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The effect of mother's voice and music therapy on pain and physiological parameters during the endotracheal suctioning procedure: A randomized controlled study

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ABSTRACT

Objective: This study aimed to examine the effects of maternal voice and music therapy on pain and physiological parameters during the endotracheal suctioning process in intubated children.
Design: The study was a single-centre, randomized controlled trial.
Setting: The Thoracic-Cardiovascular Surgery Intensive Care Unit of a University Hospital in Turkey.
Methods: This study involved three groups of 27 children, aged between 2 and 36 months. All three groups, including the control group (CG), received the standard suction protocol before, during, and after each intervention. Additionally, the children in the music therapy (MT) group listened to music titled 'The Happiest Child', while the children in the mother's voice (MV) group listened to recordings of their mothers' voices. The variables assessed are pain and physiological parameters.
Results: When the pain results of the children were evaluated, the pain score of the children in the control group was found to be significantly higher than children in the mother's voice and music voice group ($p < .05$). It was determined that the lowest FLACC Pain Scale value was in the mother's voice group ($p < .05$). When the physiological parameters results were evaluated, it was determined that the physiological measurement values of the children in the experimental group were positively affected ($p < .05$), there was a significant difference between the control group ($p < .05$) and the most effective result was in the mother's voice group ($p < .05$).
Conclusions: The application of mother's voice and music therapy to children before, during and after the aspiration procedure reduces the pain of children, positively affects their physiological parameters and improves the quality of nursing care.
Implications for clinical practice: This study provides a scientific basis for nursing practices in clinical settings and contributes to clinical practice by shedding light on future evidence-based studies.

Introduction

The most common complication in children undergoing cardiothoracic surgery is pain. Studies have shown that 24–80 % of children undergoing surgery experience moderate to severe pain (Harrison et al., 2014; Walther-Larsen et al., 2017). Children receiving mechanical ventilation are given painful stimuli an average of 10–14 times a day, and endotracheal suctioning is one of the procedures that cause the most pain in these children (American Association of Respiratory Care (AARC), 2010; de Nayara Rodrigues Gomes et al., 2023). Following routine invasive procedures that cause pain, such as endotracheal suctioning, negative physiological, metabolic, and behavioral responses may occur in children as stress and duration and severity of pain increase (Baarslag et al., 2019; Mauritz et al., 2022). Also, a baby with pain cannot adapt to the mechanical ventilator, so mechanical ventilation becomes difficult (Boyle & McIntosh, 2012). Pain that occurs following major surgeries, especially after invasive procedures, has a significant impact on children's health status and should be treated as early as possible (Rabbitts et al., 2017). Adequate pain control not only improves the quality of life of children

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undergoing cardiothoracic surgery but may also improve clinical outcomes (Barr et al., 2020). If pain is not alleviated or eliminated with effective interventions during this period, it may cause neurological and behavioral disorders in the future. Excessive and long-term pain, especially due to the interventions applied, can lead to behavioral stress and physiological imbalances (increased heart rate, respiratory distress, or increase/decrease in blood pressure) (Akcan & Polat, 2017). Interventions such as painful endotracheal suctioning may interfere with children's behavior, eating habits, interaction with the mother, and adaptation to the environment, as well as resulting in postoperative complications. In addition, experiencing pain can affect subsequent pain behaviors, causing the child to have sensitivity to pain throughout life (Yücel et al., 2020).

One of the techniques used in effective pain management in children is non-pharmacological pain management (Riddel et al., 2023). One of the non-pharmacological pain management methods applied to a child to relieve pain is mother's voice (Demir & Konuk Şener, 2023; Erdoğan et al., 2020; Küçük Alemdar, 2013; Williamson & McGrath, 2019) and the other is music therapy (Gökağaç, 2019; Maitre & Arnon, 2020; Qiu et al., 2017; Karakul & Bolışık, 2018; Demir & Konuk Şener, 2023).

Music therapy is one of the widely used non-pharmacological methods in postoperative analgesia, which can increase the release of endorphin hormone and reduce the need for analgesics by lowering catecholamine levels, stabilizing heart rhythm and respiratory rate, maintaining hemodynamic balance, affecting the regional activity of the heart, and reduce blood pressure (Kahloul et al., 2017; Karakul & Bolışık, 2018). Some studies have emphasized that the use of music therapy is an effective method for children who have undergone a major operation such as cardiothoracic surgery to reduce pain caused by interventions such as endotracheal suctioning following surgery, to ensure better oxygenation, and to improve physiological parameters (Karakul & Bolışık, 2018; Suresh et al., 2015). It has also been highlighted that music therapy reduces respiratory frequency, stabilizes breathing, stimulates the pituitary gland to secrete endorphins, and stabilizes heart rate and blood pressure by lowering catecholamine levels (Bradt & Dileo, 2014; Maitre & Arnon, 2020).

Another non-pharmacological method used in effective pain management in children is the mother's voice (Azarmnejad et al., 2015; Erdoğan et al., 2020; Williamson & McGrath, 2019). Although the mechanism of action of the mother's voice in reducing pain is not fully explained in the literature, studies have indicated that the mother's voice creates a relaxing atmosphere for children (Rand & Lahav, 2014). Some studies have shown that listening to the mother's voice before and after interventions such as endotracheal suctioning applied to infants and children in the intensive care unit reduces pain (Chirico et al., 2017; Demir & Konuk Şener, 2023; Erdoğan et al., 2020).

A literature review has shown limited research into the effect of a mother's voice and music therapy on pain and physiological parameters during the suctioning process in intubated children (Demir & Konuk Şener, 2023). It has been emphasized that more studies are needed to demonstrate the effect of "mother's voice and music therapy", which directly affects pain and physiological parameters during the suctioning process in intubated children (Bahadır & Kürtüncü, 2020; Fiona et al., 2016; Gümüş et al., 2020; Karakul & Bolışık, 2018; Sabzevari et al., 2017). Reflecting on this gap and recommendation in the literature, this study aimed to examine the effects of a mother's voice and music therapy on pain and physiological parameters during the suctioning process in intubated children.

Hypotheses of the research

H1. There is a difference between children's pain and physiological parameters in terms of group, time, and group-time interaction.

Materials and methods

Type of the study

This randomized controlled study was conducted between April 2023 and July 2024 with all 2–36-month-old intubated children who were hospitalized in the Thoracic-Cardiovascular Surgery Intensive Care Unit of a University Hospital in the western region of Turkey, had parental permission, and met the inclusion criteria. Patients selected using the stratified randomization method and met the sampling criteria were included in the study. The sample size of the study was calculated on the GPOWER 3.1 statistical analysis software based on a significance level of 0.05, a power of 95 %, and a medium effect size. It was found that 22 children were in each group to analyze variance in repeated measurements. Considering a 20 % attrition in the study, it was decided to include 27 infants in each group. Eventually, 81 infants whose parents voluntarily agreed to participate in the study were included in the sample. Of these children, 27 were assigned to the experimental group 1 (music therapy group), 27 to the experimental group 2 (mother's voice group), and 27 to the control group. Inclusion criteria were as follows: a) child aged between 2 and 36 months; b) passing the neonatal audiology test; c) requiring endotracheal suctioning; d) having stable hemodynamic parameters as followed on the monitor: "Pulse: (80–130 beats per minute), blood pressure (systolic): (60–105 mmHg), blood pressure (diastolic): (20–66 mmHg), respiratory rate: (20–50 breaths per minute), Oxygen Saturation: (%90–100), e) passing two hours since the last painful intervention; and f) parent's written consent showing voluntary participation in the research. Exclusion criteria were a) having an auditory disability and b) parents' desire to quit the study at any stage.

Randomization

A stratified randomization of the participants was performed by the researcher using a computer-based random number generator (Gender: 2 groups; age: 2 groups: (2 months–12 months, 13 months–36 months)). Of the 85 children evaluated for inclusion in the study, four were excluded from the study; one child did not pass the newborn audiology test, and the parents of three children declined to participate. The final study sample comprised 81 children. It is recommended that all stages of randomized controlled trials be carried out according to Consolidated Standards of Reporting Trials (CONSORT). The study was carried out based on the CONSORT 2017 (Updated Guidelines for Reporting Randomized Parallel Group Studies) guidelines (Fig. 1) (Schulz et al., 2010).

Instruments

Demographic form

This form was prepared by the researchers following a literature review. It consisted of questions about socio-demographic characteristics, the child's disease, and the parent's pain knowledge (Bahadır & Kürtüncü, 2020; Karakul & Bolışık, 2018). It was also used to record the child's physiological parameters (heart rate, blood pressure (systolic and diastolic), respiratory rate, and oxygen saturation) during a painful procedure.

FLACC (Face, Legs, Arms, Cry, Consolability) pain scale

The abbreviation FLACC is made up of the initials of the words face, legs, activity, cry, and consolability. The FLACC pain scale, developed by Merkel et al. in 1997 (Merkel et al., 1997), is used to evaluate the behavioral reactions to pain in children aged two months to seven years, who cannot express their pain and cannot communicate verbally. The FLACC pain scale is used to assess five behavioral domains (infant-child facial expression, mobility of the leg, activity, crying, and consolability) with scores ranging from 0 to 2 for each item. Scores on

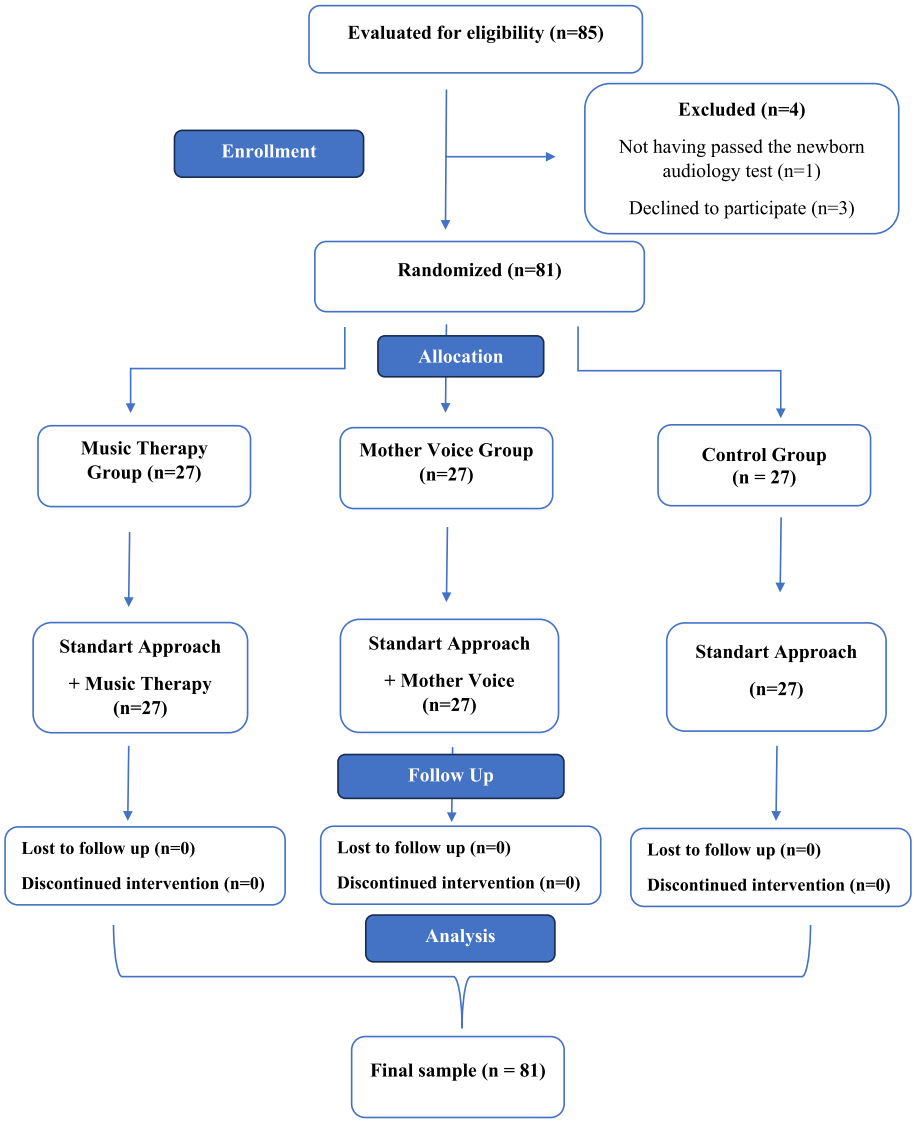

Fig. 1. CONSORT flow diagram.

the scale range from 0 to 10. It is stated that as the score increases, the pain level increases and that there is less pain when the score decreases. Scores are interpreted as follows: 0, no pain; 1–3, mild pain; 4–6, moderate pain; 7–10, severe pain. The validity and reliability of the FLACC pain scale in our country were determined by Şenaylı et al. (2016). As a result of the validity-reliability study conducted on infants and children between the ages of 1 month and 9 years who presented to 21 pediatric surgery clinics, the usability of the scale in our country was demonstrated. The five domains of the FLACC pain scale were adapted into Turkish as face, leg mobility, activity, crying, and consolability (Şenaylı et al., 2016). This scale can be applied observationally by health professionals.

Data collection

Parents of children who met the inclusion criteria were informed about the study, and children of parents who agreed to participate in the study were included. The parents were informed that the endotracheal suctioning procedure was a routine practice, the data would be recorded by three nurses and an observer who would perform the endotracheal suctioning procedure, and that the mother's voice and music therapy would also be used for pain relief, and their written consent was obtained. Then, researcher D determined which group the child belonged to using stratified randomization. Children and parents did not know which group they were included at the time of allocation concealment. The standard approach was applied to all children.

Standard approach

In the clinical routine, Paracetamol Intravenous (IV), 10 mg/kg, 4–6 dose intervals with a maximum daily dose of 40 mg/kg is administered in children aged 5–10 years for postoperative pain control. Nonsteroidal anti-inflammatory drugs (NSAIDs) are effective agents in the treatment of mild to moderate pain. They have anti-inflammatory and antipyretic effects in addition to analgesic effect effect effect effect effects. They provide better analgesia when used with paracetamol as part of multimodal analgesia. NSAIDs can be used when necessary. Endotracheal suctioning was performed by three nurses, and asepsis rules were followed. These nurses were not researchers. They had an undergraduate degree and were responsible for conducting the intervention. They had no conflict of interest, and all of them agreed to participate. The suctioning process was limited to 5–10 s as a clinical routine practice and free-flow oxygen support was given by the nurse assisting suctioning, keeping as close as possible to the endotracheal tube. The

child was monitored throughout the endotracheal suctioning procedure, and the procedure was terminated. Following the suctioning process, ventilation with a bag mask was continued for 60–90 s, and then the child was connected to a mechanical ventilator. After the endotracheal suctioning process was completed, the child was placed in an appropriate position. Children to be included in the study in each group were in their beds at rest until 30 min before the procedure began. The heart rate, blood pressure, respiratory rate, and oxygen saturation values of all the children who were monitored and the pain score evaluated with the FLACC (Face, Legs, Arms, Cry, Consolability) Pain Scale were recorded in the data form by the researchers two minutes before endotracheal suctioning, during the endotracheal suctioning and two minutes after the endotracheal suctioning procedure. No additional care was given to ensure physiological stability in all groups.

Control group

No additional intervention was performed on the control group children. A standard procedure was applied by researcher "F" and three nurses before, during the process, and after the endotracheal suctioning and the data were recorded in the form. Researcher "F" knew which groups the children were included in as she/he was not blinded to the groups. No additional care was given to provide physiological stability and reduce pain.

Mother's voice group

The parents of the mother's voice group children were explained that parental voice would be used for pain relief in the research. In the study, the researcher recorded the voice of the mother of each child who was admitted to intensive care. To ensure consistency, the same sentences were read to each mother, and each mother's voice was recorded for two minutes. Mothers were blinded to their children's groups. Measurements were made by placing the player 50 cm closer to the child and allowing him/her to listen to their mother's voice. The sound level of the player was set at an average of 45 dB. The speaker was placed approximately 30 cm from the child's ear to the side of the foot two minutes before the procedure.

Music therapy group

The parents of the music therapy group were informed about the endotracheal suctioning to be applied to the child, the owner and copyright of the piece of music to be used during the music therapy, the purpose for which the music would be used, and the purpose of the study. After obtaining consent, music therapy was applied to the children two minutes before, during the process, and after the procedure. Meanwhile, the data were recorded in the form by the observer. The parent of each child admitted to intensive care was informed about music therapy, and the parent was blinded to the group of the child. During the music therapy practice, a piece of music called "The Happiest Child" developed by FMK, one of the researchers with a rhythm therapist certificate, was used. The music used as a therapeutic intervention to stabilize physiological parameters and manage pain used a short, flowing melody with a tempo of 60 beats per minute, was slow, nonlyrical, and dramatic, and had no distracting chords or dissonant minors. The copyright of the music, which had low tones, minimal percussion, and a volume of approximately 45 dB, belonged to researcher FMK. The speaker was placed at the side of the foot, approximately 30 cm from the child's ear, two minutes before the procedure.

In both separate initiatives, two minutes before, during, and two minutes after the standard endotracheal suctioning procedure, the researcher designated as "D" performed the interventions on the child. During this period, another researcher, identified as "I," recorded the children's heart rate, blood pressure, respiratory rate, oxygen saturation levels, and pain scores, which were assessed using the FLACC (Face, Legs, Arms, Cry, Consolability) scale, on a data form. Researcher "I" was not blinded to the children, whereas the nurses and researcher "D" were blinded to the scores assigned by researcher "I." The data were subsequently coded as "A," "B," and "C" by the researchers and transferred to a computer file.

Ethical considerations

Institution approval was obtained from the University Hospital where the study was conducted, with further approval granted by the Non-interventional Clinical Trials Ethics Committee, with approval number 2023/10–12 dated March 29, 2023. Written consent was obtained from parents present with the child. This study is registered with ClinicalTrials.gov: NCT06230211. With (the Law of the Protection of Personal Data), all the records and corresponding informed consent to participation were stored safely by the principal investigator.

Data analysis

Data analysis was conducted by the researcher "M", who was blinded to the groups. Percentages and means were used to evaluate the demographic characteristics of the sample. The data were analyzed using the SPSS (22.0) software. The normality of the data was evaluated using skewness and kurtosis values. It was determined that the kurtosis and skewness values of the data were in the range of ± 2. Demographic data in the intervention and control groups were compared using the chi-square and One-way ANOVA. Since the data showed a normal distribution, repeated measurement of variance analysis and one-way ANOVA tests were used to compare physiological parameters and mean pain scores obtained from the scale. In repeated measurement of variance analysis, whether there is a difference between the groups according to group, time, and group*time interaction is evaluated. The term "group" refers to the categorical independent variable that compares the experimental and control groups based on their exposure to the intervention. In this study, participants were classified into two distinct groups: the experimental group, which received the intervention, and the control group, which did not. This distinction allows for a comparative analysis of intervention effects across different groups. The "time" variable denotes the temporal dimension at which the measurements were collected. For this study, measurements were taken at three critical time points: a baseline assessment conducted before and during the intervention and a follow-up assessment conducted after the intervention's implementation. The time variable enables the investigation of changes within and across groups. The "group*time interaction" variable represents the combined effect of group membership and time on the dependent variable. This interaction term is particularly relevant in assessing whether the changes observed over time differ significantly between the experimental and control groups. Specifically, it captures the extent to which the intervention has a differential impact on the experimental group relative to the control group across the three time points. Multivariate analysis of variance for repeated measurements was employed to compare physiological parameters and the pain score obtained from the scale according to group, time, and group*time interaction. For any statistically significant differences between the three groups, post hoc paired comparisons were conducted using the Bonferroni adjusted *t*-test. The power and effect size of the study were determined according to the analysis of variance in repeated measurements. The significance level was accepted as $p < .05$.

Results

Sample characteristics

The distribution of children's descriptive characteristics across groups is presented in Table 1. Variables such as the child's gender, age group, history of surgery, parental education level, parental age,

Table 1
Characteristics of children and parents in the study sample.

Child characteristics	Music Therapy Group ($n = 27$) n(%)	Maternal Voice Group (n = 27) n(%)	Control Group (n = 27) n(%)	X^2	p
Gender				0.300	0.861
Boy	11(41)	13(48)	12(44)		
Girl	16 (59)	14(52)	15(56)		
Age (month)				7.679	0.368
2–12	14(52)	13(52)	17(63)		
13–36	13(48)	14(48)	10(37)		
The surgery the child had				11.663	0.476
Atrial Septal Defect	4(15)	4(15)	11(41)		
Ventricular Septal Defect	5(19)	7(26)	5(19)		
Atrioventricular Septal Defect	5(19)	8(30)	4(15)		
Tetralogy of Fallot	3(11)	3(11)	1(3)		
Patent Ductus Arteriozus	2(7)	1(3)	1(3)		
Others	8(30)	4(15)	5(19)		
Has the child had surgery before?				0.159	0.810
Yes	2(7)	0(0)	1(3)		
No	25(94)	27(100)	26(97)		
The parent's closeness to the child				0.587	0.746
Mother	26(97)	25(94)	27(100)		
Father	1(3)	2 (7)	0(0)		
Parent characteristics	*M ± SD*	*M ± SD*	*M ± SD*	*F*	*p*
Parent age (year)	38.1 ± 6.0	37.2 ± 5.3	36.1 ± 6.1	6.316	0.531
Number of children	2.6 ± 1.0	2.7 ± 0.9	2.5 ± 0.9	1.012	0.348
	n(%)	n(%)	n(%)	X^2	*p*
Level of education				2.579	0.958
Elementary	15(56)	17(63)	14(52)		
High School	5(18)	8(30)	11(41)		
University	7(26)	2(7)	2(7)		
Did the parent receive training before the surgery?				3.722	0.155
Yes	15 (56)	10(37)	14(52)		
No	12 (44)	17(63)	13(48)		
Does the parent use music therapy to reduce their child's pain?				2.829	0.243
Yes	0(0)	0(0)	1(3)		
No	27(100)	27(100)	26(97)		

X^2: Chi-square, F: Anova test *p < .05.

number of children, parents' preoperative education, and parents' use of music therapy to alleviate the child's pain were found to be homogeneous ($p > .05$). In the music therapy group, 14 children (52 %) were between two and 12 months old, while 13 children (48 %) were between 13 and 36 months old. Additionally, 11 children (41 %) were boys, and 16 children (59 %) were girls. In the mother's voice group, 13 children (48 %) were between two and 12 months old, whereas 14 children (52 %) were between 13 and 36 months old. In this group, 13 children (48 %) were boys, and 14 children (52 %) were girls. In the control group, 17 children (63 %) were between two and 12 months old, while 10 children (37 %) were between 13 and 36 months old. Furthermore, 12 children (44 %) were boys, and 15 children (56 %) were girls. Regarding surgical history, in the music therapy group, 5 children (19 %) underwent ventricular septal defect surgery, 5 children (19 %) underwent atrioventricular septal defect surgery, and 8 children (30 %) underwent other types of surgery. Moreover, 25 children (94 %) in this group had never undergone surgery before. In the mother's voice group, 8 children (30 %) underwent atrioventricular septal defect surgery, and 7 children (26 %) underwent ventricular septal defect surgery. Notably, all children (100 %, $n = 27$) in this group had no prior surgical history. In the control group, 11 children (41 %) underwent atrial septal defect surgery, 5 children (19 %) underwent ventricular septal defect surgery, and 8 children (30 %) underwent other types of surgery. Additionally, 26 children (97 %) in the control group had never undergone surgery before. In the music therapy group, 97 % ($n = 26$) of the parents were mothers, compared to 94 % ($n = 25$) in the mother's voice group and 100 % ($n = 27$) in the control group. The average parental age was 38.1 ± 6.0 years in the music therapy group, 37.2 ± 5.3 years in the mother's voice group, and 36.1 ± 6.1 years in the control group. Regarding education level, 56 % ($n = 15$) of parents in the music therapy group, 63 % ($n = 17$) in the mother's voice group, and 52 % ($n = 14$) in the control group had completed elementary education. Additionally, 56 % (n = 15) of parents in the music therapy group and 63 % (n = 17) in the mother's voice group had received preoperative training, whereas 52 % (n = 14) of parents in the control group had not received such training. Furthermore, it was determined that 100 % (n = 27) of the parents in both the music therapy and mother's voice groups, as well as 97 % of the parents in the control group, had never used music therapy as a method of pain reduction.

Physiological parameters before, during, and after the endotracheal suctioning process according to groups

Heart rate before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 2). In the post-hoc analysis, no statistically significant difference was observed between the groups in terms of heart rate before endotracheal suctioning ($p > .05$). However, a statistically significant difference was found between the groups in terms of heart rate during and after suctioning ($p < .05$) (Table 4). According to Bonferroni-adjusted paired comparisons, the differences in heart rate values reported by the researcher during and after the suctioning process were attributed to differences between the control group and the music therapy group ($p = .002$) and between the control group and the mother's voice group ($p = .000$). Among the interventions, the mother's voice was found to be more effective in reducing heart rate compared to both the control and music therapy interventions (p < .05).

The intra-group comparison of measurements revealed significant differences in the mother's voice and music therapy groups before, during, and after the intervention ($p < .001$). While heart rate significantly decreased in the mother's voice and music therapy groups, it increased in the control group. Further analyses indicated a significant difference between before and during intervention values (p < .001) and between before and after intervention values (p < .001) in the mother's voice and music therapy groups. However, no significant difference was detected between any measurements in the control group ($p > .05$) (Table 4).

Blood Pressure (systolic) before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 2). In the post-hoc analysis, no statistically significant difference was observed between the groups in terms of systolic blood pressure before endotracheal suctioning (p > .05). However, a statistically significant difference was found between the groups in terms of systolic blood pressure during and after endotracheal suctioning ($p < .05$) (Table 4). According to Bonferroni-adjusted paired comparisons, the differences in systolic blood pressure reported by the researcher during and after the endotracheal suctioning process were attributed to differences between the control group and the music therapy group ($p = .000$) as well as between the control group and the mother's voice group (p = .000). Among the interventions, the mother's voice was found to be more effective in reducing systolic blood pressure compared to both the control and music therapy interventions (p < .05).

Table 2
Comparison of physiological parameters scores before, during and after the endotracheal suctioning process according in groups, at time and at group*time points.

	Music Therapy Group (n = 27)	Mother's Voice Group (n = 27)	Control Group (n = 27)	Group		Time		Group*Time	
	M ± SD(min-max)	M ± SD(min-max)	M ± SD(min-max)	F	p	F	p	F	p
Pulse (beats per minute)				12.331	0.000*	195.290	0.000*	49.916	0.000*
Pre-intervention	131.9 ± 19.9(80–130)	128.7 ± 16.6(80–130)	127.1 ± 15.8(80–130)						
During the intervention	104.4 ± 13.3(80–130)	101.1 ± 16.1(80–130)	127.2 ± 15.3(80–130)						
Post intervention	103.7 ± 12.6(80–130)	99.1 ± 13.3(80–130)	129.1 ± 15.3(80–130)						
Blood Pressure (systolic)(mmHg)				139.919	0.000*	528.251	0.000*	137.515	0.000*
Pre-intervention	132.5 ± 4.0(60–105)	132.2 ± 7.5(60–105)	131.9 ± 5.8(60–105)						
During the intervention	103.9 ± 6.5(60–105)	105.3 ± 5.5(60–105)	132.2 ± 5.8(60–105)						
Post intervention	103.1 ± 6.0(60–105)	103.2 ± 4.0(60–105)	132.2 ± 5.5(60–105)						
Blood Pressure (diastolic) (mmHg)				113.616	0.000*	257.245	0.000*	64.848	0.000*
Pre-intervention	76.5 ± 4.9(20–66)	75.8 ± 3.5(20–66)	75.7 ± 2.8(20–66)						
During the intervention	59.6 ± 2.8(20–66)	63.6 ± 4.6(20–66)	75.8 ± 3.1(20–66)						
Post intervention	58.8 ± 2.8(20–66)	63.7 ± 4.6(20–66)	75.8 ± 4.5(20–66)						
Respiratory Rate (breaths per minute)				55.557	0.000*	382.979	0.000*	121.851	0.000*
Pre-intervention	48.8 ± 6.7(20–50)	48.8 ± 6.9(20–50)	48.7 ± 6.4(20–50)						
During the intervention	27.9 ± 4.3(20–50)	30.1 ± 8.1(20–50)	49.6 ± 6.1(20–50)						
Post intervention	28.0 ± 3.7(20–50)	30.2 ± 7.8(20–50)	50.1 ± 6.2(20–50)						
Oxygen Saturation (%)				9.552	0.000*	131.421	0.000*	37.072	0.000*
Pre-intervention	92.0 ± 0.6(90–100)	92.1 ± 3.5(90–100)	92.4 ± 3.9(90–100)						
During the intervention	94.7 ± 3.0(90–100)	96.3 ± 2.0(90–100)	91.4 ± 3.8(90–100)						
Post intervention	96.6 ± 2.7(90–100)	97.9 ± 1.6(90–100)	91.3 ± 3.7(90–100)						

Abbreviations: *$p < .05$, F:Repeated Measures ANOVA.

The intra-group comparisons revealed significant differences in the values obtained before, during, and after the intervention in the mother's voice and music therapy groups ($p < .001$). While systolic blood pressure significantly decreased in the mother's voice and music therapy groups, a slight increase was observed in the control group. Further analyses indicated a significant difference between all measurements in the mother's voice group ($p < .001$) and between before and during intervention ($p < .001$) as well as before and after intervention values ($p < .001$) in the music therapy group. However, no significant difference was detected between any measurements in the control group ($p > .05$) (Table 4).

Blood Pressure (diastolic) before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 2). In the post-hoc analysis, no statistically significant difference was observed between the groups in terms of diastolic blood pressure before endotracheal suctioning ($p > .05$). However, a statistically significant difference was found between the groups in terms of diastolic blood pressure during and after endotracheal suctioning ($p < .05$) (Table 4). According to Bonferroni-adjusted paired comparisons, the differences in diastolic blood pressure reported by the researcher during and after the endotracheal suctioning process were attributed to differences between the control group and the music therapy group ($p = .000$) as well as between the control group and the mother's voice group ($p = .000$). Among the interventions, the mother's voice was found to be more effective in reducing diastolic blood pressure compared to both the control and music therapy interventions ($p < .05$).

The intra-group comparisons revealed significant differences between the values obtained before, during, and after the intervention in the mother's voice and music therapy groups ($p < .001$). While diastolic blood pressure significantly decreased in the mother's voice and music therapy groups, no change was observed in the control group. Further analyses indicated a significant difference between before and during intervention ($p < .001$) as well as before and after intervention values ($p < .001$) in the mother's voice and music therapy groups. However, no significant difference was detected between any measurements in the control group ($p > .05$) (Table 4).

Respiratory rate before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 2). In the post-hoc analysis, no statistically significant difference was observed between the groups in terms of respiratory rate before endotracheal suctioning ($p > .05$). However, a statistically significant difference was found between the groups in terms of respiratory rate during and after endotracheal suctioning ($p < .05$) (Table 4). According to Bonferroni-adjusted paired comparisons, the differences in respiratory rates reported by the researcher during and after the endotracheal suctioning process were attributed to differences between the control group and the music therapy group ($p = .000$) as well as between the control group and the mother's voice group ($p = .000$). Among the interventions, the mother's voice was found to be more effective in reducing respiratory rate compared to both the control and music therapy interventions ($p < .05$).

In the intra-group comparison of measurements, significant differences were found between the before during and after intervention values in the control, mother's voice, and music therapy groups ($p < .001$). While the respiratory rate significantly decreased in the mother's voice and music therapy groups, it significantly increased in the control group ($p < .001$). Further analyses revealed significant differences between before and during intervention ($p < .001$) as well as before and after intervention values ($p < .001$) in the mother's voice and music therapy groups. Additionally, significant differences were found between all measurements in the control group ($p < .001$) (Table 4).

Oxygen saturation before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 2). In the post-hoc analysis, no statistically significant difference was observed between the groups in terms of oxygen saturation before endotracheal suctioning ($p > .05$). However, a statistically significant difference was found between the groups in terms of oxygen saturation during and after endotracheal suctioning ($p < .05$) (Table 4). According to

Bonferroni-adjusted paired comparisons, the differences in oxygen saturation values reported by the researcher during and after the endotracheal suctioning process were attributed to differences between the control group and the music therapy group ($p = .020$) as well as between the control group and the mother's voice group ($p = .000$). Among the interventions, the mother's voice was found to be more effective in increasing oxygen saturation compared to both the control and music therapy interventions ($p < .05$).

The intra-group comparisons revealed significant differences in oxygen saturation values before, during, and after the intervention in the mother's voice and music therapy groups ($p < .001$). While oxygen saturation significantly increased in the mother's voice and music therapy groups, no change was observed in the control group ($p > .05$). Further analyses indicated significant differences between all measurements in the mother's voice and music therapy groups ($p < .001$), whereas no significant difference was detected between any measurements in the control group ($p > .05$) (Table 4).

Pain scores before, during, and after the endotracheal suctioning process according to groups

As a result of the analysis, statistically significant differences were found between the mean scores of the groups in terms of group, time, and group-time interactions (Table 3). In the post-hoc analysis, no statistically significant difference was found between the groups in terms of pain scores before endotracheal suctioning ($p > .05$). However, a statistically significant difference was observed between the groups in terms of pain scores during and after endotracheal suctioning ($p < .05$) (Table 3). According to Bonferroni-adjusted paired comparisons, the differences in researcher-reported pain scores during and after the endotracheal suctioning process were attributed to differences between the control group and the music therapy group ($p = .000$) as well as between the control group and the mother's voice group ($p = .000$). The mother's voice was found to be more effective in reducing pain scores compared to both the control and music therapy interventions ($p < .05$). According to intra-group comparisons, pain scores differed significantly before, during, and after the intervention in the mother's voice and music therapy groups ($p < .001$). While pain scores significantly decreased in the mother's voice and music therapy groups, they increased in the control group. Further analyses revealed significant differences between all measurements in the mother's voice and music therapy groups ($p < .001$), whereas no significant difference was detected between any measurements in the control group ($p > .05$) (Table 5).

Power and effect size of the study

The power and effect size of the study were calculated based on pain, the primary variable. According to the group*time interaction, the power of the study was found to be 99 %, and the effect size was 1.107 (Cohen's *f*, large effect).

Discussion

It is known that non-pharmacological methods are effective in reducing pain in children, and they increase the effectiveness of analgesics when used together (Thrane et al., 2016). Developing appropriate pain control strategies with the awareness of the impact of pain on children is a medical and ethical responsibility (Töruner & Büyükgönenç, 2015). This study examined the effects of the mother's voice and music therapy on pain and physiological parameters during the endotracheal suctioning procedure in intubated children between the ages of 2 and 36 months. There was no statistical difference between the groups in terms of socio-demographic data, so the groups were found to be homogeneous ($p > .05$), (Table 1), which was one of the strengths of the study. Also, it was observed that the effect of variables on the research results was eliminated. It is thought that variables that were likely to affect the research results could be controlled and that the similarity of the groups reduced bias and increased the reliability of the research.

Other studies have been reviewed examining the effects of using a mother's voice and music therapy on physiological parameters during the suctioning process. In a study conducted by Karakul and Bolışık (2018), when the heart rate, systolic blood pressure, diastolic blood pressure, and respiratory rate of the group receiving music therapy was examined, in parallel with this study, it was observed that there was a statistically significant difference between the experimental and control groups ($p < .05$) (Karakul & Bolışık, 2018). Similar to this study, in a study conducted by Erdoğan et al. (2020), it was found that the heart rate of children in the intervention group aged 1–3 years who listened to their mother's voice during painful procedures was lower than that of the control group ($p < .05$). Similarly, Erdoğan et al. (2020) found that the oxygen saturation values of children who listened to their mother's voice were higher than those of the control group ($p < .05$) (Erdoğan et al.,2020). In a study conducted by Sabzevari et al. (2017) on the effect of postoperative music therapy on physiological parameters, there was a statistically significant difference between the heart rate, systolic blood pressure and diastolic blood pressure values of the experimental and control groups ($p < .05$). In the same study, a significant difference was found in heart rate both before and after the intervention ($p < .05$), whereas no significant difference was observed in systolic blood pressure either before or after the intervention ($p > .05$). However, a significant difference was found in diastolic blood pressure only before the intervention ($p < .05$) (Sabzevari et al., 2017). This is also one of the strengths of this study.

In a study conducted by Demir and Konuk Şener in 2023, which examined the effects of music and a mother's voice on pain and physiological parameters before, during, and after the endotracheal suctioning process in children receiving mechanical ventilation, it was found that there was a significant difference in the heart rate, respiratory rate, and oxygen saturation values of the children in the experimental group compared to the control group during and after endotracheal suctioning ($p < .05$). In the same study, a statistically significant difference was found in heart rate between before and during the intervention, as well as between during and after the intervention in children

Table 3
Comparison of pain scores before, during and after the endotracheal suctioning process according in groups, at time and at group*time points.

	Music Therapy Group (n = 27)	Mother's Voice Group (n = 27)	Control Group (n = 27)	Group		Time		Group*Time	
	M ± SD(min-max)	M ± SD(min-max)	M ± SD(min-max)	F	p	F	p	F	p
Pain scores by FLACC*									
Pre-intervention	7.4 ± 1.7(0−10)	6.8 ± 2.0(0–10)	6.4 ± 2.0(0–10)	13.225	0.000**	209.356	0.000**	47.842	0.000**
During the intervention	3.8 ± 1.5(0–10)	3.2 ± 2.0(0–10)	7.3 ± 2.0(0–10)						
Post intervention	2.3 ± 2.0(0–10)	1.8 ± 2.3(0–10)	7.5 ± 1.8(0–10)						

Abbreviations: *FLACC (The face, legs, activity, cry, consolability) Behavioral Pain Assessment Scale, **$p < 0,05$, F: Repeated Measures ANOVA.

Table 4
Comparison of physiological parameters scores before, during and after the endotracheal suctioning process according to groups.

Variables		Music Therapy Group (n = 27) M ± SD(min-max)	Mother's Voice Group (n = 27) M ± SD(min-max)	Control Group (n = 27) M ± SD(min-max)	F	P
Pulse (beats per minute)						
Pre-intervention		131.9 ± 19.9(80–130)	128.7 ± 16.6(80–130)	127.1 ± 15.8(80–130)	1.478	0.234
During the intervention		104.4 ± 13.3(80–130)	101.1 ± 16.1(80–130)	127.2 ± 15.3(80–130)	24.194	0.000*
Post intervention		103.7 ± 12.6(80–130)	99.1 ± 13.3(80–130)	129.1 ± 15.3(80–130)	31.924	0.000*
	F	76.039	167.721	0.000		
	p	<0.001	<0.001	1.000		
Blood Pressure (systolic)(mmHg)						
Pre-intervention		132.5 ± 4.0(60–105)	132.2 ± 7.5(60–105)	131.9 ± 5.8(60–105)	1.287	0.282
During the intervention		103.9 ± 6.5(60–105)	105.3 ± 5.5(60–105)	132.2 ± 5.8(60–105)	194.740	0.000*
Post intervention		103.1 ± 6.0(60–105)	103.2 ± 4.0(60–105)	132.2 ± 5.5(60–105)	245.310	0.000*
	F	377.226	207.433	3.250		
	p	<0.001	<0.001	0.083		
Blood Pressure (diastolic) (mmHg)						
Pre-intervention		76.5 ± 4.9(20–66)	75.8 ± 3.5(20–66)	75.7 ± 2.8(20–66)	0.669	0.584
During the intervention		59.6 ± 2.8(20–66)	63.6 ± 4.6(20–66)	75.8 ± 3.1(20–66)	146.188	0.000*
Post intervention		58.8 ± 2.8(20–66)	63.7 ± 4.6(20–66)	75.8 ± 4.5(20–66)	158.982	0.000*
	F	127.362	140.409	0.194		
	p	<0.001	<0.001	0.770		
Respiratory Rate (breaths per minute)						
Pre-intervention		48.8 ± 6.7(20–50)	48.8 ± 6.9(20–50)	48.7 ± 6.4(20–50)	2.409	0.097
During the intervention		27.9 ± 4.3(20–50)	30.1 ± 8.1(20–50)	49.6 ± 6.1(20–50)	93.687	0.000*
Post intervention		28.0 ± 3.7(20–50)	30.2 ± 7.8(20–50)	50.1 ± 6.2(20–50)	105.330	0.000*
	F	216.070	206.062	33.346		
	p	<0.001	<0.001	<0.001		
Oxygen Saturation (%)						
Pre-intervention		92.0 ± 0.6(90–100)	92.1 ± 3.5(90–100)	92.4 ± 3.9(90–100)	4.275	0.017
During the intervention		94.7 ± 3.0(90–100)	96.3 ± 2.0(90–100)	91.4 ± 3.8(90–100)	12.076	0.000*
Post intervention		96.6 ± 2.7(90–100)	97.9 ± 1.6(90–100)	91.3 ± 3.7(90–100)	28.359	0.000*
	F	90.606	51.740	0.520		
	p	<0.001	<0.001	0.477		

Abbreviations: *p < 0,05, F: One-way ANOVA or Repeated Measures ANOVA.

who received the mother's voice. A statistically significant difference in respiratory rate was found only between during and after the intervention. Systolic blood pressure showed a statistically significant difference only before the intervention, while diastolic blood pressure had significant differences between before and during, as well as between during and after the intervention. Regarding oxygen saturation, statistically significant differences were observed between before and during, before and after, as well as during and after the intervention ($p < .05$). In children who received music therapy, no statistically significant difference was found in heart rate over time. A statistically significant difference in respiratory rate was observed only between before and during the intervention. Statistically significant differences were found in both systolic and diastolic blood pressure between before and during the intervention, as well as between during and after the intervention. Regarding oxygen saturation, a statistically significant difference was found only between before and after the intervention ($p < .05$) (Demir & Konuk Şener, 2023). This is also one of the strengths of this study. It is believed that the mother's voice, in particular, and music therapy contribute to a decrease in blood pressure levels by calming the children and reducing their pain levels. In the same study, similar to the findings, it was observed that the mother's voice was more effective in reducing heart rate than standard care in the control group and the music therapy intervention (Demir & Konuk Şener, 2023).

In this study and other parallel studies, it is thought that the reason why the mother's voice was more effective in reducing pain is that it is the voice the baby recognizes from the womb, creating a soothing and reassuring atmosphere. Additionally, it was found that the mother's voice was more effective in increasing oxygen saturation than routine care in the control group and the music therapy intervention. This can be explained by both the mother's voice and music therapy helping relax the children, reduce their pain levels, and thus improve oxygenation (Demir & Konuk Şener, 2023).

Küçük Alemdar (2013) reported that there was a significant difference between the oxygen saturation values of the babies in the mother's voice and control groups before, during, and after endotracheal suctioning ($p < .05$) (Küçük Alemdar, 2013). In a study by Chirico et al. (2017), babies listened to their mother's voice before, during, and after invasive interventions, and in parallel with this study, there was a significant difference between the oxygen saturation values of the babies in the mother's voice and control groups before, during,

Table 5
Comparison of pain scores before, during and after the endotracheal suctioning process according to groups.

Variables	Music Therapy Group (n = 27) M ± SD(min-max)	Mother's Voice Group (n = 27) M ± SD(min-max)	Control Group (n = 27) M ± SD(min-max)	F	p
Pain scores by FLACC*					
Pre-intervention	7.4 ± 1.7(0–10)	6.8 ± 2.0(0–10)	6.4 ± 2.0(0–10)	1.572	0.214
During the intervention	3.8 ± 1.5(0–10)	3.2 ± 2.0(0–10)	7.3 ± 2.0(0–10)	18.027	0.000**
Post intervention	2.3 ± 2.0(0–10)	1.8 ± 2.3(0–10)	7.5 ± 1.8(0–10)	38.629	0.000**
F	306.159	106.542	106.542		
p	<0.001	<0.001	0.640		

Abbreviations: *FLACC (The face, legs, activity, cry, consolability) Behavioral Pain Assessment Scale, **p < 0,05, F: One-way ANOVA or Repeated Measures ANOVA.

and after the intervention ($p < .05$). In a meta-analysis conducted by Jin et al. (2023), which included eight randomized controlled studies, it was found that the mother's voice significantly increased oxygen saturation and reduced heart rate, findings that are consistent with the results of this study (Jin et al., 2023).

Other studies in the literature examining the effects of using a mother's voice and music therapy on pain during the suctioning process have been reviewed. Similarly, Karakul and Bolışık (2018) reported that the pain score of the music therapy group was statistically significantly different from that of the control group ($p < .05$) (Karakul & Bolışık, 2018). Erdoğan et al., parallel to this study, found that the pain scores of children who listened to their mother's voice during painful procedures were lower than those of the control group ($p < .05$) (Erdoğan et al.,2020). In a study conducted by Sabzevari et al., it was found that there was a statistically significant difference in the pain scores of the music therapy group and the control group ($p < .05$) (Sabzevari et al., 2017). Küçük Alemdar (2013) reported a significant difference between the pain scores of the babies in the mother's voice and control groups before, during, and after endotracheal suctioning ($p < .05$) (Küçük Alemdar, 2013). Demir and Konuk Şener (2023) stated that there was a significant difference between the pain scores of the children in the experimental group compared to the control group before and during endotracheal suctioning, but that there was no significant difference after endotracheal suctioning ($p < .05$). In the same study, statistically significant differences were found in pain scores for children who received both mother's voice and music therapy, between before and during the intervention, before and after the intervention, as well as during and after the intervention ($p < .05$). However, no significant differences were found over time in the control group (Demir & Konuk Şener, 2023). In many studies conducted parallel to this one, music therapy applied to experimental groups following surgery significantly reduced the pain scores of children, and there was a statistically significant difference between the experimental and control groups ($p < .05$) (Bahadır & Kürtüncü, 2020; Fiona et al., 2016; Gümüş et al., 2020). In a meta-analysis study by Jin et al. (2023), similar to this study, it was determined that mother's voice significantly reduced pain. The reduction in pain can be explained by the fact that a mother's voice and music therapy provide confidence and relaxation by reducing pain in children.

This study concluded that the interventions had 99 % power and large effect size and could be used effectively to reduce children's pain and regulate their physiological parameters during endotracheal suctioning.

This study has proven that listening to the mother's voice and applying music therapy are two approaches that can be used as effective methods in pain management in critical care environments where mothers cannot actively participate in the care of their babies (Chirico et al., 2017; Demir & Konuk Şener, 2023; Erdoğan et al., 2020; Tuncay & Sarman, 2020).

This study's findings suggest that music therapy and the mother's voice can have significant analgesic effects during endotracheal suctioning. These effects may be partially explained by the role of endogenous opioid mechanisms, particularly the release of endorphins. Music therapy is known to stimulate the limbic system, binding to opioid receptors and reducing pain perception, leading to the release of endorphins, which act as natural painkillers. Similarly, the mother's voice, as a familiar and comforting auditory stimulus, may evoke a sense of safety and emotional regulation, further attenuating pain perception through decreased sympathetic nervous system activation. This dual mechanism, physiological through endorphin release and psychological through emotional reassurance, underscores the multidimensional benefits of these non-pharmacological interventions. These findings highlight the potential for integrating such approaches into clinical practice to enhance patient comfort during invasive procedures. Music therapy can directly influence respiratory and heart rates, helping to create a more balanced rhythm. On the other hand, a mother's voice naturally possesses soothing and rhythmic tones. As a familiar and trusted stimulus from birth, the mother's voice fosters a sense of "attachment," helping the child feel secure. This sense of security reduces stress and contributes to stabilizing vital signs. When stress levels decrease, the overactivation of the sympathetic nervous system manifested through increased heart rate, elevated blood pressure, and rapid breathing can be controlled. Both music therapy and a mother's voice play a vital role in promoting psychological relaxation, reducing stress, and balancing the autonomic nervous system. These interventions support the stabilization of vital signs during procedures like aspiration. Scientific studies have demonstrated that such methods are effective complementary approaches for mitigating the adverse effects of invasive procedures. A literature review reveals that limited research has been conducted on how a mother's voice and music therapy affect pain and physiological parameters during the suctioning process in intubated children (Demir & Konuk Şener, 2023). This study demonstrated the positive effects of both a mother's voice and music therapy on pain and physiological parameters during the suctioning process. These findings represent the strengths of this study.

Conclusion

At the end of this study, it was found that the mother's voice and music therapy applied to children before, during, and after the endotracheal suctioning procedure reduced pain and positively affected physiological parameters (pulse, respiration rate, blood pressure (systolic and diastolic), oxygen saturation). In line with these results, it is recommended that the mother's voice and music be integrated into an endotracheal suctioning process that is routinely applied to children on mechanical ventilation support to positively affect pain management and physiological parameters in children. For this reason, it is important to cooperate with the parents, and families should be supported in assisting with care. Healthcare professionals should be educated on pain elimination methods in children, and this education should be repeated at specific times. Besides, it is suggested that evidence-based studies be conducted to evaluate the effectiveness of music therapy and mothers' voices over various ages and larger sample groups.

Study limitations

This study has several limitations. This randomized study was conducted with children between 2 and 36 months; it cannot be generalized to other age groups. A small sample size was reached since the study was conducted only in the Thoracic Cardiovascular Surgery Intensive Care Unit of a single university hospital. However, the sample size was sufficient for the study. The preoperative preparation and postoperative pain protocol of the clinic where the study was conducted was applied and could not be excluded during the study process. In this study, there was a direct observation, but video recording was impossible due to a lack of parental consent.

Relevance to clinical practice

It was observed that applying the mother's voice and music in pediatric intensive care reduced pain caused by the endotracheal suctioning process and positively affected vital signs. In line with the results obtained from the study, it is recommended to use listening to the mother's voice or music methods to reduce pain occurring during and after an endotracheal suctioning process and to regulate physiological parameters. The results of this study provide a scientific basis for nursing practices in clinical settings and contribute to clinical practices by shedding light on future evidence-based studies. The song "The Happiest Child", the copyright of which belongs to researcher FMK and which was developed within the scope of the study, continues to be used in pain management in the clinic where the study was conducted.

CRediT authorship contribution statement

Fulya Merve Kos: Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Murat Bektaş:** Writing – review & editing, Validation, Methodology, Conceptualization. **İlknur Bektaş:** Writing – review & editing, Investigation. **Dijle Ayar:** Writing – review & editing. **Sadık Kıvanç Metin:** Writing – review & editing, Data curation.

Declaration of competing interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article. Institution approval was obtained from the Dokuz Eylül University Hospital in which the study was conducted, with further approval granted by the Dokuz Eylül University Non-interventional Clinical Trials Ethics Committee, with approval number 2023/10–12 dated March 29, 2023. Written consent was obtained from parents present with the child. This study is registered with ClinicalTrials.gov: NCT06230211. In accordance (Law the Protection of Personal Data), all the records and corresponding informed consents to participation were stored safely by the principal investigator.

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