

Application And Effectiveness of Music Therapy in The Rehabilitation of Children with Autism

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Abstract. Autism Spectrum Disorder (ASD) is a type of neurodevelopmental disorder. Current mainstream intervention methods such as Applied Behavior Analysis (ABA) and language training have limitations in improving core deficits such as emotion regulation and social motivation in children with ASD. However, music therapy, with its unique advantage of multisensory integration, has shown potential in the rehabilitation of children with ASD. Nevertheless, current research on this method still has many loopholes in terms of mechanism of action, method standardization, and cultural adaptability, providing a research space for this study. The analysis is conducted from three dimensions: language ability improvement, social interaction improvement, and emotion regulation optimization. By selecting and analyzing existing studies, this review emphasizes the synergistic effects of music therapy combined with multiple interventions in the rehabilitation of children with ASD, also pointed out existing limitations such as insufficient standardization of intervention protocols and lack of cultural adaptation. Future studies should conduct multi-center trials and establish cross-cultural adaptation frameworks and provide more strategies of standardizing the intervention and introducing better objective index.

Keywords: Music therapy; autism spectrum disorder; multi-intervention.

1. Introduction

1.1. Autism Spectrum Disorder and Music Therapy

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by social impairments, communication difficulties, and repetitive behaviors. The high prevalence of ASD not only has an impact on public health but also poses challenges for the families of patients in terms of parenting methods and access to appropriate educational resources. Therefore, the research on effective intervention methods for ASD has become a demand of contemporary society. Currently, Applied Behavior Analysis (ABA) and language training are common intervention methods for ASD. However, these treatments have limited effects on improving core issues such as emotional regulation, cognitive flexibility, and social motivation in patients, and are unable to comprehensively improve the complex conditions of children with ASD. Thus, it is necessary to explore new intervention approaches.

Music therapy, with its advantages in multisensory integration intervention and activation of the auditory-motor network, has shown certain effectiveness in improving social interaction, language ability, and even brain functional connectivity in children with ASD [1, 2]. However, there are still some research gaps in this field, such as the unclear impact of music therapy on gamma oscillations in terms of mechanism, only 12% of RCTs reporting intervention fidelity in terms of method [3], and the lack of research on the adaptability of music therapy between Eastern and Western cultures [4]. Moreover, the differences in the effects of combined intervention and single intervention still need to be further explored through experiments, leaving room for exploration in this study.

1.2. Research Questions

1.2.1 Core research question

The focus is on whether combined music therapy is more effective than single music therapy in improving core symptoms such as social interaction, language, and emotion in children with ASD.

1.2.2 Specific Research Directions

The analysis will be conducted from the following aspects. Evaluate the language improvement ability of the music therapy through scientific assessment methods, and clarify the differences in the effects of combined intervention and single music therapy on improving language understanding, expression, and language logic in children with ASD. Then focus on core deficits such as social motivation, social skills, and social response in children with ASD, and explore whether combined intervention can more effectively enhance their social interaction ability. Finally, analyze the improvement effect of combined intervention on emotional stability, emotional expression, and emotional control ability in children with ASD, and clarify its advantages over single music therapy, providing evidence-based basis for the formulation of music therapy intervention plans for children with ASD.

2. Literature review

Existing studies generally indicate that music therapy has positive effects on improving social interaction, emotional regulation, and language imitation in children with autism spectrum disorder (ASD) [5]. Its mechanisms of action may involve multiple neural pathways: musical rhythm can activate the auditory–motor network and promote neural plasticity [1]; the combined stimulation of melody and lyrics can activate both semantic and emotional processing pathways, thereby facilitating language acquisition and motivation for interaction [4]. At the same time, neuroimaging studies have also shown that music intervention may improve the social abilities of ASD children by activating the prefrontal cortex and related social brain regions [5]. With further research, combined intervention models have gradually attracted attention. Combining music therapy with sensory integration training, auditory integration training, transcranial magnetic stimulation, or cognitive–behavioral intervention can play a synergistic role in rehabilitation. Studies have shown that such combined interventions have more significant advantages than single music therapy in improving social adaptation, speech fluency, and reducing stereotyped behaviors [6, 7]. For example, the combination of music therapy and sensory integration training not only promotes multisensory integration but also enhances children’s ability to interact in real social situations. Music therapy combined with auditory integration or cognitive training has demonstrated more stable and lasting effects in language rehabilitation and improvement of cognitive flexibility.

3. Methodology

3.1. Selection and arrangement

Relying on the methods using by [8], this study uses the professional library (CNKI & PubMed) to search the articles between 2015 and 2025 with "music therapy (MT)" and "autism spectrum disorder".

3.1.1 Experiments studies

Removed the "non-RCT, non-academic periodical" "Retracted articles" "Un-full text" "Non-Chinese or English article" "Non-relevant" "Not human" "Not children" "Participants under 30" "Not MT" "Duplicate content" articles, reserve 11 experiment studies, the complete selecting steps is in Fig.1.

Arranging the 11 experiment studies to 5 perspectives "Participants" "Interventions" "Index" "Results" "Future expectations" (Table 1).

3.2. Reviews

Choosing 1 article that conclude the progress of the recent studies, 1 article that review the efficacy of the non-invasive neurostimulation techniques and 1 article that conclude the recent challenge on methodology.

Arranging 3 articles by 4 perspectives "Source" "Analysis's perspectives" "Results" "Future expectations" (Table 2).

3.3. Characteristics of included trials

Of these 11 studies, 6 have divided the participants equally, 5 did not. 9 have used the MT (or the combined-MT) as the independent variable, 2 have use the others therapy as the independent variable. All the studies have used the approved scale. 7 have reported positive effects, 3 have found out some index with no significant effects, 1 has reported no significant effects. 2 have supported the promotion of MT, 2 have juged positively the MT, 6 have given some improving advices, 1 did not support the clinical application of MT. [阳白1]

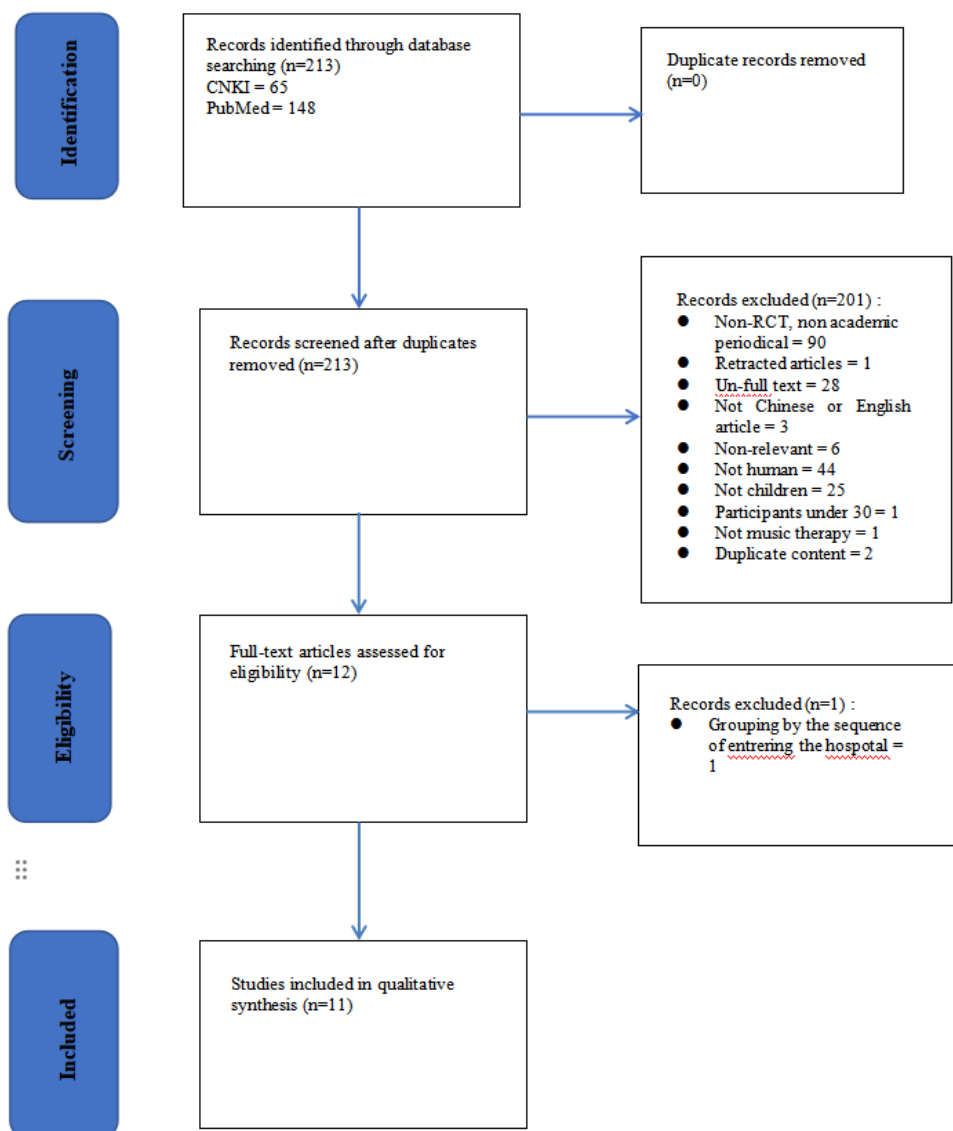


Fig. 1 Flow diagram of experiment study selection [阳白2]

Table 1. Experiments [阳白3]

| Researcher(s) | Participants (Test group/Control group) | Interventions (Test group/Control group) (Duration) | Index | Results | Future expectations |
|---------------------------|---|---|--|--|--|
| Zhang et al., (2015) [9] | 2-8 16/14 | <ul style="list-style-type: none"> ● MT+conventional language therapy/conventional language therapy ● 6-9 months | CRRC Sign-signification relations assessment | Significant | Worth popularizing |
| He et al., (2022) [4] | 2-14 50/50 | <ul style="list-style-type: none"> ● Parent-child cooperative music therapy+ABA/ABA ● 8 weeks | <ul style="list-style-type: none"> ● CARS ● ABC ● PSI-SF ● APGAR ● HHI | <ul style="list-style-type: none"> ● Group ABA shows a decline on ABC-language ● Group ABA's mothers' full-HHI and HHI- Take active actions decrease | <ul style="list-style-type: none"> ● More participants ● Longer experiment ● Some objective index |
| Ge, Xu, & Li, (2023) [10] | 4-9 34/34 | <ul style="list-style-type: none"> ● Mandala painting +MT/MT ● 6 months | <ul style="list-style-type: none"> ● PEP-3 ● CARS ● ATEC | Significant | Great effects |
| Zhang et al., (2023) [11] | 3-8 40/40 | <ul style="list-style-type: none"> ● Orff MT+rTMS+Comprehensive rehabilitation training/ rTMS+Comprehensive rehabilitation training ● 24 weeks | <ul style="list-style-type: none"> ● ATEC ● ABC ● Vestibular function | Significant | <ul style="list-style-type: none"> ● Effective ● Safe and reliable |
| Wu, Rao, & Ye, (2023) [6] | 2-10 32/33 | <ul style="list-style-type: none"> ● MT+Auditory integration training and rehabilitation/ Auditory integration training and rehabilitation ● 6 months | <ul style="list-style-type: none"> ● ABC ● CARS ● PEP-3 ● ATEC ● Language development level (Sign-signification relations assessment), emotional situation matching and quality of life | Significant | <ul style="list-style-type: none"> ● Great effects ● More participants |
| Feng et al., (2024) [2] | 2-12 30/30 | rTMS+MT+ Conventional intervention/MT+ Conventional intervention | <ul style="list-style-type: none"> ● ATEC ● ABC ● CARS ● MTS ● Multifunctional Combination | Significant | <ul style="list-style-type: none"> ● Great effects ● More participants ● Longer experiment |

| Researcher(s) | Participants (Test group/Control group) | Interventions (Test group/Control group) (Duration) | Index | Results | Future expectations |
|--------------------------------|---|---|--|--|--|
| | | | Monitor Assessment (Brain function status) | | |
| He et al., (2024) [12] | 3-7 41/49 | <ul style="list-style-type: none"> ● MT+ABA/ABA ● 8 months | <ul style="list-style-type: none"> ● ABC ● PSI-SF ● APGAR ● HHI ● Mothers' perspectives on MT | <ul style="list-style-type: none"> ● Significant ● Positives feedback from mothers | <ul style="list-style-type: none"> ● ASD children's mother's mental health ● Opinion of participants |
| Zhou et al., (2025) [13] | 2.5-6.7 15/14 | <ul style="list-style-type: none"> ● MT+standard care/standard care ● 12 weeks | <ul style="list-style-type: none"> ● SRS-2 ● ATEC ● GDS | <ul style="list-style-type: none"> ● Non-significant results on ATEC | <ul style="list-style-type: none"> ● Forms of MT: in group or motivate by oneself ● Mechanism and social benefit |
| Li & Han, (2025) [7] | 3-8 41/41 | <ul style="list-style-type: none"> ● MT+Sensory Integration Training+Conventional care/Conventional care ● 6 months | <ul style="list-style-type: none"> ● Erxin Scales: Child Developmental Scale of China ● ABC ● ATEC ● Development scale of children's sensory integration ability | Significant | Worth popularizing |
| Bieleninik et al., (2017) [14] | 4-7 182/182 | <ul style="list-style-type: none"> ● IMT+ESC /ESC ● 5 months ● International | <ul style="list-style-type: none"> ● ADOS ● SRS ● 2 scales for parents (quality of life of the child & the whole family) ● Parent-reported adverse events | <ul style="list-style-type: none"> ● No significance ● Children's enjoyment | Do not support the use of IMT for symptom reduction in children with autism spectrum disorder |
| Sharda et al., (2018) [5] | 6-12 26/25 | <ul style="list-style-type: none"> ● IMT/ Structurally matched behavioural intervention ● 8-12 weeks | <ul style="list-style-type: none"> ● CCC-2 ● SRS-2 ● PPVT-4 ● FQoL ● VABS-MB ● Social communication | <ul style="list-style-type: none"> ● No significance on SRS-2 and PPVT-4 ● increased functional connectivity between bilateral | <ul style="list-style-type: none"> ● Identifying individuals ● Integrate neuroimaging in multisite trials ● More direct |

| Researcher(s) | Participants (Test group/Control group) | Interventions (Test group/Control group) (Duration) | Index | Results | Future expectations |
|--|---|---|---|---|--|
| | | | and resting-state functional connectivity of fronto-temporal brain networks | primary auditory cortex and subcortical and motor regions (often reduced in ASD)100 and reduced over-connectivity between auditory and visual-association areas | observation-based outcomes and the role of mediators and moderators on short- and long-term outcomes |
| <p>Abbreviations: Social Responsiveness Scale-2=SRS-2; Children’s Communication Checklist=CCC-2; maladaptive behavior subscale of the Vineland Adaptive Behavior Scales=VABS-MB; Family Quality of Life Scale=FQoL; Peabody Picture Vocabulary Test=PPVT-4; Autism Treatment Evaluation Checklist=ATEC; Gesell Developmental Schedules=GDS; Applied Behavior Analysis=ABA; Autism Behavior Checklist=ABC; Parenting Stress Index-Short Form=PSI-SF; Herth Hope Index=HHI; Psychoeducational Profile-3=PEP-3; Childhood Autism Rating Scale=CARS; Music Therapy Scale=MTS; Family APGAR Index=APGAR ; Autism Diagnostic Observation Schedule=ADOS; Music Therapy=MT; Repetitive Transcranial Magnetic Stimulation=rTMS; Enhanced Standard Care=ESC(usual care plus parent counseling)</p> | | | | | |

Table 2. Reviews

| Researcher(s) | Source of the articles | Analysis’s perspectives | Results | Future expectations |
|--------------------------------|------------------------|---|--|---------------------|
| Xie, Pei, & Zhang, (2024) [15] | Not mentioned | <ul style="list-style-type: none"> ● Mechanism ● Application on the field of child rehabilitation | <ul style="list-style-type: none"> ● MT promote the rehabilitation of social interaction, improve cognitive ability, reduce anxiety, regulate emotions etc. Benefit the physiology and mental health of the patient ● Chinese researches often use the MT on ASD, intellectual disability, cerebral palsy. In addition, international researches use the MT on the neonatal pain, childhood cancer, palliative care etc. | Not mentioned |

| | | | | |
|---|---|--|--|--|
| <p>Grau-Sánchez et al., (2022) [1]</p> | <ul style="list-style-type: none"> ● PubMed in June 2022 ● "music" and "neurological rehabilitation" ● 2011-2022 | <ul style="list-style-type: none"> ● Main methodological research challenges related to treatment ● Outcomes ● Research designs ● Implementation | <ul style="list-style-type: none"> ● Better definition and description ● Incorporating devices ● Interventions to individual patients ● Adequate selection according to the study aim ● Consider individual differences ● Need framework for the development and evaluation of complex interventions | <p>Same as the results</p> |
| <p>Zhang & Zhang, (2022) [3]</p> | <ul style="list-style-type: none"> ● PubMed, Embase (1996–2021 Week 43), and Cochrane library databases ● 2011-2021 | <ul style="list-style-type: none"> ● Transcranial direct current stimulation trials ● Transcranial magnetic stimulation trials | <p>Heterogeneity impedes to draw any conclusions about the therapeutic efficacy of NIBS on ASD</p> | <ul style="list-style-type: none"> ● Choosing reliable assessors to measure the changes in response to the treatment ● Objective parameters ● More basic research on the mechanism and long-term effects of NIBS on brain |
| <p>Abbreviations: Non-invasive neurostimulation techniques=NIBS</p> | | | | |

4. Findings and discussion

As a non-pharmacological intervention, music therapy has shown unique value in the rehabilitation of children with ASD. This study systematically analyzed recent papers and examined the effectiveness of music therapy when combined with sensory integration training, auditory integration training, mandala drawing, transcranial magnetic stimulation, or cognitive-behavioral intervention. Although single music therapy can promote improvements in children’s expressive ability and social responsiveness through rhythm, melody, and prosody, it is found that the music-only group did not show statistically significant improvement in ATEC total scores, suggesting the need for combined intervention strategies [13].

First, sensory integration training and auditory integration training combined with music therapy mainly target the common sensory hyper- or hypo-responsiveness in ASD children. A randomized controlled trial by Li and Han showed that music therapy combined with sensory integration training improved social adaptation by 37%, significantly better than single training [7]. Neurophysiological evidence indicates that auditory integration training combined with music therapy can enhance the functional connectivity between the primary auditory cortex and subcortical regions [5], thereby accelerating the process of auditory tolerance training and improving language perception. Mandala drawing, as an expressive art therapy, shows unique synergistic effects when combined with music

therapy. Ge et al. found that after six months of mandala drawing combined with music therapy, the observation group had significantly higher scores in multiple dimensions of the PEP-3 scale compared with the music-only group [10].

Second, transcranial magnetic stimulation promotes neural plasticity by regulating the excitability of specific brain regions. Feng et al. found that rTMS combined with music therapy reduced ABC scores by twice as much as the control group. Brain function monitoring showed that the combined group had more significant improvement in "brain energy consumption" and "brain coordination" indicators [2]. Zhang Ling et al. further confirmed that Orff music therapy combined with rTMS not only improved core symptoms but also significantly enhanced vestibular function scores [11].

Finally, the combination of cognitive-behavioral intervention and music therapy emphasizes the adjustment of thinking patterns and behaviors. A mixed-methods study by He et al. showed that music therapy combined with CBI not only improved children's social responses but also significantly alleviated parental stress [12].

Multidimensional integrated interventions of music therapy can better meet the complex rehabilitation needs of ASD compared with single therapies. However, current studies still have important limitations. The standardization of intervention programs is insufficient, such as the selection of music types and stimulation parameters, which lack unified standards [1]. In addition, cultural adaptation research is lacking; the response characteristics of Chinese children to Five-Element Music have not yet been explored [4]. Future research should address the following key issues through multi-center randomized controlled trials: develop cross-cultural adaptation frameworks that integrate the advantages of Traditional Chinese Five-Element Music and Western neurological music therapy; and establish standardized evaluation systems, using objective indicators such as eye-tracking to replace subjective scales.

5. Conclusion

This paper has introduced the urgency of the intervention of ASD, concluded the advantage and the insufficiency of the recent studies (including the MT). On this basis, this paper has discussed the effectiveness of the multi-intervention and summarized the thoughts of the probable mechanism. The results support the multi-intervention's benefits besides the mono-MT, and have given the evidence of the effectiveness of the MT, leading the future-studies to improve on the adaptability of different culture, the standardization of the interventions and the quantity of the objective indexes. It is important to notice that this study has realized an analysis of a modest quantity of experiment study, taken a few supports on the previous reviews and deleted some studies with duplicate contents. All of this cause the result non-statistically significant. Furthermore, this study tends to select the free full text article at the selection part may provide a non-representation on this field. Futures reviews can full-screen the articles that combine the MT with other therapy to provide a result more significant. Futures experiences on the multi-intervention can standardize the intervention, the cultural adaptability and introduce more objective index to get a proof with more clinical promotion significance.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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