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ORIGINAL ARTICLE

Bach music in preterm infants: no 'Mozart effect' on resting energy expenditure

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OBJECTIVE: To study whether Johan Sebastian Bach music has a lowering effect on resting energy expenditure (REE) similar to that of Wolfgang Amadeus Mozart music.

STUDY DESIGN: Prospective, randomized clinical trial with cross-over in 12 healthy, appropriate weights for gestational age (GA), gavage fed, metabolically stable, preterm infants. Infants were randomized to a 30-min period of either Mozart or Bach music or no music over 3 consecutive days. REE was measured every minute by indirect calorimetry.

RESULT: Three REE measurements were performed in each of 12 infants at age 20 ± 15.8 days. Mean GA was 30.17 ± 2.44 weeks and mean birthweight was 1246 ± 239 g. REE was similar during the first 10-min of all three randomization periods. During the next 10-min period, infants exposed to music by Mozart had a trend toward lower REE than when not exposed to music. This trend became significant during the third 10-min period. In contrast, music by Bach or no music did not affect significantly REE during the whole study. On average, the effect size of Mozart music upon REE was a reduction of 7.7% from baseline.

CONCLUSION: Mozart music significantly lowers REE in preterm infants, whereas Bach music has no similar effect. We speculate that 'Mozart effect' must be taken into account when incorporating music in the therapy of preterm infants, as not all types of music may have similar effects upon REE and growth.

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INTRODUCTION

In a recent study, we showed that exposure to Mozart music significantly lowers resting energy expenditure (REE) in healthy preterm infants.[1] Whether this finding is related to music *per se* or to music by Mozart is unknown. Many studies have described the positive effect of music by Mozart on the human's brain, an effect known as the 'Mozart effect' that relates to multiple outcomes such as a temporary enhancement in the neuro-developmental performance[2–4] or a reduction in epileptiform activity in patients with seizures.[3,4]

We conducted the current study to test the hypothesis that music by Bach, who wrote in a different musical style, has an effect on REE in preterm infants similar to that of Mozart music.

MATERIALS AND METHODS

Patients

The study was conducted in the NICU at the Lis maternity hospital, Tel-Aviv Sourasky Medical Center. Preterm infants at post menstrual age of 30–37 weeks who were appropriate for gestational age (GA), clinically and thermally stable, gavage-fed, were eligible for recruitment. At the time of the study they were all tolerating full enteral feeding (150 to 160 cc per kg weight per day) without significant gastric residuals (<5% of total feed), they were all growing steadily, and had no electrolyte imbalance. All infants who were recruited successfully passed a hearing screening test before discharge (otoacoustic emission and automated auditory brainstem response). We excluded infants with significant complications of prematurity, such as intraventricular hemorrhage, periventricular leucomalacia, necrotizing enterocolitis, active apneas of prematurity, patent ductus arteriosus, active infection, electrolyte imbalance and major congenital anomalies. The study was approved by the local institutional review board and written informed consent was obtained from both parents of the infant.

Design

The study was a prospective randomized clinical trial with crossover, which compared the effect of Bach music, Mozart music and no music on REE. The sequence by which Bach, Mozart or no music were administered (over 3 consecutive days) was determined by randomization using random numbers. Infants listened to Bach or Mozart using the compact discs entitled 'Baby Bach' and 'Baby Mozart' (Baby smart, Nir Zvi, Israel). The music was played using a music player at a volume of 65 to 70 dB with attached speakers, which were placed at a distance of 30 cm from the infant's ears. According to the American Academy of Pediatrics recommendations:[5] the volume did not exceed 75 dB and the background noise near the infant's ears was maintained below 45 dB. Music (Mozart or Bach) was initiated 10 min before the beginning of the metabolic measurements and continued for 30 min while energy expenditure (EE) was recorded. In the same manner, EE was recorded for each infant with no music therapy. During the measurements days, the infants did not listen to any other music. Music was played at the same time of the day, that is, at noon, 1 h after the end of the last meal, while the infants were prone and asleep in their own incubators with their heads facing the incubator doors. The infants received the same type and amount of food during the 3 days of

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measurements. Measurements were stopped during body movements, which did not exceed 5% of time. Vital signs (respiratory rate (RR), pulse, saturation, temperature) were constantly recorded during the measurements and the skin temperature was kept below 37 °C.

Measurements

Metabolic measurements were performed by indirect calorimetry using the Deltatrac II Metabolic monitor (DateOhmeda, Helsinki, Finland). This system consists of a hood, which is placed over the infant's head, and of two sensors. It uses the principle of an open circuit, which allows for continuous measurements of O_2 consumption and CO_2 production. The EE is calculated using the equation $5.5VO_2 + 1.76VCO_2$.[6] Before the beginning of measurements, the system performs self-calibration according to the barometric pressure measured in its area. This method is safe and enables continuous measurements while the infant is lying in his own incubator attached to monitors, with convenient access to the infant for routine care. Prior studies in preterm infants have shown this technique to be as accurate as direct calorimetry for EE measurements.[7] All measurements were performed by a single investigator (HRK) to minimize inter-observer variations. The REE was recorded every minute and an average was calculated every 10 min (a total of three averages in 30 min).

Statistical analysis

The statistical analysis was done using Minitab version 16 (Minitab Inc, State College, PA, USA). The sample size in the study was based on our previous study,[1] and assuming that we would find similar results, using a paired, single-tailed analysis, a power of 80%, a P value of <0.05, a difference in REE of 7.55 Kcal kg^{-1} day^{-1} and a s.d. of 10.6 Kcal kg^{-1} day^{-1}.[1] Continuous variables were expressed as median with range when they were not normally distributed, and were expressed as mean with standard deviation when they were normally distributed. Dichotomous variables were expressed as percent/ratio. The values of EE and of the vital signs (respiratory rate (RR) and heart rate) were compared between the groups using repeated measures analysis of variance using the no-music period as the baseline for both Bach and Mozart music periods. Results are expressed as mean with standard deviation. $P \leqslant 0.05$ was considered significant.

RESULTS

Fourteen preterm infants were recruited to the study. One infant was excluded because of neonatal jaundice and the need for phototherapy, and another infant was excluded because of fever. In both cases, the infants were excluded before the beginning of the measurements, therefore, it could not have been an adverse effect of music. In order to minimize potential environmental effects on REE, procedures that could raise REE, such as blood examinations or subcutaneous injections of erythropoietin, and other procedures those could theoretically reduce REE such as skin to skin 'kangaroo care' or listening to music other than during the study, were postponed until the end of the measurements.

Using random numbers, six infants were exposed to Bach music on day 1, three infants on day 2 and three infants on day 3. Four infants were exposed to Mozart music on day 1, four infants on day 2 and four infants on day 3; and two infants were exposed to no music on day 1, five infants on day 2 and five infants on day 3. Table 1 depicts the demographic and clinical characteristics of the participants, to the inclusion of: maternal characteristics (age, gravity, parity, prenatal steroid use) and infant's characteristics (gender, GA, birth weight, Apgar score, need for respiratory support after birth or for medications, chronological age and weight). Infants who had required support were weaned off ventilation and oxygen more than a week before the measurements and none of them had chronic lung disease of prematurity. Three of twelve infants received caffeine because of a history of apnea of prematurity but neither had active apneas nor was there a change in the medication dose during the days of the study. Four of twelve infants received erythropoietin for anemia of prematurity. During measurements we continuously monitored the infants' vital signs (pulse, respiratory rate, saturation and temperature). Vital signs were similar during the three periods. Saturation was above 95% during the whole study period in all infants, and skin temperature did not exceed 37 °C by design.

During the no music period, there was no significant change over time in REE, which was 81.67 ± 12.8 kcal kg^{-1} day^{-1} during the first 10 min, 81.06 ± 9.66 during the second 10 min and 83.39 ± 10.70 during the last 10-min period. Thus, the baseline REE without music was used as the baseline REE for the two musical periods. Table 2 depicts the REE of the infants during the Mozart and the Bach periods. There was a significant drop in REE during the Mozart period ($P = 0.041$). On average, the effect size of exposure to music by Mozart on REE was a reduction of 7.7% within 10 to 30 min. There was no significant change in REE during the Bach period ($P = 0.59$). The difference between baseline and 20 to 30 min REE after Bach music was a drop of 1.99 ± 11.64 out of 81.67 kcal kg^{-1} day^{-1} (2.4% drop). Assuming a power of 0.8 and a $P < 0.05$, we would need 213 patients in order to prove that this drop was significant. In repeated measures analysis of variance, RR and heart rate remained unaffected by the type of music and the period of observation.

DISCUSSION

In the current study, similar to our previously published one,[1] we confirmed that Mozart music has a reducing effect on REE. The effect size was also similar, in that in the current study, we found an average reduction of REE of 7.7% within 10 to 30 min, whereas in the previous one the reduction ranged 7.3 to 12.2%. This is an

Table 1. Demographic and clinical characteristics of the participants

Characteristic	
Maternal age (years)	33 ± 6.9 (21–41)
Gravidity	1 (1–7)
Parity	1 (1–5)
Prenatal steroids	8 (66.6)
Gender of infant M/F	6:6
Gestational age (weeks)	30.17 ± 2.44 (25–34)
Birth weight (g)	1246 ± 239 (745–1586)
1 min Apgar score	7 (1–9)
5 min Apgar score	8.5 ± 1.6 (4–10)
HFOV duration (days)	0 (0–3)
CPAP duration (days)	1.5 (0–9)
Oxygen treatment duration (days)	0 (0–19)
Erythropoietin treatment exposure	4 (33.3)
Caffeine treatment exposure	3 (25)
Chronological gestational age (weeks)	33.08 ± 1.5 (31–36)
Chronological age (days)	20.5 ± 15.8 (5–59)
Weight (g)	1420 ± 126.9 (1210–1631)

Abbreviations: CPAP, continuous positive airway pressure; F, female; HFOV, high-frequency oscillatory ventilation; M, male.
Data are presented as mean ± s.d. (range) or *n* (%) except for Apgar scores, gravidity and parity, which were not distributed normally and are expressed as median (range).

Table 2. Resting energy expenditure (kcal kg^{-1} day^{-1}) during the Mozart and the Bach periods

	Mozart music	*Bach music*
No music baseline	81.67 ± 12.80	81.67 ± 12.80
First 10 min	78.83 ± 9.25	79.49 ± 10.67
10–20 min	75.87 ± 10.20	79.82 ± 11.81
20–30 min	75.36 ± 10.88	79.68 ± 15.0
P	0.041[a]	0.59[a]

[a]Last period compared with baseline without music.

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important finding, as our previous study was also a small one, comprising 18 premature infants and needed additional confirmation. We had speculated that Mozart music affects REE through better metabolic efficiency.[1] Indeed, previous studies have shown that music can modulate the hypermetabolic response of the body to stress by reducing the secretion of stress hormones (cortisol, catecholamines) and pro-inflammatory cytokines and by reducing sympathetic tone.[8,9]

Contrary to our hypothesis, we found that exposure to Bach music had no significant lowering effect on REE in these healthy preterm infants. This would suggest that the effect that we observed with Mozart music is more a 'Mozart effect' than a universal 'music effect'. In support of this statement, we quote Hughes' study[4] that analyzed the effect of music by Mozart, Hayden, Liszt, Bach, Chopin, Beethoven and Wagner.[10,11] This study showed that in adults, Mozart's music scored significantly higher on reducing electro-encephalographic seizure activity than selections from the other six composers. Hughes suggested[4] that the so-called specific 'Mozart effect' was related to long-term periodicity, namely the repetition of the melody. Indeed, it seems that Mozart repeats the melodic line much more frequently than most of the above-mentioned composers.[4] However, one exception is precisely Bach. Indeed, in a study of five famous works by JS Bach compared with five famous works by WA Mozart, the long-lasting periodicity was of 16.2 s (range 10 to 35) for Bach compared with 33.6 s (range 17 to 60) for Mozart.[4] Hughes stated that 'the super organization of the cerebral cortex resonates with the great organization found in Mozart's music'. If this statement is accurate, we speculate that such a complex organization also exists in the relatively immature brains of preterm infants, and that the shorter long-lasting periodicity of Bach music is less able than Mozart music to elicit this resonance. Alternatively, it must be stated that Mozart music is mainly homophonic, in which two or more parts are moving together in harmony.[12] On the contrary, Johann Sebastian Bach music is more complex, written mainly in a contrapunctal structure, consisting of two or more independent melodic voices.[13] The 'complexity' of Bach music may not have the same soothing effect on preterm brains than the simpler (yet brilliant) music of Mozart. The international implications of our findings are puzzling. Indeed, in many cultures, Mozart or Bach music is never heard, and the type of music humans are exposed to during their intrauterine life might be strikingly different. It would be fascinating to try and reproduce our study in such infants.

In view of the fact that our study is a small one, it is possible that the drop in REE after Bach music exposure was insignificant due to type 2 error, namely, insufficient sample size. If this 2.4% drop was to be significant, it would require 213 patients to demonstrate it, a number very difficult to reach. Nevertheless, even if this drop was significant, the effect size (2.4%) is much smaller than that observed after Mozart music, that is, 7.7% in the present study, and 7.3 to 12.2% in the previous one published by us.[1]

In conclusion, we showed that exposure to Mozart music is associated with a reduction in REE in healthy, metabolically stable preterm infants within 30 min of listening. In contrast, Bach Music did not have such an effect. The exact mechanism of this 'Mozart effect' requires further investigation. We speculate that the 'Mozart effect' must be taken into account when incorporating music in the therapy of growing preterm infants, as not all types of music may have similar effects upon REE and growth.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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