Effect of Music by Mozart on Energy Expenditure in Growing Preterm Infants

WHAT'S KNOWN ON THIS SUBJECT: Music has been shown to reduce stress, decrease heart rate and salivary cortisol, and increase oxygen saturation, nonnutritive sucking rate, and even weight gain in preterm infants.

WHAT THIS STUDY ADDS: Exposure to Mozart music significantly lowers REE in healthy preterm infants.

abstract

OBJECTIVE: The rate of weight gain in preterm infants who are exposed to music seems to improve. A potential mechanism could be increased metabolic efficiency; therefore, we conducted this study to test the hypothesis that music by Mozart reduces resting energy expenditure (REE) in growing healthy preterm infants.

DESIGN. A prospective, randomized clinical trial with crossover was conducted in 20 healthy, appropriate-weight-for-gestational-age, gavage-fed preterm infants. Infants were randomly assigned to be exposed to a 30-minute period of Mozart music or no music on 2 consecutive days. Metabolic measurements were performed by indirect calorimetry.

RESULTS: REE was similar during the first 10-minute period of both randomization groups. During the next 10-minute period, infants who were exposed to music had a significantly lower REE than when not exposed to music ($P = .028$). This was also true during the third 10-minute period ($P = .03$). Thus, on average, the effect size of music on REE is a reduction of ~10% to 13% from baseline, an effect obtained within 10 to 30 minutes.

CONCLUSIONS: Exposure to Mozart music significantly lowers REE in healthy preterm infants. We speculate that this effect of music on REE might explain, in part, the improved weight gain that results from this "Mozart effect." *Pediatrics* 2010;125:e24–e28

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KEY WORDS

metabolic rate, music, preterm infants, energy expenditure

ABBREVIATION

REE—resting energy expenditure

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Rauscher et al[1] found that a group of 36 college undergraduates improved their spatial-temporal intelligence after listening to 10 minutes of a Mozart sonata. The findings, which were later labeled "the Mozart effect," refer to an enhancement of performance or a change in neurophysiologic activity associated with listening to music.[2,3] This effect is not exclusive to adults, and music has been shown to reduce stress even in preterm infants.[3–6] In this group of patients, music decreased heart rate, salivary cortisol, and distress behavior and increased oxygen saturation, nonnutritive sucking rate, and even weight gain, thereby decreasing the length of their hospital stay.[3–6]

The mechanism of this effect of music on the rate of weight gain is unknown. One potential mechanism is that of increased metabolic efficiency; therefore, we conducted this randomized, prospective clinical trial with crossover to test the hypothesis that music by Mozart reduces resting energy expenditure (REE) in growing healthy preterm infants.

METHODS

Patients

The study was conducted in the NICU at the Lis Maternity Hospital, Tel Aviv Medical Center (Tel Aviv, Israel). We aimed to study healthy, growing, appropriate-weight-for-gestational-age, gavage-fed infants at the postmenstrual age of 30 to 37 weeks. Postmenstrual age was calculated in completed weeks on the basis of last menstrual period, consistent ±1 week with early, first-trimester ultrasound examination. All infants were clinically and thermally stable while cared for in a skin servo-controlled incubator. At the time of the study, they all were tolerating full enteral feeding (150–160 mL/kg weight per day) without significant gastric residuals (<5% of total feed), were growing steadily, and had no electrolyte imbalance. None had any significant complication of prematurity, such as intracranial hemorrhage (of any grade), periventricular leukomalacia, necrotizing enterocolitis, supplemental oxygen requirements by 28 days of age or by 36 weeks of postmenstrual age and at least 1 week before measurement, active infection, patent ductus arteriosus, or episodes of apnea of prematurity. They all were free of congenital anomalies or dysmorphism. According to our feeding protocol, infants were uniformly fed (by gravity drainage) every 3 hours bolus feeds of their mother's breast milk or a preterm infant formula. We verified after discharge that all infants who were recruited in this study had normal brainstem auditory responses (a routine procedure in all infants who are discharged from our NICU). The study was approved by the local institutional review board, and written informed consent was obtained from both parents of each infant.

Design

This study was a prospective, randomized trial with crossover of the effect of music (compared with no music) on REE. The sequence in which exposure was given (music first followed by no music or the opposite) was selected by randomization, by using random numbers. Each infant was studied on 2 consecutive days. We tested only the music of Mozart present on the Baby Mozart CD (Baby Smart, Rehovot, Israel), which was played on a mini-CD device at a volume of 65 to 70 dB. Before the study, the CD system was calibrated according to the American Academy of Pediatrics recommendations[7] not to exceed volume of 75 dB and to maintain background noise near the infant's ear <45 dB. According to this acoustic measurement, speakers were placed inside the incubator at a distance of 30 cm from the infants' ears. In both measurements, the environment was controlled to minimize possible unwanted noises and maintain noise constancy. The monitor alarms were kept silent (visual alarm only), and the ward's doors were closed to minimize outside noise. Music was initiated 10 minutes before the beginning of the metabolic measurements and was continued for the 30 minutes of REE recording. The same procedure was applied during the no-music exposure period. Importantly, no music was heard by the infants during the whole study period except for the 30 minutes of exposure related to the study.

Metabolic studies were conducted while the infants were prone and asleep and at the same time of the day (noon time) for all infants, starting 1 hour after the completion of the last feed. The same type (breast milk versus formula) and amount of food was given to the infants on both study days. Measurements were stopped during body movements (<5% of the time of measurement). During the metabolic study, infants were cared for in their own, convective incubator. Air temperature inside the incubator was skin servocontrolled to keep temperature over the back at 37°C. Thus, the 2 energy expenditure measurements were made in nearly identical thermal environments.

Measurements

Metabolic measurements were performed by indirect calorimetry, by using the Deltatrac II Metabolic monitor (Datex-Ohmeda, Helsinki, Finland). This instrument uses the principle of the open-circuit system that allows continuous measurements of oxygen consumption and carbon dioxide production using a constant flow generator. The measurement ranges for both oxygen consumption and carbon dioxide production of 5 to 2000 mL/min allow measurements in preterm infants with small tidal volumes. Before the mea-

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surement, the device performs a self-calibration that is based on independently measured barometric pressure. In addition, periodic testing for accuracy was performed by alcohol burning according to the manufacturer's instructions. This method is safe and allows prolonged measurements while allowing reasonable access to the infant for routine care. Validation studies have shown the technique to give results equivalent to direct measurements.[8,9] In our hands, the instrument has an intra-assay coefficient of variation of 3%. For controlling for interobserver variation, all measurements were performed by a single investigator (Dr Lubetzky).

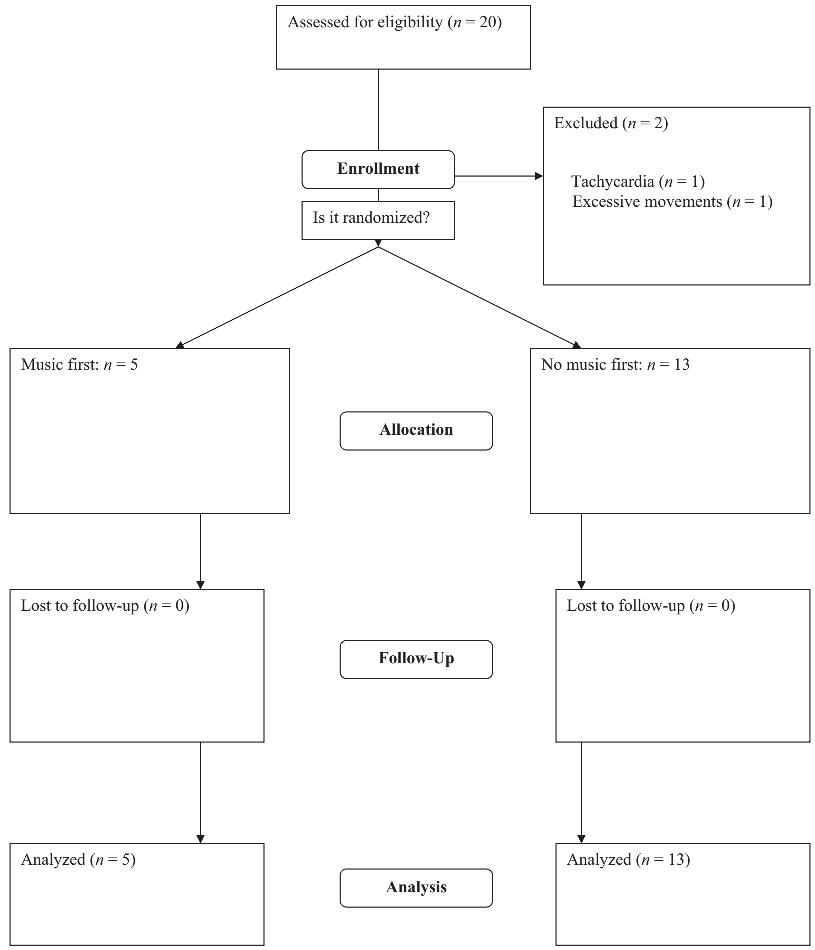

FIGURE 1
Cohort flowchart.

Statistical Analysis

This study is a pilot study that was designed to estimate the effect size of music on REE. Thus, an empirical number of 20 infants (ie, 40 measurements) was chosen. Comparison of energy expenditure values between groups was performed by using paired *t* test. For this purpose, REE results (recorded every minute by the instrument) were averaged over the first, second, and third 10-minute periods of the consecutive 30-minute total study time, whether it was a music or no-music exposure period. Results are expressed as means ± SD; $P \leq .05$ was considered significant.

RESULTS

Twenty preterm infants were recruited to the study (Fig 1). One of them was excluded because of tachycardia before the beginning of the measurement. Another 1 was excluded because of excessive body movements during the second measurement. The excessive movements of the infant were observed during the no-music session and thus could not have been an adverse effect of music.

Characteristics of the study infants are listed in Table 1 and describe their gender, birth weight, gestational age, Apgar scores, weight, and chronological age at the time of the study, as well as major medications given or procedures undertaken. Of note, 8 of 18 infants received caffeine for a history of previous apneas of prematurity but did not have any active apneas, and there were no changes in drug dosage during both periods of the study. By randomization, 5 of 18 infants were first studied during the music period.

Table 2 depicts the results of REE measurements. REE was similar during the first 10-minute period of both randomization groups. During the next 10-minute period, infants who were exposed to music had a significantly lower REE than when not exposed to music ($P = .028$). This was also true during the third 10-minute period ($P = .03$). Thus, on average, the effect size of music on REE is a reduction of ∼10% to 13% from baseline, an effect obtained within 10 to 30 minutes. When multiple regression analysis was used, the effect of music on REE remained significant, even after we introduced the caffeine intake as a potential confounder.

DISCUSSION

As hypothesized, we found in this pilot randomized clinical trial with crossover of music versus no music exposure that within 10 minutes of listening to Mozart music, healthy infants studied at a postmenstrual age of 30 to 37 weeks had a 10% to 13% reduction of their REE. In our study, this effect

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TABLE 1 Demographic and Clinical Characteristics

Characteristic	Value
Maternal age, y	
Mean ± SD	32.5 ± 3.96
Range	26–39
Gravidity, median (range)	2 (1–9)
Parity, median (range)	2 (1–2)
Prenatal steroids (Celestone), *n* (%)	16 (88.9)
Gender of infants (male/female)	6:12
Gestational age, wk	
Mean ± SD	29.3 ± 2.2
Range	26–35
Birth weight, g	
Mean ± SD	1115.2 ± 254.0
Range	726–1601
Apgar score at 1 min, median (range)	8 (1–9)
Apgar score at 5 min, median (range)	9 (4–10)
HFOV duration, median (range), d	0.7 (0.0–4.0)
CPAP duration, median (range), d	2.2 (0.0–11.0)
Erythropoietin treatment, *n* (%)	9 (50)
Caffeine treatment, *n* (%)	8 (44.4)
Chronological gestational age, wk	
Mean ± SD	33.00 ± 1.72
Range	30–37
Chronological age, d	
Mean ± SD	30.4 ± 14.1
Range	5–51

HFOV indicates high-frequency oscillatory ventilation; CPAP, continuous positive airway pressure.

lasted as long as the music was heard (ie, up to 30 minutes of the study). Based upon the fact that infants who had been first randomly assigned to the music period and were studied the following day for 30 minutes of no music had at baseline an REE very similar to that of the first 10 minutes of the music period probably means that the effect of music that we observed is not long lasting and is no longer present 24 hours after music is stopped.

The clinical implications of our findings belong to the field of speculation. Indeed, whether reduced EE induced by exposure to music leads to better metabolic efficiency and is the basis for enhanced growth rates is unclear. Previous studies found that preterm infants who were exposed to music had enhanced growth that may even have led to a decrease in their length of hospital stay.[3–6] There are many mechanisms that may lead to increased rate of weight gain; 1 of them could be an increase in appetite. Previous studies were performed of children who were fed by mouth; therefore, the effect on weight gain through an increase in appetite or efficiency of the suck-swallow mechanism may have been possible.[3,5] No studies have been performed to verify whether music may improve nutrient absorption through a hormonally driven mechanism. From our study, it is tempting to speculate that decreased REE leads to increased metabolic efficiency and thus to improved weight gain; however, our study is a pilot study in nature, limited to a very short period of 30 minutes, and reflects only REE, a component of but not all of total energy expenditure.

Other legitimate questions can be asked. The first is that whether the effect that we observed is a music effect or a "Mozart effect." In a study of adults that analyzed the effect of music by Mozart, Hayden, Liszt, Bach, Chopin, Beethoven, and Wagner, Hughes[2,10] found that Mozart's music continued to score significantly higher on reduction of seizure activity than the selections from the other 6 composers. This Mozart effect may be related to long-term periodicity, namely the repetition of the melody. It seems that Mozart repeats the melodic line much more frequently than other widely known composers. This has led Hughes to state that "the super organization of the cerebral cortex resonates with great organization found in Mozart's music."[10] If this statement is accurate, then it would be fascinating to assess whether such organization also exists in the immature brains of preterm infants.

Another important question is whether music may be considered a legitimate therapy for preterm infants. Beyond the issues of survival of extremely low birth weight infants, neonatologists and pediatric neurologists are now more concerned by the potential for long-term disabilities. Indeed, preterm birth disrupts the developmental progression of brain structures and affects the development of the sensory systems. There is a concern that the unfavorable environment of the NICU may compound this morbidity. Modification of the environment could minimize the iatrogenic effects.[11] Suggested interventions include elements such as control of external stimuli (vestibular, auditory, visual, tactile), clustering of nursery care activities, and positioning or swaddling of the preterm infant.[12] Individual strategies have also been combined to form programs such as the Newborn Individualized Developmental Care and Assessment Program (NIDCAP).[11–13] Future studies are essential to determine whether music will take its place in the NICU environment and be part of evidence-based strategies to improve outcome of preterm infants.

It is interesting that by using the same apparatus, Carlsson et al[14] found no effect of music on REE in obese adults. We have no explanation for their differing results, but Carlsson et al used music by Satie, Bach, Bartok, Stravinsky, and Henze; their patients all were ex-

TABLE 2 REE Measurements

Parameter	REE With Music, Mean ± SD, kcal/kg per d	REE Without Music, Mean ± SD, kcal/kg per d	*P*
Beginning (0–10 min)	53.15 ± 11.66	56.58 ± 17.48	.310
Middle (10–20 min)	57.08 ± 7.38	61.59 ± 9.38	.028
End (20–30 min)	53.89 ± 8.12	61.44 ± 13.07	.030

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posed to silence first (no crossover), and their dietary intake was not controlled.

CONCLUSIONS

Exposure to Mozart music significantly lowers REE in healthy preterm infants. We speculate that this effect of music on REE might explain, in part, the improved weight gain that results from this Mozart effect.

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