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Effect of intervention of music-assisted therapy on physiological parameters of premature babies - A randomized trial

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ABSTRACT

Purpose: To investigate the effect of intervention of music-assisted therapy (MAT) on the physiological parameters of premature babies.
Methods: A two-arm parallel-group randomized controlled trial. This study randomly enrolled a total of 41, 28-to-34-week-old premature babies as the subjects to measure their physiological parameters (body temperature, heartrate, respiration, and blood oxygen level). The control group (n = 20) received general routine care, the experimental group (n = 21) received the intervention of MAT (oriental Nanguan music) for three consecutive days, and the data were collected for the following three days after the intervention.
Results: The results showed that compared with the premature babies receiving general routine care, there were statistically significant differences ($p < 0.05$) in the heartrate and blood oxygen level in those receiving the MAT (experimental group). However, there was no statistically significant difference in body temperature and respiration.
Conclusion: The heartrate, respiration, and blood oxygen level in the premature babies receiving the MAT were gradually stabilized. In addition, this study also verified that oriental Nanguan music, which has a low frequency and a simple melody, could stabilize the physiological parameters and sleep behavior of premature babies. This study could provide an auxiliary care method for the developmental care of premature babies. In the future, it is hoped that MAT can be included into the regular curriculum of nursing education to provide family-centered holistic care, reduce the stress and anxiety of parents of premature babies, and improve the clinical quality of care indicators.

1. What is already known

- Many studies have implemented music-assisted therapy interventions for premature babies over the age of 34 weeks; results indicate that this intervention can stabilize the heart rate, respiration, and blood oxygen level of premature babies. Moreover, it has been shown to reduce energy consumption, which is beneficial to the nervous system integration of premature babies and the prevention of complications.
- Healthcare professionals working in the NICU have a well-established concept of developmental care. If developmental care can be applied early, it can help the physiological development of premature babies and further achieve the integration and development of premature babies.

2. What this paper adds

- The music-assisted therapy used in this study was oriental Nanguan music. The intervention was implemented in the care of 28- to 34-week-old premature babies. The effect on premature babies was the same as that of studies using Western music for intervention (i.e., significant improvements in heart rate, respiration, and blood pressure). To our knowledge, the present study is the first experiment using oriental Nanguan music as an intervention in the care of premature babies among the existing clinical studies.

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- The results of this study may serve as a reference for NICU healthcare professionals to implement the Nanguan music intervention in the care of premature babies who are younger. The findings of this study contribute to promoting music-assisted therapy as a conventional assisted care measure in the developmental care of premature babies. This study may serve as a reference for the care of infants with acute and critical illnesses.

3. Introduction

According to statistics from the World Health Organization (WHO) in 2022, an average of 15 million premature babies are born in the world every year, and more than one million of them pass away due to premature birth-related complications. In Taiwan, the Premature Baby Foundation of Taiwan (2022) announced that approximately 180,000 newborns are born every year, and 18,000 of them are premature babies (10%), of which approximately two to three thousand pass away, indicating a perinatal mortality rate of 11–15‰. The premature birth of a fetus leads to the immature development of the central nervous system, the lack of self-regulation ability, and the lack of appropriate responses to external environmental stimuli or pressure. Premature babies are prone to displaying varying degrees of behavioral reactions and neurological damage, including rapid and irregular heartrates and respiration as well as unstable blood oxygen levels and body temperature, etc. (Als et al., 2004). Dr. Heidelise Als of the United States developed an individualized developmental care model for newborns in 1986 (Als 1986). This care model aims to simulate and create an environment similar to a mother's womb for premature babies under 37 weeks old. This care model stabilizes the visual, auditory, tactile, somatosensory, and neuromotor systems of premature babies by controlling the light and volume of the neonatal intensive care unit, providing gentle strokes to premature babies, and placing them in a nest-like environment. The goal is to maintain the stability of vital signs, support the healthy growth of premature babies in a safe and low-stimulation environment, reduce the occurrence of complications, and promote the integration of their behavioral states.

Music can be transmitted through the medulla oblongata, midbrain, and pontine nerves, inducing the pituitary gland to release endogenous opiates, commonly known as endorphins, to block nerve conduction paths, reduce the transmission of pain messages and the perception of pain, and reduce muscle tension to achieve the effect of body relaxation and self-healing (Leu, 2005). In addition to stabilizing emotions, regulating respiration, heartrate, and blood oxygen levels, and reducing blood pressure, music is a low-cost non-invasive and non-drug adjuvant therapy (Tai and Liu, 2017). Currently, many scholars have administered music-assisted therapy (MAT) to the elderly, patients with mental diseases, and children with disabilities or autism (American Music Therapy Association, 2016). In recent five years, some scholars have gradually started to administer MAT to premature babies over 34 weeks old. Most of the music choices have been western music (such as lullabies) to stabilize premature babies' respiration, heartrate, blood oxygen level, and other physiological parameters (Jabraeili et al., 2016; Taheri et al., 2017). However, to date, MAT has rarely been administered to premature babies under 34 weeks old, and Nanguan music has never been chosen for investigation in terms of the choice of music. Therefore, the main purpose of this study was to investigate the administration of MAT to premature babies under 34 weeks old in neonatal intensive care units, to understand its effect on physiological parameters.

4. Physiological parameters of premature babies

The normal body temperature of a premature baby should be maintained at an axillary temperature of 36.5–37.5°, and the heartrate should be maintained at 120 to 160 beats/min, with no bradycardia (a heartrate less than 80 beats/min). The rate of respiration should be maintained at 30 to 60 breaths/min, without apnea (pause of breathing for more than 15–20 s), and the blood oxygen saturation should be greater than 90% (Chang et al., 2012). Premature babies often experience apnea, reduced heartbeat, decreased blood oxygen saturation, and immature nervous systems due to their immature respiratory centers and insufficient surface tension in the lungs (Hsu and Chen, 2012; Te Pas et al., 2009). When the external environmental pressure is too high, premature babies will experience an imbalance between the environmental pressure and internal physiological adjustment and respond in three subsystems, including: (1) autonomic and visceral stress messages, such as cramping, abnormal respiration rates, skin color changes, hiccups, gagging, vomiting, sighing, straining with bowel movements, sneezing, yawning, body tremors or shaking, etc.; (2) movement stress signals, such as weak movements of the trunk, limbs or face, and hypertonic muscle movements (e.g. trunk arched, feet hanging in the air, arms raised, fingers splayed, hands clenched, twisting constantly limbs, sticking out tongue, etc.); and (3) varying states of consciousness, such as sleeping and waking and the ability to interact during waking. The state of sleeping refers to the sleep cycle, which includes the six states of deep sleep, light sleep, drowsiness, quiet and awake, active and awake, and crying (Chwo, 2003). Stress messages associated with consciousness are conveyed through a disturbed sleep or waking state accompanied by whimpering, face twitching, eye rolling, fixing the eyes and gazing, eye avoidance, showing fright or nervousness, restlessness, crying, etc., which are all not conducive to the body's energy storage, will increase the consumption of oxygen, and cause tachycardia, which may easily lead to excessive load and failure of the body organs (Als, 2009). When a balance is reached between physiological adjustment and environmental pressure, integration will be formed. The respiration and heartrate of an integrated infant will be stabilized, energy consumption will be reduced, and stress behaviors will appear less (Als et al., 2011). The stability of the physiological state is usually regarded as the storage of energy, and its main purpose is to meet the needs of growth and repair of premature babies. Once premature babies are able to maintain and restore their physiological and integrated behavioral states, they will be able to conserve energy for growth (Chang, 2003).

5. Application of music-assisted therapy

The hearing of the fetus begins to develop between the 15th and 20th week of the mother's pregnancy. At the 25th week of the mother's pregnancy, the baby begins to respond to external sounds. In the later stages of pregnancy, the fetus's tiny brain is already busy processing the various sounds heard in the womb (Kyra and Annette, 2000). In terms of music selection for premature babies, soothing and low frequency music without too many ups and downs are mainly selected because low frequency music can stabilize the baby's heartrate and respiration, single tones can improve sucking abilities, and relaxing music can promote the parasympathetic nervous system to slow down the heartrate and stabilize blood pressure. The effect of relaxing music on the autonomic nervous system of the heart can improve the heartrate and respiration changes in premature babies (Anderson and Patel, 2018; Caparros-Gonzalez et al., 2018). Chorna et al. (2019) played lullabies for premature babies under 37 weeks old, and study that the respiration and heartrate of premature babies were stabilized.

The tones of Nanguan music are called Guanmen and include *Beishiguan, Wukongguan, Wukong Siyiguan, and Sikongguan*. The temperament is equivalent to the D key, G key, C key, and F key to western music, which is a cycle of fifths. Nanguan music originated from the coast of Fujian. Its tone frequency is deep and mellow, and the melody is slow and simple—similar to the D-flat major in western music, and the temperament is as high as the lullaby. It is easy for people listening to Nanguan music to feel drowsy. In fact, drowsiness is exactly the manifestation of integrating into the calm pace of Nanguan music (Chang, 2017). Chang et al. (2018) investigated the effect of the intervention of traditional Chinese five-element music on anxiety, depression

and other negative emotions in patients with malignant tumors, and the results showed that such negative emotions could be significantly improved.

6. Studies on the correlation between music-assisted therapy and premature babies

In terms of foreign studies, Loewy et al. (2013) randomly enrolled a total of 272 premature babies over 32 weeks old as the subjects, and found that the intervention of lullabies or rhythmic music could improve activity and stabilize heartrate, respiration, and blood oxygen levels, resulting in significant differences in sleep to waking and sucking abilities. In 2018, a study in Spain conducted a double-blind, randomized trial of 22 premature babies at the age of 32–36 weeks. The premature babies listened to 20 min of lullaby music containing synthesized Adagio bass four times a day for three consecutive days. The said study found that the heartrate and respiration rate of the experimental group were significantly lower than those of the control group. However, there were no significant differences in blood oxygen saturation and blood pressure (Caparros-Gonzalez et al., 2018). In 2018, a German study used the randomized control approach to enroll 21 premature babies over the age of 35 weeks as the subjects. The premature babies listened to 15 min of German-style Adagio three-beat music once a day. A pre-test was performed 1 h before the music intervention and a post-test was performed 1 h after. The said study found that after the music intervention, 42% of the premature babies displayed waking to drowsy behavioral states, and 26% of them were in a sleep state. However, there was no change in respiration, heartrate, and blood oxygen level (Ranger et al., 2018). The Chinese scholar Luo (2014) also found that 34-week-old premature babies who listened to 15–30 min of classical lyrical music two times a day for three days could fall asleep stably. In Taiwan, the study by Hsu and Chen (2012) of 27 premature babies (under 37 weeks old) with a birth weight of 2500 g found that the heartrate of the experimental group listening to soft classical light music was lower than that of the control group. In terms of the average heartrate, the experimental group's respiration rate was reduced after listing to the music. In addition, the blood oxygen saturation of the experimental group was higher than that of the control group. In other words, there were significant differences in all physiological parameters.

Based on the literature above, MAT has been gradually applied to premature babies. However, the age of intervention is mainly 34–36 weeks, meaning MAT has been rarely applied to premature babies under 32 weeks old. The music selection of MAT is mainly lullabies or soft music, and oriental music is never used. Therefore, the author was motivated to investigate whether the intervention of oriental music could also stabilize the physiological parameters of premature babies and benefit their neurological integration, growth, and development.

7. Method

7.1. Design

This study used random numbers chosen by a computer to enroll subjects. The subjects were enrolled from April 1 to December 31, 2021. This study enrolled patients from the NICU of a specific medical center in southern Taiwan. During the enrollment process, if parents were unwilling to have their premature babies receive the intervention or if the babies' vital signs were severely threatened due to physical factors, enrollment was immediately terminated.

7.2. Sample

The inclusion criteria included: (1) a birth week greater than 28 weeks but less than 34 weeks; (2) a birth weight less than 2500 g; and (3) agreement of the parents to participate in the study. The exclusion criteria included: (1) premature babies who were using a ventilator and sedative medication; and (2) premature babies with hearing impairment, deformities, central nervous system problems, heart disease, or other congenital diseases.

In terms of the sample size, this study used repeated measures ANOVA, between factors of G-POWER 3.1.9.4 software to estimate the number of subjects to be enrolled, with an effect size: 0.55; α err prob = 0.05, power (1- βerr prob) = 0.95, number of measurement = 7, and total sample size: 28. Due to the ages of the subjects, the attrition rate was expected to be approximately 40%. The number of subjects to be enrolled was therefore increased to 50, including 21 subjects in the experimental group and 20 subjects in the control group. Each group continuously enrolled the subjects for seven days.

7.3. Instruments

The research tools were as follows:

1. Basic data: gender, birth week, corrected birth week, birth weight, weight at enrolment, eating method, food intake, Apgar score at the first and fifth minute.
2. Digital audio player: used to play the music album of Nanfeng Qingsheng-Nanguan music, with a total of two songs, each of which was 14–15 min in length. The premature babies listened to the music for a total of 30 min.
3. Digital decibel meter: used to control the sound level in the environment. The digital decibel meter was manufactured by the Benetech Company and was verified to have good reliability and validity.

Physiological monitor: used to monitor the physiological parameters. A US-made combined bedside physiological monitor (Philips IntelliVue MX800) was used to monitor the heartrate rate and respiration rate of the premature babies, perform non-invasive blood pressure measurements, and measure the saturation concentration of the peripheral blood oxygen level. The heart rate alert value was set at 100–180 beats/min, the respiration alert value was set at 20–80 beats/min, and the blood oxygen saturation concentration alert value was set below 90%. During the study, electrocardiogram electrodes were attached on the left chest, right chest, and abdomen of the premature babies, and blood pressure cuffs were fixed on the right foot to monitor the blood pressure. The blood oxygen saturation concentration sensor was attached on the sole of the left foot. The physiological monitor (Philips IntelliVue MX800) had passed the inspection of the central Bureau of Standards, Metrology and Inspection. Nursing personnel performed primary maintenance every month, and professional engineers from Philips regularly calibrated and maintained it.

7.4. Implementation of the study

The subjects were scheduled to receive the intervention at 11:00 every morning (because no nursing activity would be performed within 1 h after mealtime at 11:00). On Day 1, this study collected the pre-test data, including physiological parameters such as body temperature, heartrate, blood pressure, respiration rate, and blood oxygen level. Starting from Day 2, the premature babies listened to Nanguan music at 11:00 every morning for three consecutive days. Before the music intervention, this study also collected data on the physiological parameters of the premature babies. At 11:30 (the end of the music intervention), this study recorded the data again. From Day 4 to Day 6, this study continuously collected data at 11:00 a.m. The pre-test data of the control group were also collected on Day 1. Starting from Day 2, this study continuously collected the physiological parameters of the premature babies at 11:00 a.m. and 11:30 a.m. for three consecutive days. The physiological parameters were also followed up and recorded from Day 4 to Day 6 (as shown in Fig. 1).

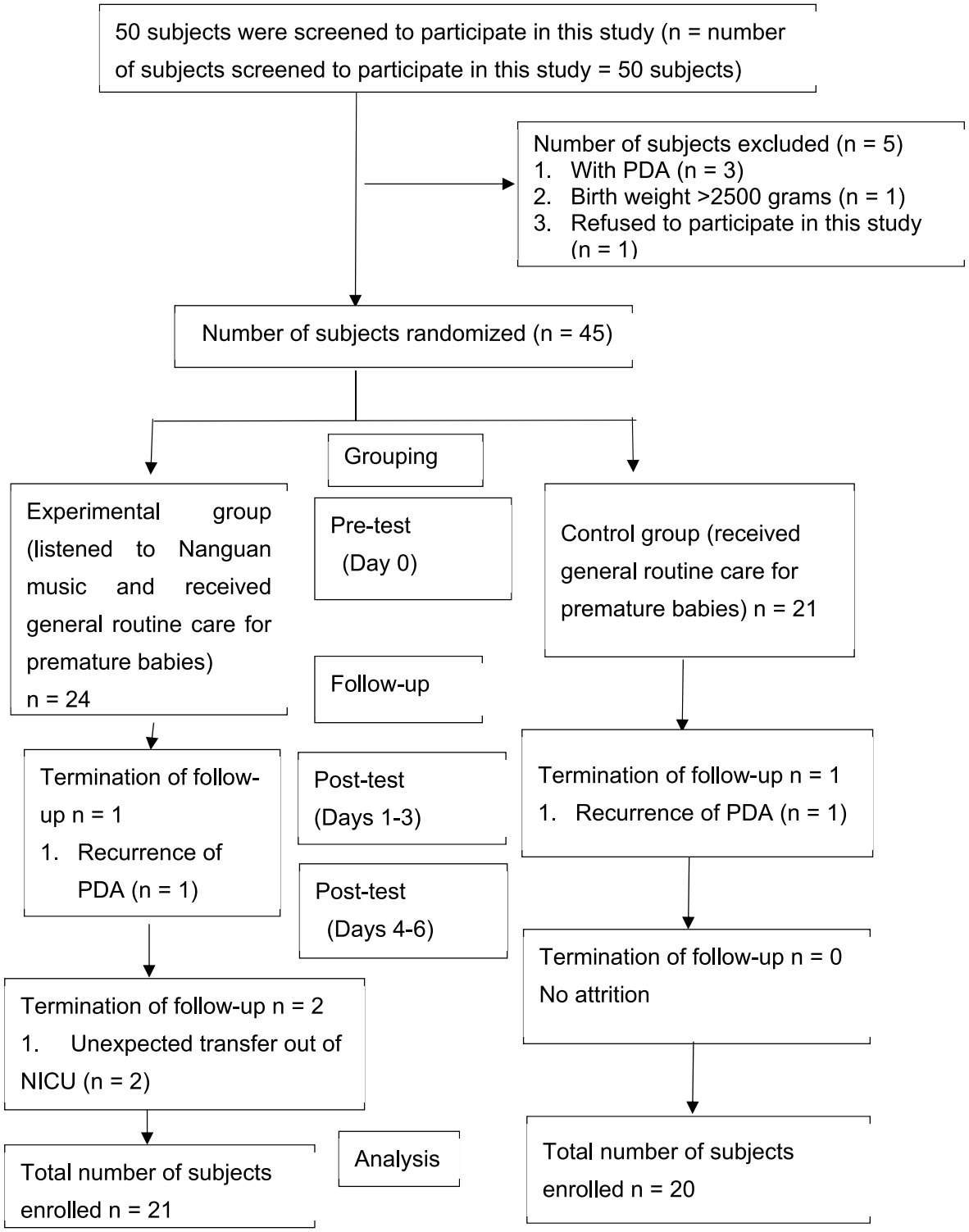


Fig. 1. CONSORT flow diagram.

7.5. Data analysis

The data collected in this study were coded after being archived in an Excel 2010 worksheet, and SPSS 25 for Windows package software (IBM) was used for data archiving and statistical analysis. This study used chi-square and t-tests to test the basic attributes and homogeneity of data. In addition, this study used repeated measures analysis and generalized estimating equations to measure the physiological parameters (heartrate, respiration, blood oxygen level, and blood pressure). All inferential statistics were set with a p value < 0.05 to achieve statistically significant differences.

8. Results

8.1. Analysis of the basic attributes

This study enrolled a total of 41 premature babies as the research subjects, including 15 male infants (36.6%) and 26 female infants

(63.4%). There were 11 subjects (26.8%) younger than 30 weeks and 30 subjects (73.2%) older than 30 weeks. This study enrolled a total of four subjects (9.76%) with a birth weight under 1000 gm and 37 subjects (90.24%) with a birth weight over 1000 gm. There were five subjects (12.2%) with a birth weight under 1000 gm and 36 subjects (87.8%) with a birth weight over 1000 gm. The birth weight at enrolment of two subjects (4.9%) was under 1000 gm, while that of 39 subjects (95.1%) was over 1000. The first minute Apgar score of six subjects (14.6%) was less than five points, that of 16 subjects (39.1%) was five to seven points, and that of 19 subjects (46.3%) was more than eight points. The fifth minute Apgar score of one subject (2.4%) was more than five points, that of seven subjects (17.1%) was five to seven points, and that of 33 subjects (80.5%) was more than eight points. In terms of food intake method at enrolment, 12 subjects (29.3%) were completely fed by mouth, 10 subjects (24.4%) were completely fed by gastric tube, and 19 subjects (46.3%) were partially fed by mouth and by gastric tube. This study performed a Chi-Square test and independent *t*-test to analyze the experimental group and control group according to gender, birth week, birth week at enrolment, birth weight, weight at enrolment, the first minute Apgar score, the fifth minute Apgar score, food intake method, and physiological parameters, such as body temperature, heartrate, blood pressure, respiration, and blood oxygen. The results showed that there was no significant difference in all variables ($p > 0.05$), suggesting high homogeneity of data.

8.2. Analysis of the status of music-assisted therapy and physiological parameters

This study used generalized estimating equation (GEE) analysis of cognitive function to measure repeated interactions. During the pre-test, the experimental group received the oriental Nanguan MAT, and their average body temperature was 0.034 °C higher than that of the control group. After repeated measures, on Day 1, the change in body temperature of the experimental group was −0.058 ($p = 0.297$) compared to that of the control group. On Day 2, the change in body temperature of the experimental group was 0.054 ($p = 0.325$) compared to that of the control group. On Day 3, the change in body temperature of the experimental group was −0.007 ($p = 0.926$) compared to that of the control group. On Day 4, the change in body temperature was 0.026 ($p = 0.666$) compared to that of the control group. On Day 5, the change in body temperature was 0.031 ($p = 0.600$) compared to that of the control group. On Day 7, the change in body temperature of the experimental group was −0.017 ($p = 0.797$) compared to that of the control group. The body temperature of the two groups did not change over time, and there was no statistically significant difference ($p > 0.05$).

In terms of the heartrate, this study found that on Day 1, the change in heartrate of the experimental group receiving the oriental Nanguan MAT was −2.672 ($p = 0.162$) compared to that of control group. On Day 2, the change in heartrate of the experimental group was −10.107 ($p = 0.001$). On Day 3, the change in heartrate of the experimental group was −7.172 ($p = 0.008$). On Day 4, the change in heartrate of the experimental group was 9.150 ($p = 0.001$). On Day 5, the change in heartrate of the experimental group was −6.839 ($p = 0.003$). On Day 6, the change in the heartrate of the experimental group was −10.074($p = 0.001$). The change in heartrate of the two groups had a statistically significant difference ($p < 0.05$), as shown in Table 1.

In terms of blood pressure, this study found that on Day 1, the change in blood pressure of the experimental group receiving the oriental Nanguan MAT was −1.159 ($p = 0.638$) compared to that of the control group. On Day 2, the change in blood pressure of the experimental group was −1.963 ($p = 0.375$). On Day 3, the change in blood pressure of the experimental group was −3.819 ($p = 0.805$). On Day 4, the change in blood pressure of the experimental group was −0.649 ($p = 0.091$). On Day 5, the change in blood pressure of the experimental group was −1.159 ($p = 0.586$). There was no significant difference as of Day 5. However, on Day 6, the change in blood pressure of the experimental group was 3.687 ($p = 0.022$), reaching a significant level ($p < 0.05$). The results showed that under the interaction between time and group, there was no statistically significant change in blood pressure between the two groups ($p > 0.05$), as shown in Table 2.

In terms of respiration, this study found that on Day 1, the change in respiration of the experimental group receiving the oriental Nanguan MAT was 2.170 ($p = 0.536$) compared to that of the control group. On Day 2, the change in respiration of the experimental group was 1.228 (p = 0.638). On Day 3, the change in respiration of the experimental group was-1.207 ($p = 0.693$). On Day 4, the change in respiration of the experimental group was −1.820 ($p = 0.554$). On Day 5, the change in respiration of the experimental group was −4.396 ($p = 0.078$). On Day 6, the change in respiration of the experimental group was −0.691 ($p = 0.058$). The results showed that under the interaction between time and group, there was no statistically significant change in respiration between the two groups ($p > 0.05$), as shown in Table 3.

In terms of blood oxygen level, this study found that on Day 1, the change in blood oxygen level of the experimental group receiving the oriental Nanguan MAT was 0.223 ($p = 0.0581$) compared to that of the control group. On Day 2, the change in blood oxygen level of the experimental group was −0.479 ($p = 0.397$). On Day 3, the change in blood oxygen level of the experimental group was-0.647 ($p = 0.212$). On Day 4, the change in blood oxygen level of the experimental group was 2.209 ($p = 0.001$). On Day 5, the change in blood oxygen level of the experimental group was 2.057 ($p = 0.001$). On Day 6, the change in blood oxygen level of the experimental group was 1.784 ($p = 0.001$).

Table 1
The heartrate of the two groups at different time points following the MAT.

Predictor variable	Estimated parameter (*B*)	95% confidence interval		Wald Chi-square test	df	*p value*
		Lower limit	Upper limit			
Intercept	162.250	157.622	166.878	4722.249	1	0.000
Groups (experimental group vs control group)	−0.051	−5.291	5.362	0.000	1	0.990
Time points (post-test vs pre-test)						
Day 1	−0.750	−3.594	2.094	0.351	1	0.605
Day 2	1.157	−3.696	6.196	.245	1	0.620
Day 3	−3.350	−8.281	1.581	1.773	1	0.183
Day 4	−2.550	−6.902	1.802	1.319	1	.251
Day 5	−2.350	−6.447	1.747	1.264	1	.261
Day 6	−1.088	−5.287	3.287	.209	1	.648
Group X time						
Day 1	−2.672	−6.658	1.110	1.959	1	.162
Day 2	−10.107	−16.016	−4.389	11.832	1	.001
Day 3	−7.172	−12.632	−1.906	7.057	1	.008
Day 4	−9.150	−14.374	−4.145	12.589	1	.000
Day 5	−6.839	−11.593	−2.374	8.816	1	.003
Day 6	−10.074	−15.094	−5.192	16.124	1	.000

Table 2
Change in blood pressure of the two groups at different time points following the MAT.

Predictor variable	Estimated parameter (*B*)	95% confidence interval		Wald Chi-square test	df	*p* value
		Lower limit	Upper limit			
Intercept	48.000	44.945	51.055	948.148	1	.000
Groups (experimental group vs control group)	.857	−2.593	4.307	.237	1	.626
Time points (post-test vs pre-test)						
Day 1	1.356	−.821	3.221	1.355	1	.244
Day 2	2.170	−.989	4.989	1.720	1	.190
Day 3	4.328	.872	7.428	6.159	1	.013
Day 4	2.183	−.937	4.937	1.782	1	.182
Day 5	3.687	.611	6.389	5.639	1	.018
Day 6	0.289	.611	6.389	5.639	1	.018
Group X time						
Day 1	−1.159	−5.215	3.196	.221	1	.638
Day 2	−1.963	−5.805	2.186	.788	1	.375
Day 3	−3.819	−4.672	3.624	.061	1	.805
Day 4	−0.649	−7.939	.591	2.850	1	.091
Day 5	−1.158	−4.925	2.783	.297	1	.586
Day 6	3.687	.571	7.515	5.209	1	.022

Table 3
Change in respiration of the two groups at different time points following the MAT.

Predictor variable	Estimated parameter (*B*)	95% confidence interval		Wald Chi-square test	df	*p* value
		Lower limit	Upper limit			
Intercept	57.875	54.189	61.611	935.369	1	.000
Groups (experimental group vs control group)	−5.925	−10.514	−1.382	6.518	1	.011
Time points (post-test vs pre-test)						
Day 1	−4.174	−8.366	.166	3.549	1	.060
Day 2	−4.717	−8.899	−.501	4.814	1	.028
Day 3	−0.493	−4.993	3.993	.048	1	.827
Day 4	−1.833	−6.655	2.955	.570	1	.450
Day 5	−3.228	−6.787	.287	3.243	1	.072
Day 6	−3.226	−7.036	.536	2.831	1	.092
Group X time						
Day 1	2.170	−4.554	8.754	.383	1	.536
Day 2	1.228	−4.658	7.105	.166	1	.683
Day 3	−1.207	−6.957	4.623	.156	1	.693
Day 4	−1.820	−7.418	3.975	.351	1	.554
Day 5	−4.396	−8.826	.469	3.106	1	.078
Day 6	−4.691	−9.272	.153	3.597	1	.058

The results showed that under the interaction between time and group, there was a statistically significant change in blood oxygen level between the two groups from Day 4 to Day 6 ($p < 0.05$); however, there was no statistically significant difference on the other days ($p > 0.05$), as shown in Table 4.

9. Discussion

9.1. Analysis of the selection of music for music-assisted therapy

This study found that listening to oriental Nanguan music gradually stabilized the heartrate and blood oxygen levels in the premature babies. This study searched domestic and foreign studies and found that no oriental Nanguan music or oriental music with the same pitch had previously been used. This study verified that the use of oriental Nanguan music could achieve the effect of stabilizing the subjects' physiological parameters. The possible reason was that although oriental Nanguan music is slow-paced and has a low frequency, its pitch is similar to that of a lullaby and D-flat major. Besides, slow music can activate the parasympathetic nerves. This result was similar to that of the study by Kobus et al. (2021), who chose to hum songs, such as lullabies, at the study site.

9.2. Effect of music-assisted therapy on physiological parameters

This study found no significant differences in the body temperature, respiration, and blood pressure of the premature babies listening to oriental Nanguan music. This result was similar to that of the study by Silva et al. (2013). This result may have been due to the study site where the subjects were enrolled. The study hospital was equipped with a nursing room for premature babies, in which the indoor temperature was maintained at a constant temperature of 26 °C throughout the year. At the time of enrolment, each premature baby slept in an incubator. The temperature of the incubator was set according to the birth week and body weight of the premature baby. Therefore, the change in body temperature may have been insignificant. Although there was no statistically significant difference in blood pressure ($p > 0.05$), this study also found that starting from Day 2, the blood pressure of the experimental group was lower than that of the control group by 2 mmHg, and was maintained within a normal range. This finding was different from that of the study by Ranger et al. (2018). The reason might be that the research design of this German scholar also included the kangaroo care implemented by mother prior to the listening of German pentatonic lullabies for one day. The heartrate and blood pressure of premature babies might have been in a relatively calm and relaxed state after contact with the mother's skin during care. As a result, there was no significant difference.

The results related to heartrate in this study were similar to the findings of Caparros-Gonzalez et al. (2018), which used western relaxing and bass chord orchestration, of which the pitch is similar to the oriental Nanguan music chosen by this study. Such music has a low frequency and a slow pace, which can soothe emotions, activate parasympathetic nerves, reduce the release of cortisol, lower the heart rate, and stabilize blood pressure.

The results related to blood oxygen level and respiration in this study were consistent with those of most domestic and foreign studies, thus verifying that MAT could help premature babies stabilize their blood oxygen levels. However, the result related to the reduction in respiration rate was not the same as that of most domestic and foreign studies. This study found that the respiration gradually stabilized with the increase in the number of days of listening to oriental Nanguan music. In particular, on Day 7, the respiration rate of the experimental group was 44 times/min, which was lower than that of the control group in more than 10 data recordings, indicating a significant difference ($p < 0.05$). On the other hand, on Day 4 after the MAT, this study found that the blood oxygen saturation level in the experimental group was 2% higher than that in the control group, and this level was maintained until Day 7. The reason might be that the music could promote stable and regular respiration, support the development of premature babies, maintain the rhythm of the swallow-suction-respiration action, improve neural development, and prevent pauses in respiration (Hsu and Chen, 2012; Loewy et al., 2013; Jabraeili et al., 2016; Span et al., 2021).

Based on the research results listed above, this study found that after the MAT, although the premature babies only listened to oriental Nanguan music for three days, their heartrate and blood oxygen levels were gradually stabilized and their respiration rates were reduced to a stable rate, which helped reduce the crying behavior of premature babies until Day 7. It could be speculated that the premature babies would remember and continue to respond to music. Oriental Nanguan music has a low frequency and a steady rhythm, similar to the frequency and pitch of western lullabies, and it can enhance the parasympathetic nervous

Table 4
Change in blood oxygen level of the two groups at different time points following the MAT.

Predictor variable	Estimated parameter (*B*)	95% confidence interval		Wald Chi-square test	df	*p value*
		Lower limit	Upper limit			
Intercept	96.585	96.033	97.167	111355.131	1	.000
Groups (experimental group vs control group)	1.129	.360	1.868	8.393	1	.004
Time points (post-test vs pre-test)						
Day 1	0.015	−.634	.634	.000	1	1.000
Day 2	0.765	−.020	1.520	3.648	1	.056
Day 3	0.115	−.660	.860	.067	1	.796
Day 4	−0.685	−1.216	−.184	7.071	1	.008
Day 5	−0.485	−1.124	.124	2.468	1	.116
Day 6	−0.585	−1.408	.208	2.120	1	.145
Group X time						
Day 1	0.223	−.607	1.083	.305	1	.581
Day 2	−0.479	−1.538	.609	.719	1	.397
Day 3	0.647	−.378	1.702	1.557	1	.212
Day 4	2.209	1.478	2.969	34.184	1	.000
Day 5	2.057	1.270	2.873	25.635	1	.000
Day 6	1.784	.774	2.807	11.929	1	.001

Note 1. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.
Note 2. The reference group was the control group X pre-test. The meaning of the interaction was (experimental group post-test - experimental group pre-test) – (control group post-test - control group pre-test). The change (progress) was compared between the two groups.

system of premature babies, reduce their heartrate and respiration levels, and increase their blood oxygen levels. After the intervention of the MAT, the premature babies' heartrate and respiration levels decreased and their blood oxygen saturation levels increased. In addition, this study found that when the physiological parameters of the premature babies were stable, their sleep states increased, their crying behavior decreased, and their quiet activity behavior increased. The reason might be that MAT provided the premature babies with a social contact signal that reduced their negative stress response. However, this study found that the subjects' body temperature and blood pressure levels did not change significantly after the MAT. Whether this result was associated with the number of days and time of continuous listening to MAT or the week number of premature babies is worthy of continuous investigation in the future. This study found that the intervention of oriental Nanguan music and the use of lullabies in western countries could all lead to changes in heartrate, respiration, and blood oxygen levels. Therefore, oriental Nanguan music and lullabies both have a positive effect on the physiological parameters and behaviors of premature babies.

10. Conclusion

Most of the empirical studies in Europe, the United States, and Taiwan have used Brahms' lullaby, white music, or classical music for music-assisted interventions, and oriental Nanguan music has never been used. Therefore, the use of oriental Nanguan music for MAT was the major feature of this study. This study found that the use of oriental Nanguan music had a significant effect on premature babies' physiological parameters.

This study used oriental Nanguan music as the intervention measure. The inclusion criteria were: premature babies over the age of 28 weeks and under the age of 34 weeks; premature babies who had never used ventilator or sedatives/painkillers; premature babies without hearing impairment, deformity, central nervous system disease, congenital heart disease or other congenital diseases. The premature babies in the experimental group received the MAT for three days, and their physiological parameters were continuously recorded until Day 7. This study found that the premature babies' sleep became stabilized, their crying behavior while awake was reduced, their physiological parameters and behavioral states were stabilized, and their energy consumption was reduced, which was consistent with the results of studies using western lullabies and other music. Apparently, regardless of the type of music, as long as it has a low frequency and a simple melody, it will have a positive effect on the physiological parameters of premature babies.

11. Research limitations and suggestions

This study only enrolled 28- to 34-week-old premature babies as the subjects. In addition, the study site was limited to the NICU, and premature babies using a ventilator were excluded. Therefore, future studies are advised to enroll premature babies using a ventilator, extend the intervention of MAT to at least seven days, expand the follow-up on whether the body weight, growth, and other physiological parameters, and sleep-waking behavior were stabilized following the intervention of MAT. Due to the impact of COVID-19 pandemic, this study only enrolled 41 subjects, and the sample size was too small to make inferences. However, this study still found that there were changes in premature babies' physiological parameters and behavioral states. Future studies should increase the sample size to expand the inferences on the changes in physiological parameters and behavioral states after the intervention of MAT in premature babies. In this way, more differences could be observed in the statistical analysis results.

12. Application to clinical practices

Under the current situation of medical advancement and the active promotion of national health insurance, although premature babies can receive good medical care after birth, the occurrence of complications is still inevitable. In order to reduce the occurrence of complications and avoid the increase of medical costs, clinical practice should include high-quality developmental care for premature babies. Oriental Nanguan music can be used as an intervention to stabilize premature babies' physiological parameters and behavioral states, provide growth energy, integrate development, and reduce the number and length of hospital stays. Hospitals can be encouraged to include MAT as part of the routine care of premature babies and provide relevant courses to healthcare staff to understand the function of MAT and the variety of music choices. Nursing schools can also incorporate MAT into the nursing curriculum. For existing nurses in the workplace, the Premature Baby Foundation of Taiwan should cooperate with various medical institutions in Taiwan to offer related courses, so that neonatal intensive care can be used to not only stabilize the physiological and behavioral states of premature babies but also provide family-centered holistic care that attaches importance to the physical, mental, and spiritual development of parents and children.

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Author statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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