a non-invasive tool and to detect brain waves during the music.
- Finally, we found a system for real-time gesture tracking developed by the Signal and Images Lab of ISTI-CNR. Magrini and Pieri [49] affirm that the developed algorithms can extrapolate features from the patient - such spatial position, arms, and legs angles etc.- and the system the operator can link these features to sounds synthesized in real time, following a predefined schema. In this way, the movements made during the music therapy psycho-motorial rehabilitation sessions are automatically recorded.

Consequently, this systematic review shows that only 2,16% of the records referred to the technology available for data collection or for assessment in music therapy from 2013 to June 2023. However, more than half of these studies -5 out of 8- were published in 2022, showing a clear increase in interest nowadays in this theme.

One explanation for this current increase could be the need to have appropriate assessment tools in music therapy [23], adapted to the clinical context, to obtain significant and reliable results [50] and to assure of the quality of the evaluation for the continuous development of the discipline [17] But maybe it could be also triggered by the advent of artificial intelligence [43] and the new paradigm evidenced after COVID-19, which further demonstrates the need to find flexible and resilient technological designs in favor of health and well-being [44].

In contrast, 97.84% of records in this systematic review are focused on the use of technology with other functions; but not taking advantage of this technology for data collection or for subsequent evaluation. Among these excluded records, the most common use of technology is as part of music therapy sessions, either creating music, to promote the progress of the patient or helping achieve the music therapeutic goals. This group represents 25.41% of the records.

The 362 recorded excluded -for not meeting the inclusion criteria- are mainly divided into four themes:

- -The use of technology as part of music therapy sessions - either using digital instruments or devices that allow musical production.
- The technology applied to other therapies carried out by the patient, in a process that also combines traditional music therapy.
- Technology as part of the context and the day-a-day of the patient who attends music therapy.
- Technology as a tool to carry out music therapy sessions - due to distance or during the COVID-19 pandemic.

## 6 Conclusion

The findings of this systematic review clearly show that there has been great growth in the use of technology in music therapy in the last 10 years, but this has been focused on technology as a complement to carrying out music therapy sessions or using technology systems to facilitate musical production. However, there is growing the number of studies focused on finding more accurate solutions for data collection and assessment in music therapy through technology.

A special growth is registered in 2022 and it seems that music therapy data collection and assessment technology could have more development soon. The advent of artificial intelligence and the consequences of the COVID-19 pandemic may have motivated this increase, but this study suggests that the research in this context is insufficient for this moment, so it is necessary to continue looking for technological tools for data collection and assessment in music therapy to ensure the quality and achieve a standardized process in the future.

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