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Effects of Mozart–Orff parent–child music therapy among mothers and their preschool children with autism spectrum disorder: A mixed-methods randomised controlled trial

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Abstract

Background Autism spectrum disorder (ASD) negatively impacts mental health, particularly in mothers of autistic children who experience heightened stress. Applied behaviour analysis (ABA) and music therapy are recognised interventions for improving ASD symptoms. However, the specific benefits of parent–child music therapy and ABA for autistic children and their mothers remain uncertain. This study evaluated the effects of parent–child music therapy on preschool autistic children and their mothers.

Method A randomised controlled trial was conducted with 100 mother–child pairs assigned to either the control group receiving ABA or the intervention group receiving both music therapy and ABA. Qualitative interviews were conducted post-intervention for 12 mothers.

Results Children in the intervention group exhibited lower scores for ASD symptoms than those in the control group. Moreover, mothers in the intervention group demonstrated reduced dysfunctional parent–child interaction, lower overall parental stress, significantly improved family functioning, and increased levels of hope compared with those in the control group. Mothers held positive views regarding music therapy.

Conclusions Combining ABA with parent–child music therapy can alleviate ASD symptoms in children and reduce stress in mothers. Improved parent–child interaction and enhanced family functioning further support the benefits of this combined approach. Parent–child music therapy, combined with ABA demonstrated positive outcomes for autistic children, including reduced ASD symptoms, improved parent–child interaction, decreased parental stress, enhanced family functioning, and increased hope. These findings highlight the potential of incorporating music therapy as a valuable component in the comprehensive treatment of ASD.

Trial registration This study was registered in the Chinese Clinical Trial registry (05/07/2021, ChiCTR2100048261, https://www.chictr.org.cn/showproj.html?proj=128957). Ethical approval was obtained from the Research Ethics

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Committee of Fujian Medical University and the study hospital (Fujian Provincial Maternity and Child Health Hospital; 2017 – 105), and informed consent was obtained from all subjects and/or their legal guardian(s).

Keywords Applied behaviour analysis, Autism spectrum disorder, Mozart–Orff parent–child music therapy, Parenting stress in mothers, Preschool-aged children

Background

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterised by deficits in social communication and repetitive, typical sensory-motor behaviours [1]. Autistic individuals can be categorised into those with high-functioning (characterised by abilities much better than those of healthy people in one specific field) and low-functioning (characterised by much more severe symptoms) autism, with most individuals commonly experiencing challenges such as emotion dysregulation, attention deficit hyperactivity, and insomnia, which have been linked to various negative mental and physical health outcomes [2–5]. Recent studies have shown a global prevalence rate of ASD among children as high as 7.6 per 1,000 among children [6]. In China, it has been found that 22.1% of children aged 2–3 years with intellectual disabilities and 22.4% of those aged 4–6 years with intellectual disabilities are diagnosed with ASD [7]. Due to their age and disabilities, autistic children can hardly ever take care of themselves, consequently, the demanding care needs of autistic children often place a significant problem on their mothers, who typically serve as their primary caregivers [8, 9]. Additionally, studies have shown that mothers of children with ASD report higher levels of stress than those of neurotypical children due to the poor parent-child relationship, a core factor that affects the behaviours of autistic children [8, 10–12]. Furthermore, parental characteristics, such as psychological distress, also contribute to parent–child relations [13]. Hence, improving parent-child relations and altering the negative mental situation are crucial.

Applied behaviour analysis (ABA), a traditional treatment rooted in the Early Start Denver Model, has been widely acknowledged as a contemporary training approach for rehabilitating children with ASD [14]. However, this treatment mainly focuses on its efficacy for repetitive behaviours in children, ignoring the psychological stress and the weak relationship between autistic children and their mothers in ABA research [15, 16].

Music therapy, a form of child psychotherapy, and the clinical and evidence-based use of music interventions to accomplish individualised goals have now been used widely to enhance the emotional expression of autistic children and promote the establishment of a parent-child attachment relationship [17–21]. Some of the proposed mechanisms of music therapy advocate that the reasons for inducing therapeutic changes include priming neural networks that link music with non-music functions such as autobiographical memory and language, activation of the mirror neuron system, auditory–motor coupling, facilitation of motivation and reward, and neuroplasticity [19]. Regarding autistic children who are sensitive to music and respond better to music than to words, the musicality of sounds–a nonverbal language–can help them communicate more easily during the therapeutic sessions [22]. The Orff approach, a renowned and influential music therapy worldwide, advocates music activities that integrate music, dance, movement, and language through practical techniques to actively stimulate physical movement and language ability in children with ASD [23]. Neuroimaging studies have found through resting-state functional magnetic resonance imaging that listening to music leads to extensive neural activity in the frontoparietal network and limbic system [24, 25]. Participating in music activities involves multiple brain regions such as hearing, movement, emotion, pleasure, and memory, allowing the therapeutic effects related to music to shift to areas unrelated to music through structural and functional brain changes [24, 25]. A previous study has indicated that Orff music enhances social communication skills, including parent–child interaction and social ability of autistic children, thereby benefiting parent–child relationships [26]. Given these benefits, it may be beneficial for children with ASD and their parents to participate in Orff music therapy [27].

However, the Orff approach can only be delivered by music therapists with a variety of instruments in hospitals and dedicated training schools, it cannot be conducted at home, where autistic children spend the most time. Moreover, the restrictions introduced by the government during the COVID-19 pandemic led to limited access to offline Orff interventions. These circumstances reinforced the need to create online music interventions that can be delivered at home through another music form.

The *Mozart effect* refers to the enhanced functioning of the nervous system that occurs after listening to Mozart's music. This phenomenon has attracted interest from clinicians and scientists since Rauscher et al.'s (1993) report that normal participants performed better in a spatial task after listening to Mozart's piano sonata K448. There are two possible explanations for this result: The first is the priming theory, which suggests that music directly influences the *Mozart effect* by activating relevant brain regions; evidence for this theory mainly lies in the fact that music stimulation can trigger electroencephalograph

changes in brain regions involved in spatial processing. The second explanation is the preference theory, which mainly posits that music exposure can regulate the transmission of neurotransmitters and alter the levels of certain neurohormones in individuals [28, 29]. Mozart's music has already been utilised to alleviate defective social interaction skills, delayed physical movement, and other clinical conditions in patients with epilepsy, depression, and dementia; such limitations are similar to those in autistic children [30–32]. However, no research has investigated whether this effect can apply to children with ASD, either independently or in combination with Orff music therapy.

Most interventions, including traditional approaches such as ABA and music therapy, tend to focus primarily on the effects on children and overlook the mental health of primary caregivers, particularly mothers. Therefore, this study aims to develop a music therapy programme that integrates Orff music therapy with Mozart's compositions, assess its efficacy in preschool-aged children with ASD and their mothers, and explore participants' experiences. The following hypotheses are proposed:

1. Mothers in the music therapy group report lower levels of parenting stress and higher levels of hope than those in the control group.
2. Children in the music therapy group manifest better sensorimotor ability, social interaction, physical movement, language skills, and self-care ability than those in the control group.
3. Mothers in the music therapy group hold positive attitudes and satisfaction towards this intervention.

Materials and methods

Study design

A before-and-after, assessor-blind, randomised controlled design was used. Descriptive qualitative research was employed to explore mothers' experiences and satisfaction and the changes they perceived in their children after participating in the music therapy intervention [27, 33].

Setting and sample

Children were selected from a special education school in Fuzhou, China, and were diagnosed with ASD by doctors according to the *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition) before they were enrolled in that school. Mothers of preschool-aged children with ASD were recruited in April 2021. Paper-informed consents were obtained from mothers who were the legal guardians of their children. Mozart's music was provided online through the broadcasting station 'Himalayan', which could track the listening record from mothers and their children by sharing the music from WeChat [34].

The inclusion criteria were (1) children aged 3–7 years diagnosed with ASD according to the *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition), (2) children with normal hearing and visual acuity, (3) mothers who were their children's primary caregivers and volunteered to participate, and (4) mothers able to read and understand Mandarin Chinese. The exclusion criteria were (1) children diagnosed with Down syndrome, cerebral palsy, epilepsy, schizophrenia, bipolar disorder, or depression and those with a history of severe brain injury; (2) children with aggressive behaviour; (3) parents who refused to join the study; (4) mothers with a history of mental illness; and (5) children and/or mothers who had participated in other relevant experimental research within the past 30 days.

The sample size was calculated using PASS 15.0 based on the children's total scores on the Autism Behaviour Checklist (ABC) in the preliminary test. An alpha of 0.05 (two-sided) with a power of 90% indicated a minimum sample size of 35 cases per group. The corrected sample size was 44 parent–child pairs per group, with a 20% dropout rate.

Group allocation

A random number network was used to generate 88 random numbers, sorted from small to large. Subsequently, a coin toss was used to determine that the first and last 44 numbers comprised the music therapy and control groups, respectively. The random allocation scheme was placed in a sealed envelope, coded in sequence, and provided to a third party—a postgraduate student of the research group, who was not involved in the study. When the eligible participants were confirmed, the postgraduate student opened the envelope and assigned each participant to their corresponding group.

Intervention

Control group

The control group did not receive any form of music intervention and only received ABA-based therapy in the classroom of a special training school from April 2021 to May 2021. ABA-based training was conducted by unified special education teachers or therapists trained in ABA methods for 20 h per week over 8 weeks. A personalised intervention plan, the key way of ABA-based training, was formulated according to the evaluation results, including fine motor skills training, speech expression, sensory integration, life skills, and gross motor skills training [14–16].

Music therapy group

In addition to ABA-based training (19 h/week), the experimental group listened to music by Mozart (online, 5–10 min/week for 8 weeks) and Orff (offline, 50–55 min/week for 8 weeks) from April 2021 to May 2021 [30–33]. Orff music intervention was conducted by a researcher in a classroom in the special training school, and the Mozart music intervention was performed in participants' own homes by mothers and children themselves. The intervention was conducted by a researcher who had obtained piano grade 10 and music theory level 2 certificates in China and could play various piano pieces and other instruments. A music teacher who had the music therapist license from the school and other research group members also assisted.

Mozart music intervention was complemented by each pair separately by themselves at their own homes. Mothers were required to play Mozart's music, including the first three movements of 'Sonata in D Major for Two Pianos K448', using WeChat/Himalaya software as background music during daily parent–child activities, with no special restrictions on the time to play that music.

Regarding Orff music activities, at least five pairs participated together. Orff music intervention was conducted in the classroom and divided into three parts, with each part continuing 17–18 min. First, during the researcher–pairs interaction, the researcher played the ukulele and sang Orff's 'Hello Song' and 'Goodbye Song' to indicate the activity's beginning and end, respectively, and asked each pair to show 'hello' and 'goodbye' gestures to the researcher. The researcher then played the 'Happy Song' on the piano. Each pair sat within a circle. Various instruments were displayed, allowing participants to select and play them according to their preferences. Second, during the mother–child interaction, the researcher played the piano and sang 'Twinkle Twinkle Little Star' at different speeds. Mothers were told to massage some parts of their child's body according to the rhythm of the music. Third, during the pair–pair interaction, the researcher played the djembe using an arbitrary speed and beat. Each pair walked around in rhythm. When they heard a bell, they stopped walking and hugged any other mother–child pair. Each pair then stood at any position in the treatment room. When the researcher played 'Looking for Friends' on the piano and sang the lyrics 'Try to find a good friend', each pair followed the rhythm to change their positions and spontaneously performed actions they had chosen themselves with another pair (e.g. hugging, shaking hands) [27] (Table 1).

Primary outcome measures

ABC

ABC was designed by Lu et al. [35] to identify and evaluate symptom severity among children with ASD aged 2–14 years. It has 57 items across five dimensions: sensory, social interaction, physical movement, language, and self-care ability. Scores above 67 indicate more severe ASD symptoms. In this study, Cronbach's α for the total scale was 0.783, and retest reliability was 0.922.

Parenting stress index-short form (PSI-SF)

PSI-SF [36] was used to evaluate parenting stress. The scale has 36 items, evaluated using a 5-point Likert-type scale (1 [strongly disagree] to 5 [strongly agree]), with total scores ranging from 36 to 180; higher scores indicate higher stress levels. PSI-SF evaluates three dimensions: parenting distress, parent-child dysfunctional interaction, and difficult child. In this study, Cronbach's α for the total score was 0.806, and retest reliability was 0.825.

Secondary outcome measures

Family APGAR index (APGAR)

The five-item APGAR, which stands for adaptation, partnership, growth, affection, and resolve [37, 38], was used to evaluate mothers' satisfaction with their family functioning. The scale has five items in total, with one item per dimension: adaptation, partnership, growth,

Table 1 Application of theoretical components

Music intervention	Theoretical components	Intervention activity
Orff music	Dance	1. Pair–pair interaction: Each pair walked around in rhythm. When they heard a bell, they stopped walking and hugged any other mother–child pair.
Orff music	Movement	1. Researcher–pairs interaction: Each pair to show 'hello' and 'goodbye' gestures. 2. Mother-child interaction: Massage some parts of their child's body according to the rhythm of the music.
Orff music	Music	1. Researcher–pair interaction: Various instruments were displayed, allowing participants to select and play them according to their preferences.
Orff music	Language	1. Pair-pair interaction: When the researcher played 'Looking for Friends' on the piano and sang the lyrics 'Try to find a good friend', each pair followed the rhythm to change their positions and spontaneously performed actions they had chosen themselves with another pair.
Mozart music	Listening to Mozart music	1. Mothers were required to play Mozart's music, including the first three movements of 'Sonata in D Major for Two Pianos K448', using WeChat/Himalaya software as background music during daily parent–child activities, with no special restrictions on the time to play that music.

affection, and resolve. All items were scored using a 3-point scale ranging from 0 (rarely) to 2 (often like this). The higher the score is, the better the family functioning. In this study, Cronbach's α for the total scale was 0.747 and retest reliability was 0.736.

Herth hope index (HHI)

HHI [39, 40] was used to evaluate mothers' hope levels. It comprises 12 items across three dimensions: temporality and future, positive readiness and expectancy, and interconnectedness. Items are scored from 1 to 4 points, reflecting respondents' degrees of agreement or disagreement. Low, medium, and high levels are determined based on total scores of ≤24, 25–35, and ≥36 points, respectively. In this study, Cronbach's α for the total scale was 0.821 and retest reliability was 0.622.

Mothers' perspectives on music therapy

Mothers in the music therapy group were asked to participate in one-on-one, semi-structured interviews that were conducted in a natural and quiet environment, such as a coffee shop, participants' homes, or an interview room in the special school, which was chosen by the participants. Moreover, the interviewer did not guide the interviewees. The researcher explained the study's purpose, asked for the interviewees' consent, and decided on an appropriate interview time and place. During the interviews, the researcher observed and recorded the interviewees' body movements, expressions, and expression methods, as well as the researcher's thoughts. Interviews lasted approximately 20–30 min, and data were collected until saturation [41, 42].

The research purposes, literature review, and discussion among the research group were the bases for the interview outline. After the pre-interview, any content that was difficult to understand was modified. The final interview outline was as follows:

(1) How did you feel during the music therapy process?
(2) What changes did you observe in your child after music therapy?
(3) How do you view these changes?
(4) Are you willing to continue music therapy in the future?
(5) What improvements do you think music therapy needs?

Data collection

Two postgraduate students from our research group, who were blinded to treatment allocation, collected data in the assessment room of the school on demographic characteristics and measured outcomes using paper questionnaires on the second day or third post-intervention. For the interviews, data processing, and analysis were conducted simultaneously, with data collection by a researcher who obtained a PhD degree and had joined the Academic Conference on Qualitative Theory Research using NVivo 11 software. The thematic analysis was employed using an inductive approach. The researcher transcribed the recorded data verbatim within 24 h.

Statistical analysis

IBM SPSS 21.0 was used for statistical analysis. Descriptive statistics, such as means, standard deviations, frequencies, and percentages, were used to report the demographic and outcome variables. Independent two-sample t-tests, chi-square tests, and Mann–Whitney U tests were used to compare baseline characteristics and results between the two groups post-intervention. $P<0.05$ was considered statistically significant. NVivo 11.0 was used to analyze the interview content and code, as well as to summarise and refine the text data.

Results

Participants

Initially, 132 mother-child pairs were recruited, of which 32 pairs did not meet the inclusion criteria: eight children had aggressive behaviour, three had a history of severe brain injury, four were diagnosed with Down syndrome, and 10 were over 7 years old; moreover, four mothers were not conversant in Mandarin and three had a history of mental illness. As several more mothers wished to participate, we added 12 pairs to the sample size previously calculated—with permission from the hospital ethics committee—and allocated them using the above method of randomised allocation (50 pairs each for the music therapy and control groups). Ultimately, 90 pairs completed the study (Fig. 1).

Participant characteristics between the two groups at baseline differed insignificantly (all $P>0.05$; Table 2), illustrating that the two groups were comparable.

Primary outcomes

Autism behaviour

Regarding the ABC at pre-intervention, no between-group differences were observed in the scores for each dimension and total scores ($P>0.05$). Post-intervention, the music therapy group showed statistically significant improvements in all dimensions, except self-care ability, compared with the control group, showing that children in the music therapy group had significantly lower total scores and scores for each dimension, except for self-care ability, than those in the control group; this signifies the intervention was significantly effective for the severity of autistic children ($P<0.05$; Table 3).

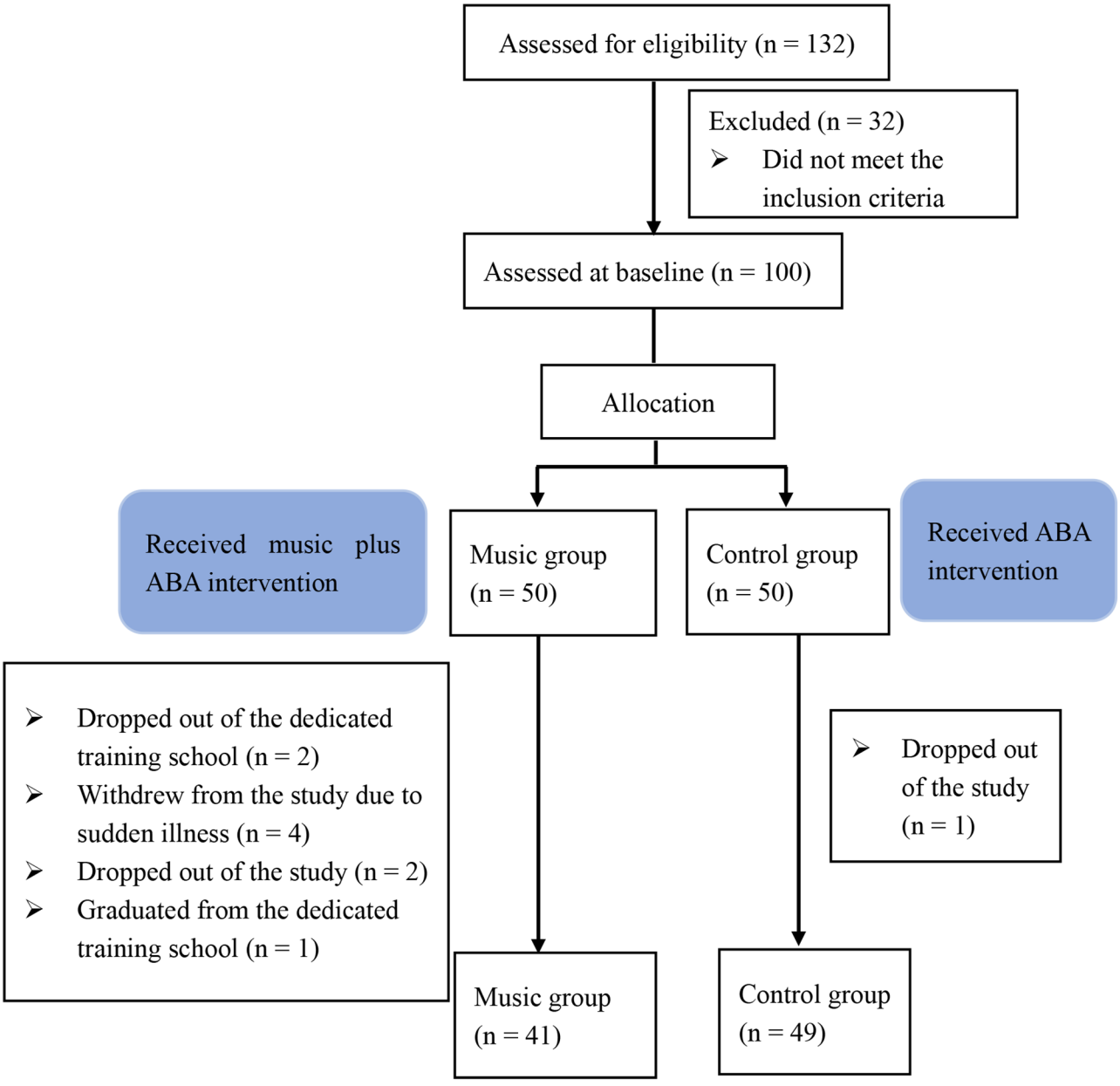

Fig. 1 Study flowchart

Parenting stress

Regarding the PSI-SF, no between-group differences were observed in pre-intervention scores ($P>0.05$); however, post-intervention scores for parent-child dysfunctional interaction and total PSI-SF scores among mothers were statistically lower in the music therapy group ($P<0.05$) than in the control group, indicating that music therapy was effective against dysfunctional interactions between mothers and their children, as well as for stress relief in mothers. Furthermore, no between-group differences were found for parenting stress and difficult child dimensions post-intervention ($P>0.05$; Table 3).

Secondary outcomes

Family function

No between-group differences were observed in APGAR scores pre-intervention ($P>0.05$), whereas a statistically significant difference was found post-intervention between the groups: mothers who participated in music therapy exhibited notably higher scores for the adaptation, partnership, and resolve dimensions and total scores than those in the control group ($P<0.05$), which proved that this intervention was beneficial for parent-child family functioning between mothers and their children with ASD in various aspects, ranging from adaptation to the

Table 2 Participants' characteristics at baseline (n = 100)

Variable	MT group (n = 50), n (%)	Control group (n = 50), n (%)	x^2/Z values	*P*-value
Children				
Age (years), M (P25, P75)	3.670 (3.000, 4.000)	3.900 (3.500, 4.300)	-1.936[a]	0.053
Gender				
Male	35 (70.0)	32 (64.0)	0.407[b]	0.523
Female	15 (50.0)	18 (36.0)		
Mothers and family				
Age (years), M (P25, P75)	31.000 (30.000, 33.000)	31.000 (29.000, 32.000)	-0.792[a]	0.428
Education				
High school or below	14 (28.0)	14 (28.0)	0.000[b]	1.000
College	20 (40.0)	20 (40.0)		
Bachelor's degree or above	16 (32.0)	16 (32.0)		
Work status				
Full-time	16 (32.0)	14 (28.0)	5.288[b]	0.259
Part-time	11 (22.0)	11 (22.0)		
Resigned to care for children	18 (36.0)	14 (28.0)		
Paid vacation	2 (4.0)	9 (18.0)		
Unemployed	3 (6.0)	2 (4.0)		
Residence				
Urban	31 (62.0)	31 (62.0)	0.106[b]	0.948
Rural	9 (18.0)	8 (16.0)		
County	10 (20.0)	11 (22.0)		
Average monthly household income, ¥ (US$)				
3001–6000 (446–890)	1 (2.0)	-	1.014[b]	0.602
6001–9000 (891–1336)	14 (28.0)	14 (28.0)		
≥ 9001 (≥ 1337)	35 (70.0)	36 (72.0)		
Average monthly treatment expense, ¥ (US$)				
5001–10,000 (737–1474)	42 (80.0)	40 (78.0)	0.271[b]	0.603
10,001–15,000 (1475–2210)	8 (20.0)	10 (22.0)		
Subvention				
Yes	47 (94.0)	49 (98.0)	1.042[b]	0.307
No	3 (6.0)	1 (2.0)		
Family structure				
Nuclear family	18 (36.0)	17 (34.0)	0.056[b]	0.997
Stem family	18 (36.0)	19 (38.0)		
Joint family	6 (12.0)	6 (12.0)		
Single-parent family	8 (16.0)	8 (16.0)		

Note: [a] Mann–Whitney *U* test; [b] x^2 test

partnership. No differences were found for the growth and affection dimensions (Table 4).

Hope

Pre-intervention, no between-group differences were observed in the HHI scores ($P>0.05$), whereas a statistically significant difference was found post-intervention between the groups: mothers in the music therapy group had higher scores for each dimension than those in the control group ($P<0.05$; Table 4). No between-group differences were observed in hope levels pre-intervention ($P>0.05$), whereas post-intervention, the percentage of mothers with a medium hope level sharply decreased from 51.2 to 24.4% in the music therapy group, and 11 more mothers reported higher levels of hope than they did at pre-intervention. In the control group, the level changed from a high to medium hope level in 13 mothers, with significant between-group differences noted post-intervention ($P<0.05$; Table 5). The results of the HHI scale showed that Mozart and Orff music therapy was effective in improving the hope level of mothers who were suffering from taking burden of taking care of their children with ASD.

Mothers' perspectives on music therapy

Twelve mothers were interviewed; their demographic characteristics are presented in Table 6.

Table 3 Comparison of ABC and PSI-SF scores between groups ($n = 90$)

Variable	MT group (n = 41) Mean (SD)/M (P25, P75)	Control group (n = 49) Mean (SD)/M (P25, P75)	Z/t values	*P*-value
ABC				
Sensory				
Pre-test	13.000 (10.000, 15.500)	13.000 (12.000, 14.000)	-0.675[a]	0.500
Post-test	11.000 (7.500, 13.500)	11.000 (10.000, 12.500)	-2.123[a]	0.034
Social interaction				
Pre-test	15.510 (4.467)	16.100 (4.602)	-0.614[b]	0.541
Post-test	13.000 (10.000, 17.000)	14.000 (11.500, 17.000)	-1.987[a]	0.047
Physical movement				
Pre-test	14.000 (11.000, 17.000)	14.000 (13.000, 15.000)	-0.172[a]	0.863
Post-test	12.000 (8.500, 14.000)	12.000 (11.000, 13.000)	-2.275[a]	0.023
Language				
Pre-test	20.100 (5.603)	20.840 (5.222)	-0.647[b]	0.519
Post-test	18.000 (15.000, 22.000)	21.000 (18.000, 21.500)	-2.406[a]	0.016
Self-care ability				
Pre-test	15.000 (13.000, 17.500)	16.000 (13.500, 19.000)	-1.038[a]	0.299
Post-test	14.000 (11.000, 16.500)	15.000 (13.000, 17.500)	-0.958[a]	0.338
ABC total score				
Pre-test	77.540 (17.076)	80.240 (13.980)	0.827[b]	0.410
Post-test	68.000 (59.000, 79.500)	72.000 (64.000, 81.500)	-2.854[a]	0.004
PSI-SF				
Parenting stress				
Pre-test	34.000 (26.000, 39.500)	33.000 (31.000, 35.000)	-0.232	0.817
Post-test	28.000 (22.000, 36.000)	31.000 (29.000, 33.000)	-1.740	0.082
Parent–child dysfunctional interaction				
Pre-test	32.290 (8.232)	34.840 (2.552)	-1.904[b]	0.063
Post-test	26.000 (19.000, 31.500)	34.000 (32.000, 36.500)	-6.875[a]	<0.001
Difficult child				
Pre-test	35.730 (6.485)	36.730 (3.973)	-0.864[b]	0.391
Post-test	31.510 (6.889)	32.630 (3.173)	0.138[b]	0.890
PSI-SF total score				
Pre-test	101.070 (20.860)	104.670 (7.169)	-1.054[b]	0.297
Post-test	86.000 (69.500, 104.000)	97.000 (92.500, 103.000)	-4.021[a]	<0.001

Note: [a] Mann–Whitney *U* test; [b] *t*-test

Theme 1: Attitudes towards and evaluation of music therapy

Music therapy was interesting and novel

Music therapy was a completely new rehabilitation training experience in mothers' views, mainly resulting from various instruments for their children and themselves to use.

> *The children were allowed to follow some instructions along with the music rather than sing specific songs. I think the whole process was so appealing in that everyone could participate—both the children and the mothers. I think it was very special. (Participant B)*

> *I think this music therapy was good because we had not thought about taking our children to this type of class before. (Participant C)*

> *We have never had such a collective class, and no one could play musical instruments at home. I feel that taking this class was a new thing for us. (Participant G)*

> *I think this course was very interesting because there were many games and music. (Participant K)*

> *It was not an ordinary music class. It was specially developed for these children, so I think it was very relevant. (Participant L)*

Theme 2: Changes in children after music therapy

Music therapy improved children's compliance

Children with ASD lacked compliance ability due to communicative and comprehensive deficits, which resulted in reverse behaviour and difficulty of being in control.

Table 4 Comparison of APGAR and HHI scores between groups (n = 90)

Variable	MT group (n = 41) Mean (SD)/ M (P25, P75)	Control group (n = 49) Mean (SD)/ M (P25, P75)	Z/t values	*P*-value
APGAR				
Adaptation				
Pre-test	1.000 (0.000, 2.000)	2.000 (1.000, 2.000)	-1.802[a]	0.071
Post-test	2.000 (1.000, 2.000)	2.000 (1.000, 2.000)	-1.195[a]	0.023
Partnership				
Pre-test	1.000 (0.000.1.000)	1.000 (0.000.1.000)	-0.266[a]	0.790
Post-test	2.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-4.405[a]	<0.001
Growth				
Pre-test	1.000 (1.000, 2.000)	1.000 (0.000, 2.000)	-0.643[a]	0.520
Post-test	1.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-0.415[a]	0.678
Affection				
Pre-test	1.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-0.066[a]	0.947
Post-test	2.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-1.074[a]	0.283
Resolve				
Pre-test	1.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-0.556[a]	0.578
Post-test	2.000 (1.000, 2.000)	1.000 (1.000, 2.000)	-2.038[a]	0.042
APGAR total score				
Pre-test	5.490 (2.712)	5.780 (1.636)	-0.595[b]	0.554
Post-test	8.000 (6.000, 9.000)	7.000 (6.000, 8.000)	-2.900[a]	0.004
HHI				
Positive readiness and expectancy				
Pre-test	12.000 (11.000, 13.000)	12.000 (12.000, 14.000)	-0.625[a]	0.532
Post-test	13.000 (12.000, 14.000)	11.000 (10.000, 12.000)	-6.445[a]	<0.001
Temporality and future				
Pre-test	12.000 (11.000, 13.000)	12.000 (11.000, 13.000)	-0.058[a]	0.954
Post-test	12.000 (11.000, 14.000)	12.000 (11.000, 13.000)	-2.860[a]	0.004
Interconnectedness				
Pre-test	11.000 (11.000, 12.000)	11.000 (10.500, 12.000)	-0.910[a]	0.363
Post-test	13.000 (12.000, 14.000)	11.000 (10.000, 12.000)	-5.974[a]	<0.001
HHI total score				
Pre-test	35.000 (33.500, 38.500)	36.000 (33.500, 38.500)	-0.224[a]	0.823
Post-test	39.000 (35.500, 41.500)	34.000 (32.500, 36.000)	-6.859[a]	<0.001

Note: [a] Mann–Whitney *U* test; [b] *t*-test

Table 5 Comparison of Hope levels on the HHI scale between groups (*n* = 90)

Variable	MT group (n = 41), n (%)			Control group (n = 49), n (%)			X^2 values	*P*-values
	Low	Medium	High	Low	Medium	High		
Pre-test	-	21 (51.2)	20 (48.8)	-	22 (44.9)	27 (55.1)	0.358	0.550
Post-test	-	10 (24.4)	31 (75.6)	-	35 (71.4)	14 (28.6)	19.756	<0.001
Decrease/increase rate	-	[a]11 (26.8)	[b]11 (26.8)	-	[b]13 (26.5)	[a]13 (26.5)	-	-

Note: [a] decrease; [b] increase

However, mothers found that their children's ability to comprehend and comply with instructions improved during this intervention.

After this intervention, I found that he was much better at following instructions than he was before. When you said 'start,' he knew that meant 'I should start to complete some tasks.' When you said 'stop,' he knew that he should stop and shouldn't run around the classroom. In these music lessons, I think he could actually understand the instructions and tried to perform some of the necessary actions. (Participant C)

Maybe he didn't know what to do when he heard the music in the beginning. Later, he knew what he should do after instructions were given. His disci-

Table 6 Mothers' characteristics

Number	Age (years)	Education	Average monthly treatment expense, ¥ (US$)	Residence	Family structure
A	36	High school or below	6,001–9,000 (891–1,336)	Rural	Stem family
B	28	Bachelor's degree	≥ 9,001 (≥ 1,337)	Urban	Stem family
C	35	College	6,001–9,000 (891–1,336)	Urban	Stem family
D	34	Bachelor's degree	≥ 9,001 (≥ 1,337)	Urban	Stem family
E	32	College	≥ 9,001 (≥ 1,337)	Urban	Nuclear family
F	31	Junior-senior high school or below	6,001–9,000 (891–1,336)	Urban	Nuclear family
G	30	Junior-senior high school or below	6,001–9,000 (891–1,336)	Rural	Nuclear family
H	29	Bachelor's degree	≥ 9,001 (≥ 1,337)	Urban	Nuclear family
I	29	Junior-senior high school or below	6,001–9,000 (891–1,336)	County	Joint family
J	27	Bachelor's degree	≥ 9,001 (≥ 1,337)	Urban	Stem family
K	32	Junior-senior high school or below	6,001–9,000 (891–1,336)	Rural	Single-parent family
L	26	College	≥ 9,001 (≥ 1,337)	Urban	Nuclear family

pline got better, and the instructions also got better. (Participant D)

I think he can understand some instructions better than before. As I said just now, it was impossible to complete instructions in the past because children were required to understand these instructions. Now, he is quite different. He can understand some of the instructions. When you give an instruction, he follows it. (Participant H)

Music therapy motivated children's interests

Children with ASD were characterized by repetitive and typical sensory-motor behaviours driving to the lack of interest, which improved after music therapy, as reported by their mothers.

I found that he had been singing and dancing very frequently during this period, and I didn't know that he liked singing so much. (Participant I)

I didn't know what he liked in the past, but I found that he was interested in music after this intervention. We became unexpectedly happy. (Participant J)

My child enjoyed listening to music and was very active in every activity. As soon as the music started, he moved his body. (Participant E)

Music therapy improved children's social abilities

The music therapy curriculum covered substantial interactive content, which improved children's social interaction abilities. This was primarily manifested in a sense of peer cooperation and their ability to pay attention to others.

In the past, he could not get close to people, but he has improved a lot now. His behavior problems have also largely resolved as he engages in social interactions, which was truly a need for some older children. (Participant A)

Now, she gradually understands how to cooperate with other children to complete a task and how to interact with people around her. (Participant B)

As soon as the music started, he would interact with others. For example, earlier, when you asked them to pass musical instruments or hug each other, he would not do it. Now, he does it very well. (Participant C)

After this intervention, I felt that she seemed to gradually understand how to play with children. Sometimes, when she sees children in school, she takes out snacks from my bag to share with them. (Participant G)

My child is more willing to be close to people and has gradually shown some social behaviors, such as nodding and shaking hands. (Participant H)

Social contact ability has changed a lot. Now, he will take the initiative to play with his older brother and build things with blocks with his older brother sometimes. (Participant I)

After music therapy, he could nod and shake hands with others, and he knew how to integrate into collective life and greet and socialize with others. (Participant J)

Music therapy improved children's eye-tracking ability

In general, music played with instruments is attractive to individuals, and music-related games can maintain the attention of children, particularly relating to their eye-tracking ability. In this intervention, Orff music was filled with musical games that motivated children's interest and attention, which was believed by most mothers to have effectively improved their children's eye-tracking ability.

I think his joint attention improved a lot. That is, when you were talking, he was following your voice. Where you were, that's where he looked. (Participant D)

I found that his attention was much better than before. (Participant G)

When I was in music class, I found that he made eye contact; that is, his eyes could follow where you were and follow what you did. (Participant J)

Music therapy improved children's sitting ability

Sitting ability is also mostly associated with the attention of children. The interviewed mothers found that their children's sitting ability showed progress during and after music therapy.

She used to be very vigorous and energetic, and no one could calm her down, even when she ate meals at home. However, after this music therapy, things changed. Each music class was about an hour, which she could finish quietly. Her sitting ability has improved a lot. (Participant B)

Other teachers also told me that he is not as active as he was before and that he can sit for longer. (Participant I)

He isn't as manic as before and can sit down quietly. (Participant J)

Theme 3: Changes in mothers after music therapy

Music therapy relieved stress and filled mothers with hope

Mothers joined in this therapy with their children together, participated in the whole intervention process, and provided themselves a chance to relieve pressure and find their children's progress step by step, which had a certain mental relaxation effect on them and helped them regain hope for their children's rehabilitation.

She made such rapid progress in music therapy, which was beyond my expectations. I realized that my child was not so hopeless. I should accompany her to take intervention classes. My mood has gotten much better, at least more hopeful than before. (Participant B)

I think this class at least let me know how parents could help children in the intervention. In the past, we were carrying a heavy mental load and refused to communicate with others. When we underwent music therapy together, the children learned to socialize, and we relaxed at the same time. We could make some friends in this class so that we will not be so stressed. (Participant I)

I think it can help me relax, and I won't be so anxious for success when facing my children. (Participant J)

Discussion

Following a dramatic increase in its prevalence, ASD has become a severe public health problem worldwide. Drug treatment for the core symptoms of ASD is lacking, and the efficacy of available drugs is controversial. Treatment is mainly based on long-term rehabilitation training; however, because the related symptoms are permanent, there is substantial psychological pressure on the family members of individuals with ASD [43–45]. In traditional Chinese culture, mothers are likely to be the primary caregivers; therefore, they may experience greater psychological pressure than other family members when raising children with ASD. However, few studies have explored the efficacy of ASD interventions for children and their mothers. Although several studies have included mothers in the intervention process, they have only reported on its effectiveness for children [27, 34].

In this quantitative section of this study, children in the intervention group exhibited lower scores for ASD

symptoms than those in the control group, and mothers in the intervention group demonstrated reduced dysfunctional parent-child interaction, lower overall parental stress, significantly improved family functioning, and increased levels of hope, showing that combining ABA with parent-child music therapy can alleviate ASD symptoms in children and reduce stress in mothers. Various reasons contributed to this result: First, this intervention was conducted for children and mothers simultaneously. Mother-child and pair–pair interactions were set up, which provided opportunities for parent-child cooperation and communication and an environment for social interaction with others. Furthermore, mothers participated in the entire music therapy process and witnessed their children's progress, which helped reduce their stress, increase hope levels, and improve their ability to actively cope with the stressful process of taking care of children with ASD.

Music therapy is a supporting tool for the mental health of an individual in medical treatment, education, and daily life, helping people improve their physical, intellectual, spiritual, social, emotional, and communication abilities using music or musical elements [23, 46–48]. A previous study described the characteristics of appropriate music for children with ASD [27]. First, the length of the selected music is generally four to eight lines, which is effective in helping children with ASD remember melodies and lyrics. Second, the melody and rhythm should be relatively fixed and change insignificantly. Third, 2/4 or 4/4 beats are generally preferred so that children with ASD can easily follow the rhythm. Fourth, it is generally better to select phrases with similar structures that can be accompanied by instruments such as a piano, guitar, or ukulele. Fifth, music in a major key is generally selected as the main theme because the expressed emotions are usually cheerful and bright and will evoke positive emotions in children with ASD. Contrastingly, music in minor keys usually reflects sad emotions and evokes negative feelings in children with ASD, leading to negative effects.

In this study, music in a major key with 2/4 or 4/4 beats was played on a ukulele, djembe, or piano in the Orff music activity, and similar music was selected for online music intervention, which met the criteria for music for children with ASD. The findings showed that Mozart–Orff parent-child music therapy enhanced sensory abilities, social interactions, physical movement, and language for children with ASD. Several studies have reported similar outcomes, confirming that music therapy can improve the social function of children with ASD, as evaluated using various scales [20, 23, 33, 48–50]. Qing-Rui et al. [51] also used the ABC as the primary outcome measure; however, their results differed slightly from ours, which may be related to the intervention dose and period. They randomly assigned 108 children with ASD to either music therapy or a routine rehabilitation group, with a music intervention or standard care, once a day for 30 min, 5 days a week, over 6 months. Post-intervention, each dimension changed and was statistically different from that in the routine rehabilitation group. Therefore, future studies should verify the most efficient course for music therapy.

As a supplement to the quantitative results, qualitative interviews provided an individualized and more detailed understanding of the changes experienced by children and mothers through their participation in music therapy intervention from the perspective of mothers, which was also a crucial tool for exploring the feasibility of this intervention based on the experience of participants. The interviews provided more detail than the questionnaire results post-intervention. Most mothers had never attempted music therapy before; therefore, the intervention was fresh and appealing to them. They felt that their children's social interaction abilities had significantly improved and that the children began to show great interest in and passion for music following the interventions. In addition, the establishment of standardized music therapy for children with ASD in China benefited from participant suggestions, considering that most interventions focused on quantitative results while ignoring participants' perspectives and that music therapy was not standardized in the country.

Although the Chinese Music Therapy Association was established in 1989, music therapy in China remains in its infancy [52]. Music therapy in dedicated training schools is mainly performed by music teachers with special education degrees. In hospitals, it is usually conducted by rehabilitation therapists who have graduated from medical colleges and lack relevant knowledge about a particular disorder or the skills to play musical instruments. Furthermore, no standardized training or music therapy methodology is available for music therapists. Moreover, the modes and approaches of music therapy are quite diverse, which influences its effects. Therefore, a standardized music therapy intervention model should be established for the Chinese context, and professional treatment teams comprising medical staff and music therapists should be trained to benefit more children with ASD and their families.

Limitations

First, we could not implement a longer intervention period because of the COVID-19 pandemic and related prevention measures. This may be why some dimensions, such as growth and affection on the APGAR, had no statistically significant changes. Second, this study lacked objective outcomes and only assessed the intervention

Table 7 List of abbreviations

Full name	Abbreviation
Autism Spectrum Disorder	ASD
Applied behaviour analysis	ABA
Autism Behaviour Checklist	ABC
Parenting Stress Index-Short Form	PSI-SF
Family APGAR Index	APGAR
Herth Hope Index	HHI

effects based on self-reported measurement scales, which were inevitably affected by participant subjectivity.

Conclusions

This research indicates it is necessary to establish and popularise Mozart–Orff parent-child music therapy. The music chosen in this study, the instruments used in the intervention, and the music-oriented games in this research are worthwhile to generalize in clinical practice. Moreover, online and offline interventions are beneficial for the rehabilitation of children with ASD under COVID-19 restrictions.

A list of abbreviations in this study can be found in Table 7.

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Author contributions
YS H, GH L, and RF H designed this study. YS H, BY Z, TT C, and SX H implemented the intervention, interviewed participants, and YS H wrote this manuscript. A W revised this manuscript and chose journals for submission. GH L analyzed data, and YH Z allocated the group. JL L and H L collected data.

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Data availability
The datasets used and or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Research Ethics Committee of Fujian Medical University and the study hospital (Fujian Provincial Maternity and Child Health Hospital; 2017 – 105). All participants were informed that participation was voluntary and that they could refuse or withdraw from the study at any time without negative consequences for any other treatments. Informed consent was obtained from all subjects and/or their legal guardian(s).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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