

Music Therapy and Musical Stimulation in Preterm Infants in Neonatal Intensive Care Units

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Abstract

Every year, more than 15 million preterm infants are born of which a significant number is admitted to the Neonatal Intensive Care Unit. The combination of a critical period in neurocognitive development, parental isolation and a hostile environment makes these patients particularly vulnerable to various cognitive, motor, linguistic, behavioral and socio-economic disabilities. Therefore, music therapy is proposed as a non-invasive alternative to improve variables related to nutrition, pain and stress response, the physiological parameters of the newborn and breastfeeding.

Keywords: music, sound, preterm birth, neonatal intensive care unit, non-invasive, review.

1. Introduction

A preterm infant is baby born before the 37th week of gestation (1). Every year, more than 15 million preterm infants are born, which amounts to 1 in 10 births. Despite technological improvements increasing the survival of these infants, the rate of preterm births is rising on a worldwide scale (2). Preterm birth can affect the cognitive, motor, linguistic, behavioral and socio-economic development of the infant, as well as the family's mental health, especially that of the mother (3). A significant number of these infants requires intensive care to survive outside the intrauterine environment and, therefore, the Neonatal Intensive Care Unit (NICU) becomes the source of their first stimuli.

These units are characterized by parental isolation and the high number of invasive procedures (and thus painful and stressful) to which patients are subjected (4). These events occur during a period of early brain development, characterized by the formation of synaptic connections, the development of dendritic spines, axonal myelination and neocortical folding (5,6).

Several studies suggest the system of preterm infants possesses both the anatomical and neurochemical capabilities of pain perception (4), so those admitted to the NICU appear to be a particularly susceptible group for the potential disruption of these neurodevelopmental milestones. Furthermo-

re, the stress response is activated by means of the hypothalamus-pituitary-adrenal axis and the sympathetic system, which determine physiological responses to the fight-or-flight response. These responses include an increase in heart and respiratory rates and an increase in cortisol. The implementation of these responses diverts energy resources from the forming nervous system (6).

2. Preterm infant nutrition

In terms of feeding, it has been observed that music therapy (MT) helps preterm infants in the NICU to gradually substitute intravenous feeding with oral feeding. The use of a music player with songs sung by the mother significantly favors oral feeding. It was found that 94% of the infants stimulated with a music player with mother's voice recordings were successfully fed orally at least 7 days earlier than those who were given a standard tranquilizer or listened to the mother's voice only occasionally.

There were no significant differences regarding weight gain between the intervention and control groups. It should be noted that other studies suggest that oral stimulation has better results in improving oral feeding in preterm infants than the auditory stimulation (with lullabies). However, preterm infants who had auditory stimulation improved more than those in the control group, who had no intervention except for routine care (11). The differences between these groups were significant,

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finding that the group that received oral stimulation reached full oral feeding in a shorter period of time than those who received the auditory stimulation.

Finally, infants in the control group who had no intervention took longer to reach full oral feeding. Based on these data, differences in the suction capacity of the different groups were also found. This capacity was associated with the improvement of the oral feeding.

In some reviews, differences in the results obtained were considered depending on whether infants were exposed to live or recorded music. It is suggested that both types of MT improve the suction capacity of the premature infants and the time required to achieve full oral feeding (3). Other studies suggest that live music helps the premature infant to sleep more deeply than recorded music (12). The type of music also influences the amount of improvement. It has been observed that lullabies help improve oral feeding and increase the daily caloric intake of the infant. Additionally, the use of music players with songs sung by the mother significantly improves oral feeding when compared to other MS methods (13).

Figure 1 outlines the most representative findings of MT and MS on preterm neonatal nutrition.

3. Pain and stress response

Preterm infants, mainly those who are admitted to the NICU, are usually in a stressful and over-stimulating environment during their hospital stay. Furthermore, they are exposed to numerous painful procedures, both diagnostic and therapeutic. All this has adverse consequences for their neurological development and pain perception system, as well as negative physiological alterations (6, 14-15). The negative effects of some analgesics, their misuse, and the (sometimes excessive) duration of their effects make non-pharmacological methods such as MT a widely used alternative (16).

Although many studies have been conducted on the effects of MT on newborns and preterm infants, these tend to focus on behavior and stimulation for development. Few studies investigate the response to pain (14) and stress, although some of them consider parameters related to both. In some randomized controlled trials, all referring to the newborn blood spot test, a decrease in respiratory rate (RR) and pain measured in the Neonatal Infant Pain Scale (NIPS) and Neonatal Facial Coding System (NFCS). An increase in transcutaneous partial pressure of oxygen (TcPO₂) and significant effects on behavior were also observed. Infants older than 31 weeks benefited the most from this, especially

right after the procedure (17). According to some authors, this could be due to their greater development, which allows for a better response to musical stimulation (14).

Regarding the type and form of application of the music, only recordings have been studied, these being classical music, intrauterine maternal pulse rates with relaxing music and lullabies, including Pacifier Activated Lullaby (PAL). Classical music had no significant positive results, nor did it managed to improve the benefits of breastfeeding. Likewise, PAL had no effect on pain, but on stress and behavior. Lullabies are recommended due to small variations in their melody, and so is live music. There are no comparable results for music volume, although some NICU recommendations on noise can be followed, such as not exceeding 45dB. It has also been suggested that joint implementation with other non-pharmacological methods, such as sucrose or non-nutritive sucking, could have greater positive effects than the application of MT alone, with the exception of breastfeeding (as mentioned above).

In conclusion, MT could have beneficial effects in the management of procedural pain in preterm infants in the NICU. However, there are very few studies on this subject, with little sample and very heterogeneous variables as to establish concrete practical indications to that effect. In relation to stress, although improvements in physiological parameters have been observed, it would be necessary to conduct further studies with objective measures of the activation of the hypothalamus-pituitary-adrenal axis (6).

4. Physiological parameters

Several studies conducted in different parts of the world (including Spain), demonstrate the impact of MT on the physiological parameters of those born prematurely. In this section, multiple studies conducted with different sample sizes will be discussed. In the first case, MT produced beneficial physiological outcomes for 8 of the 12 preterm infants treated. After, individual evaluation, the following conclusions were drawn:

- In 3 cases, music is confirmed to improve short-term heart rate (HR) and oxygen saturation (SpO₂).
- In 5 cases, classical music was used, Mozart being the most effective. The response to recordings of the mother's voice was also evaluated, obtaining an improvement of SpO₂ levels in 2 infants (13).

In the systematic review written by Van der Heijden et al. (18), 20 studies were reviewed, in which different categories of results were assessed. Of these, 14 evaluated the effect of MT and MS on HR, RF, SpO₂ and cortisol levels. They found that in 7 of the 12 cases in which recorded music was used, there were no significant differences. Nevertheless, among the remaining cases, significant differences were observed. These were:

- An increase in SpO₂.
- A decrease in HR and RR during and after MT.

Lastly, in four studies which measure the effect of live music, the reviewers concluded that significant differences could be observed in just two studies in terms of HR reduction.

Another study analyzed different parameters in newborns in two Spanish hospitals. Those parameters were measured before and after a 20-minute intervention of relaxing music three times a day, for three consecutive days. This study concluded that the use of relaxing music improves physiological parameters during hospitalization without any negative effects. The intervention group showed obtained improvement in HR and RR, with no significant changes in SpO₂ and blood pressure (19). Similarly, various studies point to improvements in the physiological parameters of newborns treated with MT. One of these studies specifies that MT reduced infants' RR by 3.91 breaths per minute. The result of HR was not significant – however, the authors attributed this result to the high volume of the recordings used (20).

In conclusion, all studies show an overall improvement of HR and RR, as well as an increase in SpO₂ after MT and MS interventions in hospitalized newborns (3). Figure 1 shows the most relevant findings of this meta-analysis.

5. Breastfeeding

Breastfeeding is beneficial for newborns as it provides them with all the nutrients they need during their first months of life. It contains the optimal amount of carbohydrates, proteins, fats, minerals, vitamins, digestive enzymes, hormones and antibodies. Thus, breastfeeding is important in preterm infants, as they are more immature due to a shorter gestation period and are at risk of suffering from different illnesses. Furthermore, preterm infants in the NICU require a higher quality nutritional intake than term infants. For this reason, their mothers need to be in the best conditions to breastfeed them. Nonetheless, mothers in the NICU experience high levels of stress and face physiological difficulties derived from an incomplete development of their

breastfeeding mechanism. All this reduces the quality and quantity of the mother's milk.

Health services should take measures to improve breastfeeding, such as the use of MT. This therapy helps reduce stress during breastfeeding sessions, improving the volume and fat content of breast milk. However, there is no evidence that it affects oxytocin levels (21).

On the other hand, it has been proved that MT lowers cortisol levels, which is a stress marker. It also decreases RR, arterial pressure, while changing fingertip temperature and perceived relaxation (22-23). Moreover, relaxation techniques that use images of the newborns improve the mother's secretory activity, in addition to being a non-invasive procedure (21). MT constitutes one of the most accessible therapies as it can be being after discharge at a low cost. The choice of the music by the mothers, together with their involvement in music-based activities, has also revealed an improvement in milk production. At the same time, combining MT with yoga, progressive muscle relaxation, or guided imagery has given a better result in reducing maternal stress thus favorably affecting breastfeeding (21, 23-24).

In conclusion, as indicated in Figures 2 and 3 and Tables 1 and 2, breastfeeding provides physical and psychological benefits to both the mother and the infant (especially for preterms). Therefore, it is not only important to encourage breastfeeding through health education, but to provide activities and interventions like MT. This may help reduce maternal stress, improving the volume and quality of milk and strengthening the mother-child in such delicate situations as the newborn's admission to the NICU.

6. Conclusion

The purpose of this review was to examine the results published to date on MT and MS, and their impact on the health of preterm infants and breastfeeding in the NICU. Most studies and reviews seem to indicate that both MT and MS have positive effects on pain, stress, breastfeeding and physiological parameters. However, due to the great heterogeneity of interventions, methodology, data analysis and evaluation of the results, as well as the lack of a consistent and long-term follow-up, these results must be interpreted with caution. Likewise, it has been observed that MT and MS can be used together with other procedures and relaxation techniques. Future investigations may explore the efficiency of combined interventions. Regardless of the clinical significance of these therapies, their harmlessness and low cost make them an innovative strategy to improve the quality of infants admitted to the NICU infant and their families. Their admis-

sion of preterm infants to the NICU represents a critical situation that demands the best possible care and the most rigorous scientific work.

Conflicts of interest statement

The authors declare that there are no conflicts of interest in this article.

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Annex I: Tables

Table I: Effect of the MT and MS over breastfeeding parameters

| | Oxytocin levels | Perceived relaxation of the infant | Fat content | Caloric content | Volume of milk | Frequency of feedings |
|-----------------|-----------------|------------------------------------|-------------|-----------------|----------------|-----------------------|
| Keith y col. | - | - | ↑ | = | ↑ | ↑ |
| Jayamala y col. | - | - | - | - | ↑ | ↑ |
| Yu y col. | - | ↑ | - | - | - | ↑ |
| Vianna y col. | - | - | - | - | - | ↑ |

This table sums up the findings and the relevant effects in breastfeeding parameters of the four manuscripts revised for this publication

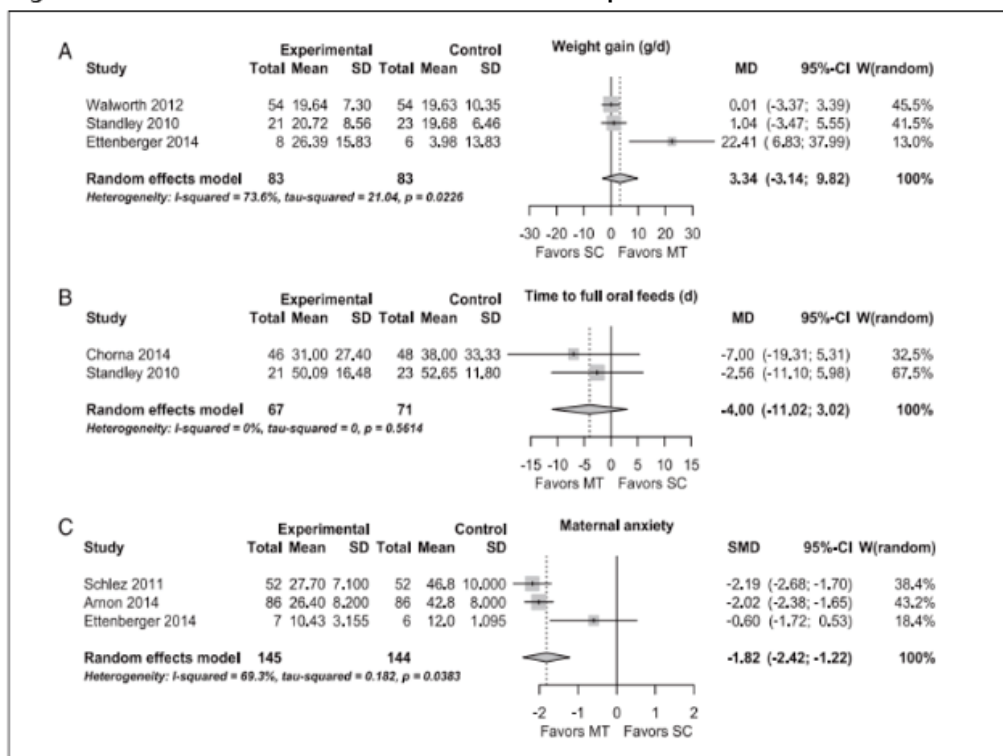
Table II: Comparison of the volume of milk in mL with or without MT

| Parameters | Without MT | With MT | P-Value |
|------------|------------|---------|---------|
| First day | 6.56 | 7.04 | 0.024 |
| Second day | 6.26 | 6.71 | 0.001 |
| Third day | 6.55 | 6.85 | 0.0001 |
| Fourth day | 7.34 | 7.86 | 0.0001 |

Taken from Jamala et al. (2015).

Annex II: Figures

Figure I: Short-term effect of MT in infants and parents with 95% CI



Taken from Bieleninik et al. (2016)

Figure II: Effects of auditory approach (MT and MS) in nutrition parameters

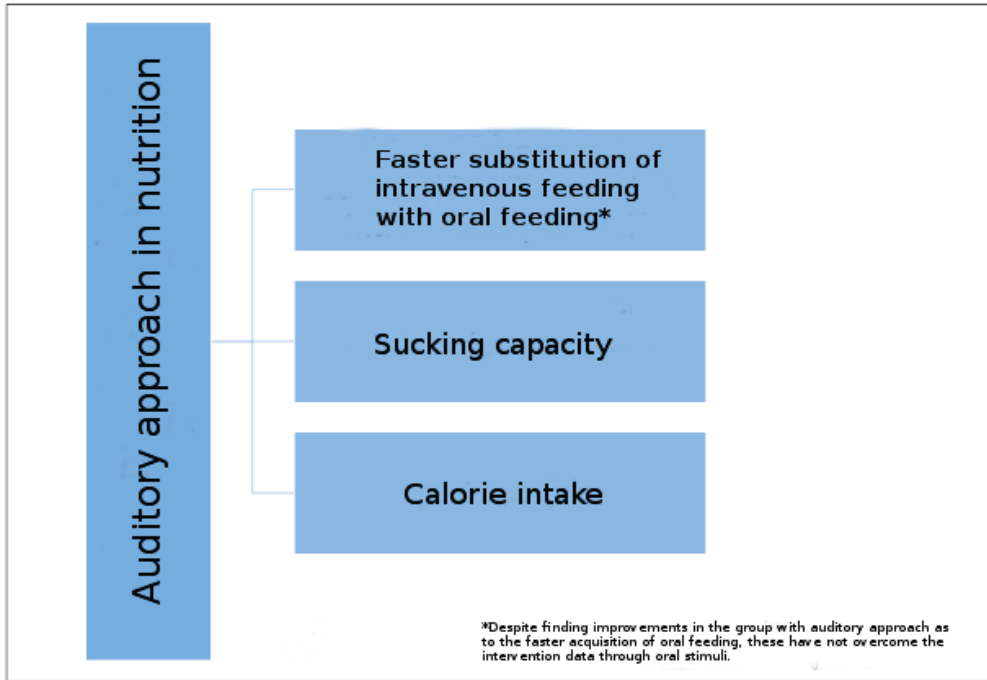
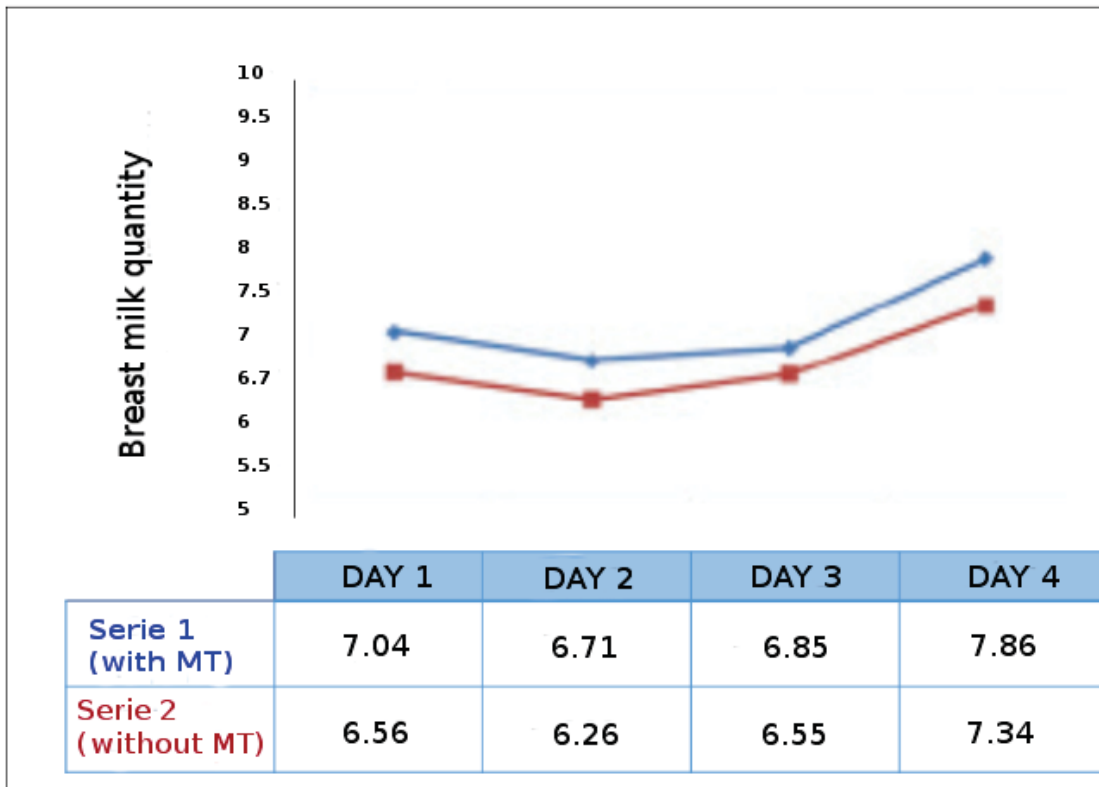


Figure III: Comparison between breast milk quantity expressed in mL with or without MT



Taken from Jayamala et al. (2015)