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Reducing Relative Food Reinforcement in Infants by an Enriched Music Experience

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Abstract

Objective—The reinforcing value of food may be established early in life. Research shows that infant weight status is related to the relative reinforcing value of food versus non-food alternatives (food reinforcing ratio, FRR). The purpose of this pilot study was to assess the effects of a 6-week music enhancement program (Music Together®, $n = 14$) versus an active play date control group ($n = 13$) on the FRR in 9- to 16-month-old infants who were high in relative food reinforcement.

Methods—Participating parents and infants attended six weekly 45-min group classes. Parents in the music group and the play date group were encouraged to listen to the Music Together program CD or play with the play date group's toy with their infants at home, respectively.

Results—Intent-to-treat analysis showed a decrease in FRR for infants in the music group (mean ± SD: −0.13 ± 0.13) in comparison to a slight increase in the control group (0.04 ± 0.11) ($F_{[1, 24]} = 11.86$, $P = 0.002$).

Conclusions—These findings provide evidence that relative reinforcing value of food can be reduced by promoting alternative reinforcers at an early age.

Introduction

Food is a powerful primary reinforcer (1) that motivates people to eat and is one potential mechanism for weight gain and obesity (2). Food reinforcement is related to energy intake in the laboratory and predicts energy intake in the natural environment, as evidenced by food recalls (3) and food frequency questionnaires (2). The reinforcing value of food is cross-sectionally related to obesity in pre-schoolers (4), children (5), and adults (3,6), as people with obesity find food more reinforcing than people without obesity. It is also prospectively related to weight gain in children, adolescents, and adults (7–9). We have recently shown in

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two separate studies that food reinforcement develops early, and 9- to 18-month-old infants' weight status is related to the relative reinforcing value of food versus non-food alternatives (10). The high relative food reinforcement observed among the overweight infants was primarily driven not by strong motivation for food in the heavier infants, but by their low motivation to work for access to alternatives to food (10).

The relative reinforcing value of food is fundamentally a choice between food and an alternative to food, and the choice depends as much on the characteristics of the alternative as those of the food. One hypothesis from our previous works is that obesity develops in children who find food more reinforcing, in part, due to a lack of strong alternatives to food. Observational research with children (infant through age 6) suggests that the risk of overweight and obesity during adolescence is lower for those who have greater access to an enriched environment, such as availability of cognitively enhancing activities at home (11). Additionally, clinical research has shown that overweight children in a family-based behavioral treatment do better if they have access to more alternative reinforcers (12). Research with adults suggests that adults with obesity derive less pleasure from non-food activities than leaner adults (13), and access to alternatives to food is related to both short- and long-term success in adult weight loss (14). On the basis of these data, access to alternative reinforcers may serve as a protective factor against excessive eating and weight gain. The purpose of this pilot study was to assess the effects of a 6-week music enhancement program versus an active control group (play date) on food versus non-food reinforcement of infants (9–16 months) who were high in relative food reinforcement.

Methods

Participants

Families with infants aged 9–16 months were recruited using posted flyers, craigslist, Facebook, and an existing database. Infants were excluded from participation if: they were preterm (<37 weeks gestation); they had a low birth weight (<2,500 g); they had known developmental delay(s) according to maternal report; the maternal age was <18 years at the time of pregnancy; any maternal smoking or illicit substance use during pregnancy was reported; maternal alcohol use of ≥4 alcoholic drinks on a single occasion or average of >1 alcoholic drink per day; the pregnancy was a high risk pregnancy (e.g., placenta abruption, pre-eclampsia). Thus, the sample consisted of healthy infants with no current or past developmental delays. Given task demands, we also excluded infants who were not yet eating finger foods and those whose families were unwilling to participate in the 6-week intervention. A total of 46 families completed the pre-intervention assessments and 27 families met the criteria of high relative food reinforcement, defined by responding relatively more for food than music at baseline (food reinforcing ratio, FRR [Food P_{max} ÷ (Food P_{max} + Music P_{max})] ≥ 0.5) in two cohorts. A participant flow chart is provided in Figure 1.

Study design

This study is a mixed design with group as the between subject factor, and pre- and post-intervention as the within subject factor. Eligible infants were stratified by sex, age, and baseline FRR, and randomly assigned, in two cohorts, to one of two groups, a music group

(n = 14) or an active control (play date) group (n = 13). One caregiver served as participating caregiver who attended the majority of the classes and assessment visits with his/her infant (mother, n = 23; father, n = 3; grandmother, n = 1).

Procedures

The study procedures were approved by the State University of New York at Buffalo Social and Behavioral Sciences Institutional Review Board. Interested parents were screened via telephone interview or online screener, and eligible infants were scheduled for two 45 min laboratory appointments (pre-intervention assessment). Visits were scheduled during a time the parent felt the infant would be awake, alert, and willing to do the food/non-food reinforcement task. The first and second appointments were scheduled within 2 days of each other and at the same time of day, if possible, to control for alertness, hunger cues, and mood. Parents were instructed to avoid feeding their child one hour prior to the visit and to provide the infant's favorite solid food for the food portion of the task. Favorite foods used in the task included: crackers such as Goldfish® crackers or Gerber® Crunchies; cereal such as Cheerios® or puff cereal; fruit such as bananas, blueberries, strawberries, watermelon, and cantaloupe; cheese; M&Ms®, chocolate chips; and bread. As infant food preferences can change during development, parents were asked to bring the child's current favorite food to the pre- and post-intervention assessments, which may have changed during the 6-week intervention time. Upon arrival in the lab, parents were given a brief description of study protocols and completed a consent form for their infant's participation and a daily health condition survey. While parents were completing these forms, researchers interacted with the infants by playing with toys and reading books with them to establish a relationship to facilitate completion of the food and music reinforcing value computer task. Following the second pre-intervention appointment, research staff measured the height and weight of the parent and infant.

After the 6-week intervention, 2 post-intervention lab appointments were scheduled within 2 weeks from the last day of the intervention and within 2 days of each other, if possible. When possible, the same research staff ran appointments to maintain familiarity with staff, especially the experimenter who delivered the reinforcers to the infants. Following the second post-intervention appointment, research staff again measured the height and weight of the parent and infant. Parents were debriefed and received compensation for their participation.

Intervention

The 6-week music intervention, the Music Together® program, was designed in collaboration with a local music studio, Betty's Music Together. This program introduced infants to the pleasures of music making with their parents rather than passively receiving it from CDs or TV. This program provided a rich variety of music and playful activities, which encouraged infants and parents to participate at their own level in singing, moving, listening, or exploring musical instruments. Participating parents and infants attended weekly, 45-min classes as a group for 6 weeks. Besides attending classes, parents were encouraged to listen and sing together with their infants at home during everyday home activities such as bath

time, meal time, and bed time using the CD and instructional song book provided by the program.

The active control group consisted of weekly, 45-min play dates held during the same 6 weeks as the music group. We provided a variety of age appropriate toys (no musical toys) and books for participating parents and infants to play with and enjoy. Families in the play date group received a toy, Baby's First Blocks (Fisher-Price®, East Aurora, NY) to take home. Parents were encouraged to play with their child at home during everyday home activities such as bath time, meal time, and bed time using the toy provided by the program.

Parents in both groups were advised to attend all classes, with an opportunity to attend one makeup session. In addition, components of ecological momentary intervention (EMI) were used to foster at-home engagement by prompting the parents to sing songs or play with the play date toy with their child daily, and requesting responses by filling out the daily home practice survey when music or play time was completed. Each day, each family received one text in the morning to encourage them to sing songs or play with the play date toy with their child. In the evening, each family was prompted to fill out the daily home practice survey and was reminded again to either sing songs or play with the play date toy with their child. Later in the night, each family received a text reminding them to fill out the daily home practice survey. Families that filled out at least five of the daily home practice surveys and attended that week's class or play date were entered into a drawing for a $5 gift card to a local grocery store or coffee shop each week.

Measures

Food/non-food reinforcement task—The reinforcing value of food and music was assessed using a computerized task by having infants press a mouse button to earn rewards. Figure 2 demonstrates the experimental set up of present study. Infants worked for access to the two rewards sequentially during two different laboratory visit days, one reward on each day, counterbalanced between participants. Developmentally appropriate modifications were made to the station setup and schedule of the food/non-food reinforcement task for infants 9–16 months to obtain a reinforcing value measure (10). During the task, the infant was placed in a high chair ($n = 24$) or on the parent's lap ($n = 2$), depending on the infants' comfort level and parents' request. The infants' placement was kept consistent between these two appointments, and between pre- and post-intervention assessments. The parents were seated next to their infant if the infant was placed in a high chair. Parents were allowed to be present during the task to avoid the separation anxiety and anxiety around strangers experienced by infants in this age group. Research staff directed the infant's attention to a mouse button, the response manipulandum. Infants received a short training (up to 10 min in length) to learn and adapt to the task. Throughout the experiment, researchers remained neutral in their instructions to the infants and only used scripted cue phrases. Praise was given by the researcher after the infants pressed the button during all trials for all reinforcers (e.g., "that's right," "good job"). The parents were instructed to only use the scripted phrases or phrases used by the researcher during the computer task.

The computer task used progressive fixed-ratio (FR) schedules, and a reward was presented after a predetermined number of responses were given by the infants. The schedules of

reinforcement began by requiring one button press (one response, FR1) to earn a reward, and increased linearly up to a maximum of FR15 responses (i.e., 1,1,2,2,3,3,. . .,15,15). The reinforcing value of food or music was assessed over two separate days to avoid infants' fatigue and short attention span. When food was earned during the task, the researcher placed a piece (approximately 1 cm × 1 cm × 1 cm) of the infant's favorite solid food in front of the infant. Infants were provided the opportunity to consume their food as it was earned. When music was earned, research staff played the song "Singin' Everyday" [by Kenneth K. Guilmartin, based on a South African melody (Music Together, LLC/ASCAP) © 2000] for approximately 10 sec while simultaneously playing musical instruments. The song used for both pre- and post-intervention assessments was not used in the 6-week music program to avoid familiarity and biases. The infant continued to play the task, and earn rewards, until he or she gave signs of wanting to stop (e.g., crying, signing "all done," saying "all done," head turning away, etc.); the parent was asked to confirm the infant's cues.

Reinforcing values of food and music were determined based on the maximum schedule achieved for the favorite food (Food P_{max}) and the non-food alternative, music (Music P_{max}). FRR of infants' favorite food was calculated as the proportion of food responses in comparison to the total responses [e.g., Food P_{max} ÷ (Food P_{max} + Music P_{max})].

Anthropometrics—A calibrated digital weight scale was used to measure participating parents' weights, measured to the nearest 0.1 kg (Tanita, Arlington Heights, IL). A calibrated stadiometer was used to measure participating parents' heights, measured to the nearest 0.01 cm (SECA, Hamburg, Germany). Using the measured height and weights, parent's body mass indexes (BMI) (kg/m^2) were calculated. To measure the infants' lengths, infants were placed in a supine position on an infantometer (SECA, Hamburg, Germany). A calibrated scale was used to measure the infants' weights, measured to the nearest 0.001 kg (SECA, Hamburg, Germany). The World Health Organization (WHO) infant growth chart was used to calculate the infants' weight for length *z*-score, weight for age *z*-score, and length for age *z*-score.

Questionnaires: Demographics and daily home practice—Demographics and socioeconomic status were assessed using a standardized questionnaire. Data were collected on age, educational attainment, race, ethnicity, household income, employment, and marital status. Parents filled out daily home practice surveys for the duration of the intervention. Parents were asked to report how often they listened to the Music Together CD or played with the provided play date toy (none, 1, 2, 3, 4, or >4 times), and if they listened to the CD or played with the provided play date toy during everyday home activities such as bath time, meal time, bed time, or clean-up time (yes or no).

Data analysis

Descriptive demographic data (mean ± SD) are presented in Table 1. Differences between groups were tested by using one-way analysis of variance (ANOVA) for continuous variables or a chi-square test for categorical variables. Changes in FRR, Food P_{max}, Music P_{max}, and weight for length *z*-score were explored using intention-to-treat (ITT) by including all infants who were randomized. The ITT analysis replaced missing post-

assessment data with pre-assessment values. Changes in FRR, Food P_{max}, Music P_{max}, and weight for length *z*-score were examined using a mixed ANOVA, with group (music vs. play date group) as the between factor and phase (pre- and post-assessments) as the within factor. An additional between-subject variable of cohort was initially entered into the analyses to assess cohort effects. This variable was dropped from the models when differences between cohorts were not observed. Changes in FRR, Food P_{max} and Music P_{max} were classified as decrease or no change/increase, and percentages were calculated. Chi-square analysis was used to analyze differences in percentages of decrease or no change/increase between groups. All data analyses were conducted using SYSTAT 11 (SYSTAT Software Inc., Richmond, CA).

Results

No significant differences were observed for baseline demographic and anthropometric data for randomized participants, as shown in Table 1. Complete data was collected for 25/27 families, as two families, one from each group, dropped out from the study after attending three sessions of classes. They were included in the ITT analysis assuming no change. One parent in the control group used food as a reward to encourage their child to play the music task in the lab, therefore, this family was excluded from the final analysis.

Besides the two families who dropped out from the study, the rest of the families attended all of the six group classes. The percentage of participants who filled out the daily home practice surveys was 85.4% in the music group and 84.8% in the play date group. On average, families in the music group listened to the Music Together® CD 1.4 times/day, and families in the control group played with the play date toy 1.6 times/day, with no differences of daily home practice ($P = 0.40$).

The ITT analysis (Figure 3) showed significant interaction between group and phase ($F_{[1, 24]} = 11.86$, $P = 0.002$) for FRR due to a reduction of FRR among infants in the music group (mean ± SD: −0.13 ± 0.13) in comparison to a slight increase in the control group (0.04 ± 0.11). Chi-square analysis showed that 78.6% of participants in the music group decreased in their FRR compared with 41.7% in the control group ($P = 0.05$). Absolute music reinforcement (Music P_{max}) non-significantly increased in the music group (0.43 ± 2.10) compared to a slight decreased in the control group (−0.25 ± 2.22) ($F_{[1, 24]} = 0.64$, $P = 0.43$). Chi-square analysis showed that 71.4% of participants in the music group increased or had no change in their Music P_{max} compared with 50.0% in the control group ($P = 0.26$). Food reinforcement (Food P_{max}) decreased among infants in the music group (−2.14 ± 3.48), but not in the control group (0.67 ± 1.61) ($F_{[1, 24]} = 6.57$, $P = 0.02$). Chi-square analysis demonstrated that 71.4% of participants in the music group decreased in their Food P_{max} compared with 25.0% in the control group ($P = 0.018$).

While we did not expect significant between group differences in weight for length *z*-score over such a short observation period, weight for length *z*-score did decrease in the music group (−0.13 ± 0.48) and increased in the control group (0.15 ± 0.45) ($F_{[1, 24]} = 2.43$, $P = 0.13$).

Discussion

Our findings provide initial evidence that alternatives to food may be cultivated at a young age to alter the reinforcing value of food in children who are strongly motivated to eat. Infants significantly reduced their FRR after a 6-week music program. We observed a high adherence to the program among families in both groups, with most families attending the required classes. Families either listened to the Music Together® CD or played with the play date toy at least once a day.

We previously demonstrated that relative food reinforcement could be measured in 9- to 18-month-old infants, and that overweight infants did not work as much for a non-food reinforcer when compared with lean infants (10). Our current intervention demonstrated that it is possible to alter the relative reinforcing value of food versus non-food alternatives of infants. One hypothesis is that the development of obesity is due to a lack of access to pleasurable alternatives in one's environment, thereby increasing the reinforcing value of eating (12). These findings may provide evidence of the role of alternative reinforcers as a protective factor against overeating and, thus, weight gain. In a prospective study, Strauss and Knight measured the home environment of 2,913 normal weight children ranging in age from infancy to 8 years, and found that having low or moderate scores on positive aspects of the home environment that enhanced cognitive development was associated with 2.3 to 2.6 times the risk of developing obesity 6 years later, compared to those with high positive aspects of home environment (11). Similarly, randomized control trials in children (12) and adults (14) show that having access to non-food activities is associated with treatment success in weight loss programs. Eating is often an option among many other available activities for individuals. Having parents foster an enriched home environment at an early age may be important in altering a child's choice of food and weight gain.

Strengthening access to alternative reinforcers is one way to build an enriched environment, and one of the hypotheses for how enriched environments influence individuals is by providing access to alternative reinforcers (15). Research on enriched environments was originally used to study the effects of the environment on brain plasticity in animal models. Rodents raised in enriched environments have improved performance on learning and memory tasks, as well as increased brain size (16,17). Later research shows that environmental enrichment plays a significant role in attenuating substance abuse (18–20). These results suggest that environmental enrichment may reduce sensitivity to rewards (21,22) and impulsivity (23), and to the extent that obesity is due to excess motivation to eat, an enriched environment and access to alternative reinforcers may be related to the development of obesity.

As a pilot feasibility study, there are limitations. We studied a small sample of families, which were generally highly educated, middle class families, and infants recruited in the studies were of mothers who did not drink, smoke, or use drugs during pregnancy. The duration of development of an enriched environment was relatively short. With a longer intervention duration, we might be able to observe significant change in the motivation to gain access to music among the infants in the treatment group. Lastly, we only studied one alternative reinforcer, music. Nonetheless, this is the first evidence showing change in the

differential patterns of responding for food versus alternative reinforcers in infants after strengthening an alternative reinforcer. The current study has a sufficient signal to indicate the potential of providing non-food alternatives to enrich the environment of infants who are strongly motivated to eat to reduce their food reinforcement, and thus, alter the trajectory of their weight gain. Future research should extend the study to infants in families with low socioeconomic backgrounds, and should study a wider sample of alternative reinforcers to maximize the chance of identifying alternative reinforcers that can be maintained by families.

Conclusion

In conclusion, results from this study extend our knowledge of the relative reinforcing value of food and alternative reinforcers by providing insight into the role of non-food alternatives in altering one's motivation to eat. Interventions targeting non-food behavior may be a new and promising avenue for the prevention of obesity in infants.

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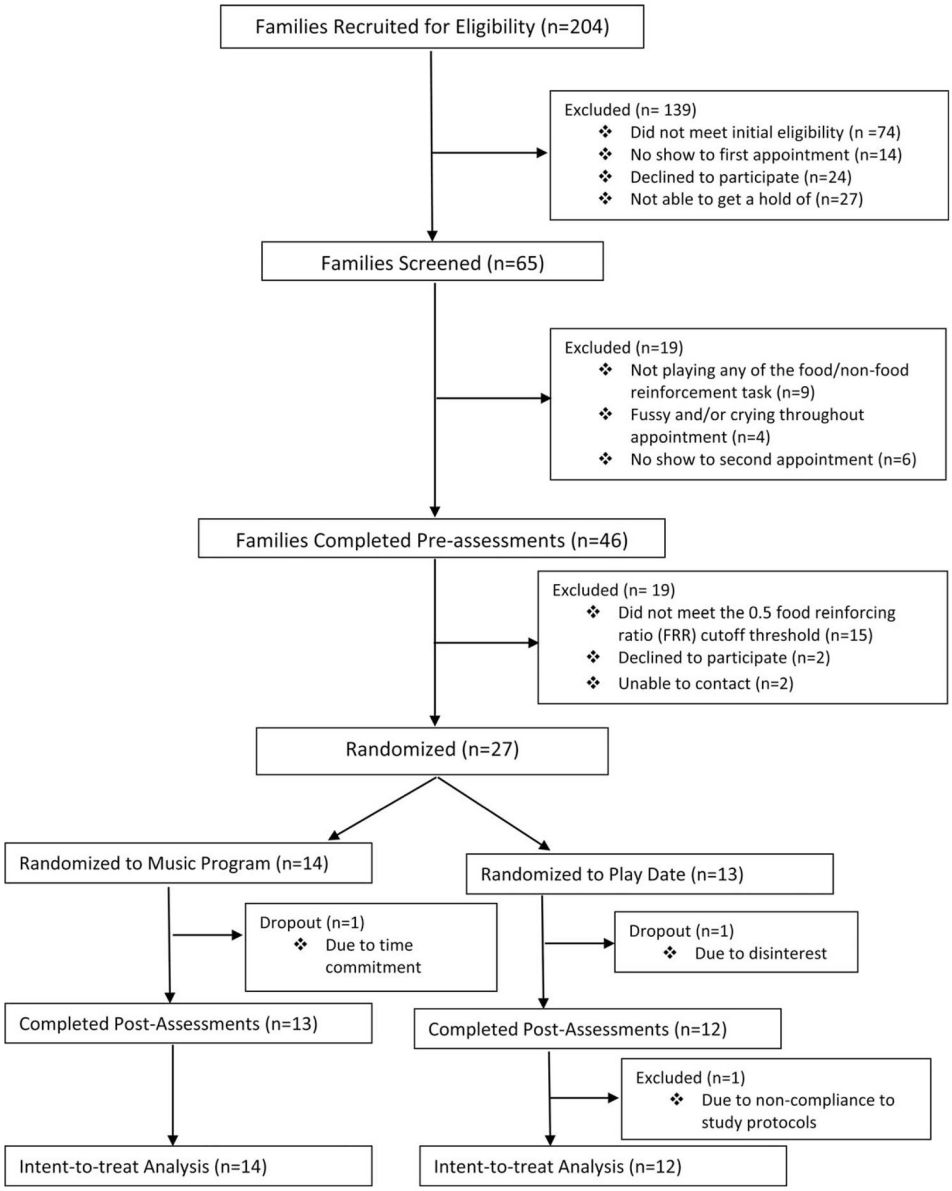

Figure 1.
Participant flowchart.

Figure 2.
Experimental setup of the study. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

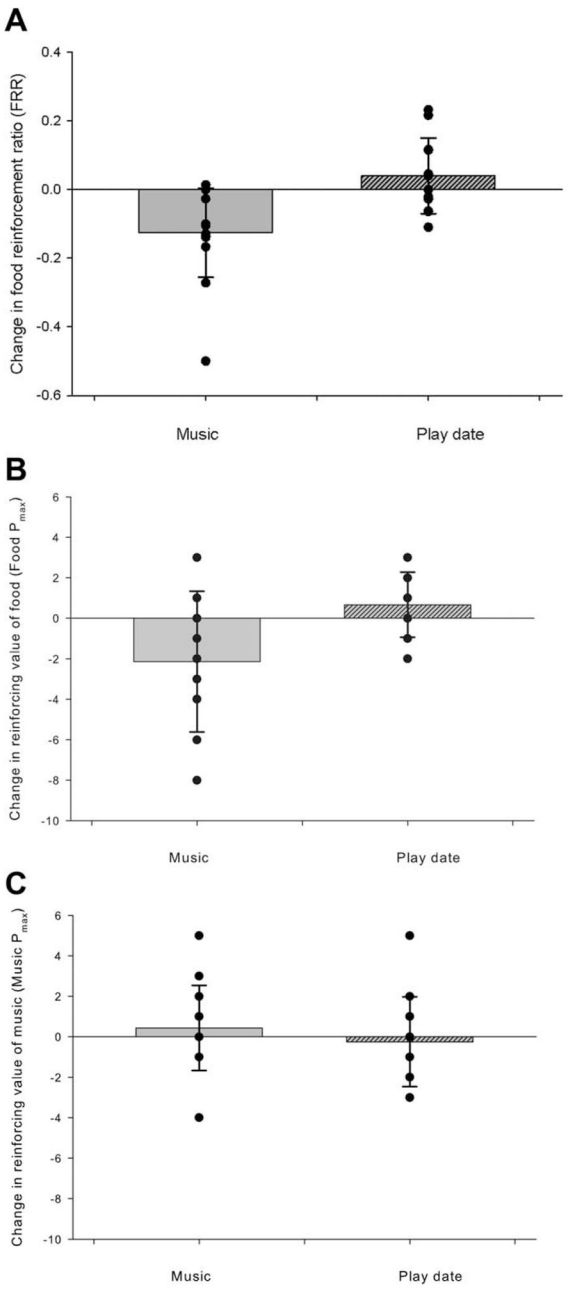

Figure 3.

The effects of a 6-week music enhancement program on the relative and absolute reinforcing value of food and music in infants. Mixed ANOVA show significantly lower (**A**) food reinforcement ratio (FRR) ($F_{[1, 24]} = 11.86$, $P = 0.002$) and (**B**) absolute reinforcing value of food (Food P_{max}) among infants in the music group compared to control ($F_{[1, 24]} = 6.57$, $P = 0.02$). (**C**) No significant between group change was observed for the absolute reinforcing value of music (Music P_{max}) ($F_{[1, 24]} = 0.64$, $P = 0.43$).

TABLE 1

Child, maternal, and household characteristics of participants

	Music program (*n* = 14)		Play date group (*n* = 13)	
Variable	**Mean (SD)**	***N* (%)**	**Mean (SD)**	***N* (%)**
Child				
Sex				
Male		7 (50.0)		7 (53.8)
Age, months	12.2 (2.14)		12.2 (2.44)	
Race				
Caucasian		9 (64.3)		9 (69.2)
No response		0 (0.0)		2 (15.4)
Birth weight, kg	3.59 (0.46)		3.61 (0.37)	
Weight for length *z*-score[a]	0.93 (1.03)		0.86 (1.00)	
Weight for age *z*-score[a]	0.44 (1.20)		0.44 (1.04)	
Length for age *z*-score[a]	−0.38 (1.22)		−0.29 (1.02)	
Breastfeeding duration, months				
< 6 months		6 (42.9)		3 (23.1)
≥ 6 months		8 (57.1)		10 (76.9)
First introduction to solids				
< 4 months		0 (0.0)		0 (0.0)
4–5 months		6 (42.9)		9 (69.2)
≥ 6 months		8 (57.1)		4 (30.8)
FRR	0.61 (0.07)		0.60 (0.09)	
Food P_{max}	8.07 (2.76)		7.85 (1.82)	
Music P_{max}	5.29 (2.49)		5.53 (2.40)	
Mother				
Age, years	31.03 (3.64)		30.64 (5.69)	
Race				
Caucasian		11 (78.6)		12 (92.3)
No response		0 (0.0)		1 (7.7)
Education level				
Some college or lower		4 (28.6)		4 (30.8)
College graduate or higher		10 (71.4)		9 (69.2)
Parity				
Primiparous		6 (42.9)		7 (53.8)
Current BMI, kg/m^2	30.76 (8.09)		27.3 (6.66)	
Normal		4 (28.6)		6 (46.2)
Overweight		3 (21.4)		3 (23.1)
Obesity		7 (50.0)		4 (30.8)
Household				
Total income, $				

	Music program (*n* = 14)		Play date group (*n* = 13)	
Variable	**Mean (SD)**	***N* (%)**	**Mean (SD)**	***N* (%)**
<**$50,000**		3 (21.4)		4 (30.8)
≥**$50,000**		10 (71.4)		8 (61.5)
No response		1 (7.1)		1 (7.7)

[a]Calculated using WHO growth chart.

SD = standard deviation; BMI = body mass index; FRR = food reinforcing ratio of infant's favorite food; Food P_{max} = reinforcing value of food; Music P_{max} = reinforcing value of music.

Primiparous = first-time pregnant women.