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Research Paper

Effect of an Indian Percussion Music Instrument on the Oral Health, Motor Skills and Social Skills of Children with Autism

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ABSTRACT

Background: Children with Autism Spectrum Disorder (ASD) are characterized by deficit in social skills. Motor skill impairments and poor oral health are consistent with these individuals. An intervention targeting an improvement in multiple deficits of ASD needs to be developed. This study aimed to improve the oral health status, motor skills and social skills of children with autism by means of a music therapy involving self-playing a percussion music instrument. Methods: This study employed a randomized controlled trial design where children with autism between 4-12 years of age were divided into a control (n=12) and an experimental (n=12) group. Both groups were given the music therapy that involved training in playing the Tabla. The control group received only oral hygiene instructions whereas the experimental group received a music therapy intervention along with the oral hygiene instructions. Standardized scales were used for measuring the oral health status, motor skills and social skills. Descriptive independent t-test was done for intergroup comparison and paired t-test was done for intragroup comparison. Results: There was a significant change in the plaque index, motor skills, social participation and social reciprocation of the participants in the experimental group. Conclusion: This study showed that music therapy for children with autism through playing the Tabla shows potential for improving their oral health, motor skills and social skills.

Keywords: *Autism, Tabla, Oral Health, Motor Skills, Music Therapy, Social Skills*

Autism Spectrum Disorder (ASD) is a pervasive neurodevelopmental disorder characterized by impairments in social communication and restricted, repetitive patterns of behavior, interests or activities (DSM-V, 2013). Even though not a part of its diagnostic criteria, motor skill impairments can be commonly seen in children with ASD.

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These motor skills when combined with their cognitive dysfunction can hinder those activities that are performed in a sequential manner (Mari et al., 2003).

Social skills are directly related to cognitive functioning that help in routine activities pertaining to health care, grooming, eating, etc. The shortcomings in performing these tasks can be seen in individuals with ASD. They exhibit stereotype behaviours that are linked with the upper limbs and body balance (Jasmin et al., 2009; Jeste, 2011). One social behaviour commonly exhibited by autistic individuals is tactile defensiveness. It is described as "a hypersensitivity or hyperresponsivity to touch situations that most persons find nonthreatening." Patients exhibiting tactile defensiveness often display an avoidance-withdrawal response when they are confronted to a certain tactile stimulus. Aversion to dental care is one of the commonly seen behaviours in tactile defensiveness. Since dental care is considered as a self-care skill, this particular trait is categorized under "Level 2/Moderate" severity of sensory defensiveness syndrome (Baranek et al., 1997; Stagnitti et al., 1999). Thus, children with autism exhibit a poor oral health status (da Silva et al., 2017; du RY et al., 2019).

Apart from social skills, the deprived oral health in autistic individuals can be attributed to their motor skill comorbidities. Impaired finger-thumb opposition, clumsiness, lack of visuo-motor co-ordination are commonly reported behaviours in autism (Mari et al., 2003; Jasmin et al., 2009). Furthermore, motor components are directly related to broader aspects of development, including language, social interaction and learning (Jeste 2011). Toothbrushing itself requires the involvement of multiple muscles of the upper limb along with better cognitive ability (Uenoyama & Inada, 1990). Hence, poor upper limb motor coordination is one of the reasons which leads to poor oral hygiene in children with autism (Luppanapornlarp et al., 2010).

There have been multiple attempts in the past to teach autistic individuals the daily routine of toothbrushing. These include dividing the action of toothbrushing into various steps as a learning pattern, visual pedagogy, video modelling and Picture Exchange Communication System. However, each of these teaching methodologies were either time-consuming, did not guarantee any improvements in the oral health or were difficult for the caretakers to accept (Smith and Belcher, 1985; Matson et al., 1990; Pilebro and Backman, 2005; Popple et al., 2016; Al-Batayneh et al., 2019). We are thus inclined to approach a new intervention system that helps in improving the oral health status of children with autism such that the mode of teaching is interesting and engaging for the parents as well.

Music provides a multimodal stimulus, that can activate the visual, somatosensory, auditory and motor components of the brain (Wan et al., 2010). The World Federation of Music Therapy defines music therapy as "the professional use of music and its elements as an intervention in medical, educational, and everyday environments with individuals, groups, families, or communities who seek to optimise their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and wellbeing. Research, practice, education, and clinical training in music therapy are based on professional standards according to cultural, social, and political contexts" (WFMT, 2020).

Music therapy through interactive or self-instrument playing helps in achieving a significant improvement in areas associated with cognitive, communication, behavioural, musical and motor skills in autistic individuals (Kaplan and Steele, 2005).

Musical characteristics in children with autism were first described in 1953 (Sherwin, 1953). The key points were:

- An unusual interest in music
- A tendency to sing differently from an average child
- An oftentimes unusual ability to reproduce familiar pieces with extraordinary accuracy

Music therapy has been used as an intervention for autism since the 1940s. The earliest studies done on children who fell in the autism spectrum that involves playing of percussion instruments by the subjects were reported by Goldstein C. and Thaut M. Furthermore, the studies that link social skills and autism were carried out by Paul Nordoff and Clive Robbins in the early and mid-1960s (Reschke-Hernandez, 2011).

An Indian Percussion Music instrument called Tabla consists of a pair of drums. Sound is produced by hitting the Tabla on its leather-covered surface with precision and power of the fingers and palm, in co-ordination with the wrist, elbow and shoulder. Hence, the entire arm is used in order to produce the desired sound from the instrument.

Music making is one medium that engages the mirror neuron system (MNS). This is responsible for goal-directed, sequential and skilled movements (Wan et al., 2010). The hand is given a major portion of neural apparatus (somatosensory and motor cortical areas) in the brain (Mari et al., 2003). Thus, playing an instrument like Tabla that utilizes the entirety of the upper limbs can have multi-fold effects. One of these effects includes training those muscles of the hand that are utilized both in playing the Tabla and while brushing the teeth.

Rhythmic cueing through an electronic metronome or a prepared form of music has been shown to improve the muscular control, time-based movements and proprioceptive control mechanisms (Sarkamo et al., 2013; El-Shemy and El-Sayed, 2018). In this study, an electronic metronome (Sunadamala Dx 2009, Radel Electronics Pvt. Ltd.) delivered the rhythmic auditory cueing.

Considering the lack of evidence available among children with ASD, the present study was planned to evaluate the changes in oral health status, motor skills and social skills by training them in playing a percussion instrument (Tabla) (Figure 1).

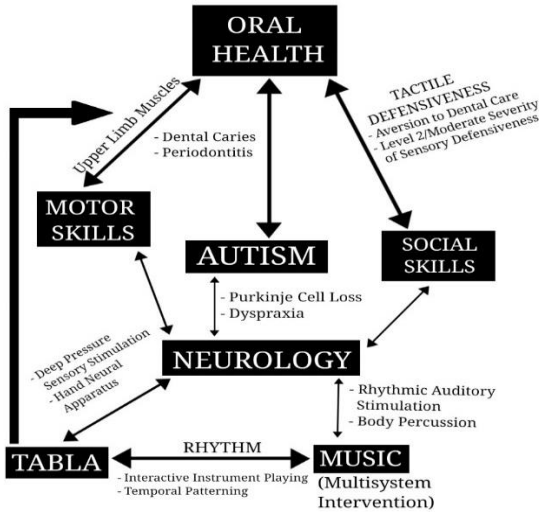


Figure 1 Linking Autism, Oral Health and Music

MATERIALS AND METHODS

Objective

The present study was conducted to study the effect of a music therapy intervention on the oral health status, motor skills and social skills of children with autism. In order to evaluate the efficacy of the intervention on the outcome variables, a randomized controlled trial design was employed. Participants chosen for the study were randomly divided into a control and an experimental group through a simple randomization technique wherein allocation of the participants to either group was blinded from the researchers.

Inclusion criteria

Participants chosen for the study were required to have a confirmed diagnosis of ASD as per the Childhood Autism Rating Scale (CARS). This diagnosis was confirmed by the pediatric neurologist and a psychologist. All included participants should be in the age range of 4-12 years. Children with autism were included only if they had a signed written consent from their caretaker or parent addressing their participation in the study.

Exclusion criteria

Children with impaired vision, hearing or having congenital absence of limbs were excluded from the study. The children who were involved in any training sessions for music, drawing, creative drama, etc. during the intervention period were excluded from the study. A child was not included in the study if they received another music therapy intervention within six months prior to the start of the training duration. A child is excluded from the study if he or she skipped a music therapy session.

Sample size calculation

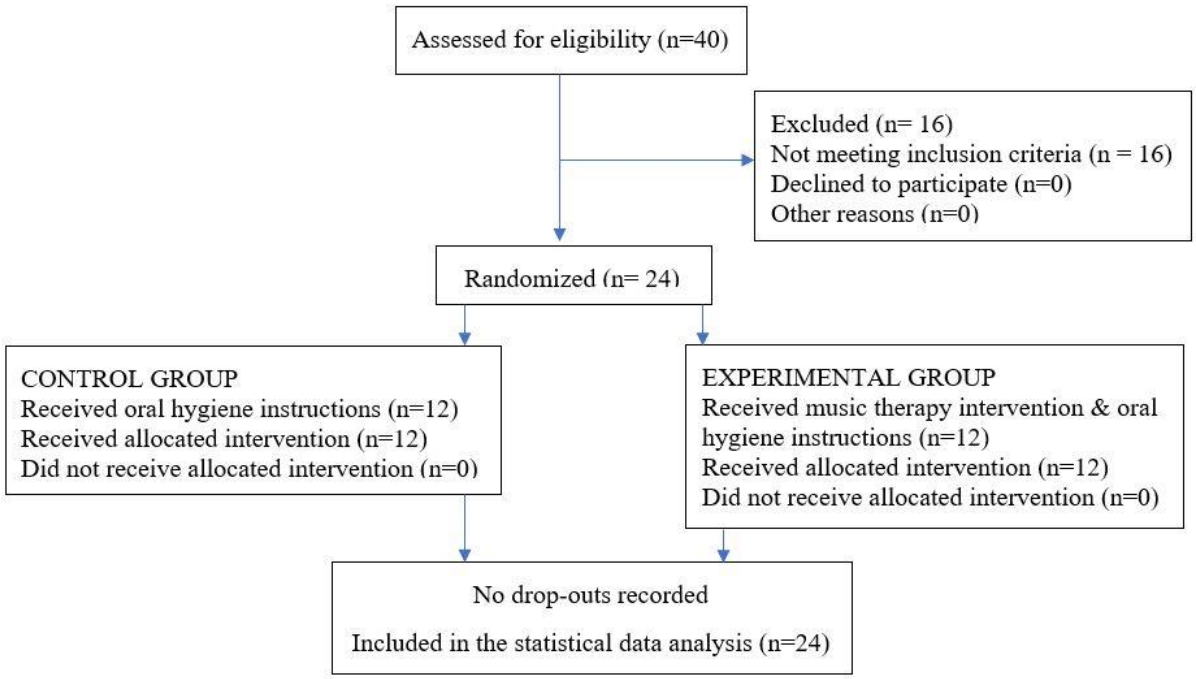
- **Sample size** calculation was done using beta power method. An effect size of 0.97 was considered given the mean and standard deviation values considered. A two-tailed input at a power size of 85% revealed the total sample size to be 22 – 11 in each group.
- **Enrollment:** 40 children from two special kids' school in Ahmedabad, India were initially screened. 24 participants who met the inclusion criteria were enrolled in the study. Out of the 24 participants chosen, 19 were boys and 5 were girls.
- **Randomization:** A simple randomization technique utilizing a computer-generated lottery method was used to allocate the participants into an experimental and control group of equal sample size (n=12 for each group).
- **Allocation concealment:** Participants were assigned a number that was computer-generated. This allocation was unknown to both the researchers and participants involved in the study.
- **Blinding:** The assignment of participants into a control and an experimental group was blinded from the researchers who would be involved in carrying out the pre- and post-intervention evaluations of the outcome variables and the ones involved in carrying out the intervention.

Ethical Approval

- Ethical clearance was obtained from the Institutional Ethics Committee College of Dental Sciences and Research Centre, Ahmedabad.
- Participants were included in the study only if their parents or caretakers signed a written consent that explained the benefits of music therapy program by training them

in playing the Tabla, which could subsequently enhance their oral health status, motor skills and social skills.

- A "No Objection Certificate" was obtained from both the schools whose children participated in the study. This certificate ensured that the schools had no issue in letting the music therapist teach the children with autism.



METHODOLOGY – ASSESSMENT, SCORING AND DATA COLLECTION

Pre-intervention assessment

Diagnosis of autism was confirmed by the Childhood Autism Rating Scale (CARS) by the pediatric neurologist and a psychologist. The CARS score varies between 15-60. Below 29.5, a child is considered non-autistic, between 30-36.5 is scored as mild to moderately autistic and between 37-60 is recorded as moderate to severely autistic. The CARS has an internal consistency reliability alpha coefficient of 0.94, inter-rate reliability correlation coefficient of 0.71 and a test-retest correlation coefficient of 0.88 (Schopler et al., 1988).

Children in both groups were assessed for oral health status, motor skills and social skills prior to the commencement of the training sessions. The oral health status was evaluated by a pediatric dentist who was unaware of the group allocation.

Gingival Index: Condition of the gingiva includes assessing its quality and location at all four locations of the teeth (buccal, mesial, distal, lingual). The Gingival Index helps in understanding the level of inflammation of the gingiva (Loe, 1967).

Plaque Index: Oral Health can worsen if plaque gets accumulated and the periodontal condition weakens. The Plaque Index is thus used for assessing the severity and location of soft debris aggregates on all four surfaces of the teeth (Silness and Loe., 1964).

Both these indices are recorded on six index teeth in each arch. In children, if any permanent index tooth is absent, its primary counterpart was used for scoring (Tandon S., 2018). A mouth mirror, dental explorer and periodontal probe was used for recording the scores.

Calculation of the scores in each index follows the same steps. In each index, the scores of each tooth are added and divided by the total teeth examined. Based on this, the scores vary from 0 to 3. These scores are interpreted as Excellent (0), Good (0.1-0.9), Fair (1.0-1.9) and Poor (2.0-3.0).

Autism Social Skills Profile: This scale has three subscales that cover the areas of social reciprocity, social participation/avoidance and detrimental social behaviour. The scores are calculated by asking the caretaker a questionnaire whose answers are rated on a 4-point Likert scale (Bellini and Hopf., 2007). All questions regarding each participant were answered by the caretakers to one researcher. This researcher was blinded from group allocations.

Social Reciprocity: This subscale consisted of questions pertaining to active maintenance of social interactions and demonstration of perspective-taking skills.

Social Participation/Avoidance: This subscale comprised of questions related to social engagement or withdrawal from participation.

Detrimental Social Behaviour: This subscale included items representing socially inappropriate behaviours that could lead to directly negative peer interactions.

Internal consistency reliability score was high ($\alpha = 0.926$) and test-retest reliability coefficient score was 0.904.

Quality of Upper Extremity Skills Test (QUEST): The upper limb movements help in understanding their functionality and are indicative of typical development. The QUEST helps in describing quality of movements and planning intervention programmes. It assesses the performance of the upper limbs by observing the performance of the participants in various activities pertaining to dissociative movements, grasp, weight bearing and protective extension. Based on this, the participants are scored out of a total score of 100. The test-retest reliability of QUEST ranges from 0.75 to 0.95 (DeMatteo et al., 1993). The test was carried out by a physiotherapist and an occupational therapist. Both these therapists were blinded from group allocations.

Music therapy – Teaching the Tabla to Children with Autism

Training duration

Children in the experimental group were given music therapy training in self-playing a musical instrument for 3 months. Each training session lasted for 1 hour and each child was taught on a one-on-one basis for 10 minutes. The time frame for teaching each child during each session varied depending on the child's attention span, mental state and reciprocal behaviour of each child. Based on the experience of the music therapist, it is important to note that this time span varied in each autistic child.

Training regime

The training sessions were held in a closed room present in the school premises. The child and the music therapist sat on the floor facing each other. One pair of Tabla was placed in front of the child while the other pair was placed in front of the music therapist. An electronic metronome (Sundamala Dx, Radel Electronics Pvt. Ltd.) was used for enhancing the quality of teaching rhythmic patterns.

The training sessions were inspired and executed from the music therapy treatment model proposed by Michael Thaut. This treatment model was divided such that the training sessions were had three levels: Basic, Intermediate and Complex (Thaut, 1984). Some variations did exist in each level based on the speed of learning of the child and his/her reactions to the acoustics of the instrument.

Basic Level

The beats played on the Tabla are based on the way the fingers are positioned on the instrument. The initial beats were played by striking the palms on both drums. This striking was expected to be rhythmic. The basic level focused on letting the autistic child manually explore the musical instrument and let the musical instrument serve as a mutual point of contact for the therapist and the participant. Physical contact with the child needs to be established right from the basic level. This can be done by guiding the child's hands to the area of the drum where the desired sound is produced (Figure 2). Further reinforcement of the taught beat can be done by asking the child to imitate the beat played by the therapist.

Intermediate Level

The next beats taught saw more use of individual fingers that had to be curled at times to produce the beat. These beats were also taught using the echo back technique where the participant was asked to play the same beat the therapist played. Each beat targeted the involvement of multiple muscles from the fingers to the shoulders. In this level, special focus is laid on body percussion activities and clapping patterns which keeps the autistic child's interest consistent. The beats and claps are expected to match the electronic metronome. There should be special focus on imitation exercises where the child tries to match the beats that the therapist plays (Figure 2). These help in improving the attention and focus of the child.

Complex Level

When individual beats are satisfactorily played, a combination of beats is taught to the children. This helped in establishing the right/left awareness among the participants. In order to make it more interesting for them and to help them memorize these beats, the children were often taught by associating the beats with numbers, letters, songs or voices resembling the sound produced by the beats. These additional exercises helped in strengthening the rhythmic sense of the children. Children were also paired and made to play together in order to check their inter-playing co-ordination skills (Figure 2).

Figure 2 Rhythmic Music Therapy Training Regime

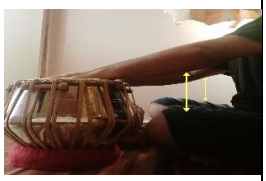
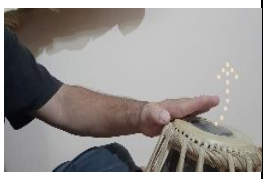
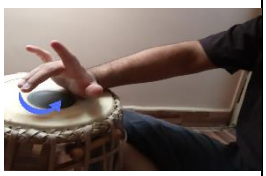
List of beats taught	How to play the beat	Drum	Muscles involved in toothbrushing						
			FPB	FCR	FPL	FDS	PT	BB	D
	Posture for playing tabla involves sitting cross-legged with a straight back. The elbows should never take the support of the thighs. It is important to note that a radial wrist deviation is always constant. *	Both					●		●
	DIN: This beat is played by adducting the fingers. Sound is produced when these fingers strike the black circle and immediately lift the palm when a resonated sound is produced. A variant of this beat, "TUN" is played by abducting the fingers.	RD	●		●		●		●
	TI: This beat involves adducting the middle & ring finger. Sound is produced when these two fingers hit the black circle. The final position should see the distal phalanges of these fingers grasp the instrument.	RD		●		●	●		●
	TE: This beat is often played in conjunction with "Ti." It follows the same rules for "Ti." However, it is played only with the index finger.	RD				●	●		●
	TAK: This beat involves curling the fingers with the thumb by giving it a concave shape. Sound is produced when these fingers grasp & adhere to the black circle tightly.	RD	●	●	●	●	●		●
	KE: This beat involves moving the palm in hyperextension, extension, neutral and flexion position solely with the wrist. Sound is produced when the palm and fingers hit the drum.	LD	●	●	●	●	●		●
	GHE: This beat involves curling the middle & ring finger from their extension to flexion. The resonance of the sound is produced by the power & precision of the distal phalanges of the two fingers.	LD		●		●	●		●
	GA: This beat is played in the same way as "Ghe." However, in this beat, only the index finger is used.	LD		●		●	●		●

Table 1 List of Beats Taught; LD=Left Drum, RD=Right Drum, FPB=Flexor Pollicis Brevis, FCR=Flexor Carpi Radialis, FPL=Flexor Pollicis Longus, FDS=Flexor Digitorum Superficialis, PT=Pronator Teres, BB=Biceps Brachii, D=Deltoid; * Radial Flexion of the wrists is also seen during toothbrushing; ● Indicates muscle used while playing the beat

Caretakers were educated on the importance of maintaining the oral health of children with autism. They were advised to use a soft bristled toothbrush, pea-sized amount of toothpaste and the correct toothbrushing method that the child must employ.

Post-Intervention Assessment
At the end of the training sessions, the children were once again assessed for oral health status, social skills and motor skills.

Statistical Analysis
The statistical data was analyzed using the SPSS (version 23) software. This study had a control and an experimental group, each having 12 participants (n=24). Following the intervention, pre-test and post-test results were recorded and analyzed. Descriptive independent t-test was done for intergroup comparison and paired t-test was done for intragroup comparison.

RESULTS

Oral Health Status
Oral health of the participants was analyzed using the Gingival Index and Plaque Index. The gingival index suggests a non-significant change in the experimental group. However, the plaque index showed a significant change in the experimental group in the intragroup comparison ($p < 0.001$). Intergroup comparisons reveal that there is a reduction in the mean gingival and plaque index values in the experimental group. However, these values were statistically not significant ($p > 0.05$) (Table 2 and Table 3).

Social Skills
Social skills evaluation comprised of analysing the social reciprocation, social participation and detrimental social behaviour scores. There was a statistically significant improvement in the social participation ($p < 0.009$) and social reciprocation ($p < 0.001$) scores in the experimental group in the intragroup comparisons. Social participation was also significantly improved in the experimental group in the intergroup comparisons ($p < 0.033$). Detrimental Social Behaviour scores showed a decrease in the experimental group. However, these results were not significant in both intergroup and intragroup comparisons (Table 2 and Table 3).

Motor Skills
Motor skills was evaluated for the upper limbs primarily. There is a statistically significant difference observed in both the intergroup and intragroup comparisons ($p < 0.005$) in the experimental group (Table 2 and Table 3).

Table 2 Intragroup comparisons done using paired t-test

Group	Parameter	Duration	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P value
Control	Gingival Index	Before	1.18	12	.06	.01623	.01667	0.427 NS
		After	1.16	12	.06	.01862		
Experimental	Gingival Index	Before	1.16	12	.06	.01746	.02500	0.100 NS
		After	1.14	12	.06	.01867		
Control	Plaque Index	Before	1.20	12	.09	.02527	.00167	0.953 NS
		After	1.20	12	.09	.02614		

Experimental	Plaque Index	Before	1.23	12	.09	.02551	.08333	0.001*
		After	1.15	12	.05	.01553		
Control	Social Reciprocation	Before	47.083	12	5.8536	1.6898	.6667	0.452 NS
		After	46.417	12	5.2649	1.5199		
Experimental	Social Reciprocation	Before	46.333	12	8.4781	2.4474	-1.9167	0.001*
		After	48.250	12	12.7288	3.6745		
Control	Social Participation	Before	23.33	12	5.2281	1.5092	-.5000	0.491 NS
		After	23.83	12	5.6057	1.6182		
Experimental	Social Participation	Before	23.75	12	7.0340	2.0305	-5.0000	0.009*
		After	28.75	12	4.9383	1.4256		
Control	Detrimental Social Behaviour	Before	30.083	12	5.9614	1.7209	-.8333	0.376 NS
		After	30.917	12	4.5817	1.3226		
Experimental	Detrimental Social Behaviour	Before	30.167	12	6.0277	1.7401	.2500	0.475 NS
		After	29.917	12	4.9810	1.4379		
Control	Motor Skills	Before	76.75	12	10.1902	2.9417	-.5000	0.590 NS
		After	77.25	12	9.8177	2.8341		
Experimental	Motor skills	Before	80.42	12	14.3809	4.1514	-9.2500	0.005*
		After	89.67	12	7.1774	2.0719		

Table 3 Intergroup comparisons done using descriptive independent t-test

Group	**Parameter**	**Duration**	**Mean**	**N**	**Std. Deviation**	**Std. Error Mean**	**Mean Difference**	**P value**
Control	Gingival Index	Before	1.18	12	.06	.01623	.01667	0.427 NS
		After	1.16	12	.06	.01862		
Experimental	Gingival Index	Before	1.16	12	.06	.01746	.02500	0.100 NS
		After	1.14	12	.06	.01867		
Control	Plaque Index	Before	1.20	12	.09	.02527	.00167	0.953 NS
		After	1.20	12	.09	.02614		
Experimental	Plaque Index	Before	1.23	12	.09	.02551	.08333	0.001*
		After	1.15	12	.05	.01553		
Control	Social Reciprocation	Before	47.083	12	5.8536	1.6898	.6667	0.452 NS
		After	46.417	12	5.2649	1.5199		
Experimental	Social Reciprocation	Before	46.333	12	8.4781	2.4474	-1.9167	0.001*
		After	48.250	12	12.7288	3.6745		
Control	Social Participation	Before	23.33	12	5.2281	1.5092	-.5000	0.491 NS
		After	23.83	12	5.6057	1.6182		
Experimental	Social Participation	Before	23.75	12	7.0340	2.0305	-5.0000	0.009*
		After	28.75	12	4.9383	1.4256		
Control	Detrimental Social Behaviour	Before	30.083	12	5.9614	1.7209	-.8333	0.376 NS
		After	30.917	12	4.5817	1.3226		

Experimental	Detrimental Social Behaviour	Before	30.167	12	6.0277	1.7401	.2500	0.475 NS
		After	29.917	12	4.9810	1.4379		
Control	Motor Skills	Before	76.75	12	10.1902	2.9417	-.5000	0.590 NS
		After	77.25	12	9.8177	2.8341		
Experimental	Motor skills	Before	80.42	12	14.3809	4.1514	-9.2500	0.005 *
		After	89.67	12	7.1774	2.0719		

DISCUSSION

Poor oral health of children with autism can be attributed to several reasons like uncontrolled and autism spectrum disorders (ASD) is an inclusive term for a group of neurodevelopmental disorders sharing similar impairments in communication, reciprocal social interaction, and restricted, repetitive behavior (Fournier et al., 2010). The National Institute of Child Health and Human Development has defined the autism spectrum disorders as, "A complex biological disorder that generally lasts for a person's entire life, beginning before the age of three, in the developmental period, and causes delays or problems in many different ways in which a person develops or grows" (Ferrazzano et al., 2020).

An observation of "abnormal children" made by a Viennese paediatrician named Ronald in 1944 is said to be the first mention of Autism in India. The prevalence of ASD today is around 3 million in the Indian sub-continent (Sam et al., 2020; Juneja and Sairam, 2018). The range of symptoms exhibited by each individual diagnosed with autism can range from "highly skilled/functional" to "severely challenged/autistic." Autism typically appears during the first 3 years of life showing symptoms like stereotyped motor behaviour, abnormal responses to sensations, absent or delayed speech or language and abnormal ways of relating to people, objects and events. Genetic, environmental and neural factors affect each child differently irrespective of their age. the cognitive and behavioural characteristics of children with ASD show great heterogeneity, with the degree of deficit being unclear (Green et al., 1995). In this study, the participants that were included in the study were between 4 to 12 years of age.

Children with ASD are at a high risk of developing oral health conditions like dental caries and have compromised gingival and periodontal hygiene. Higher levels of anxiety, heightened response to stimuli, poor co-operation, low dental attendance, are highlighting factors of poor oral health in children with autism compared to neurotypical children (Liu et al., 2019). This can be attributed to the improper fine motor skills in children with autism, who have poor upper limb co-ordination and insufficient manual dexterity required for performing tooth brushing and flossing (Luppanapornlarp et al., 2010; Bartolome-Villar et al., 2016; Ferrazzano et al., 2020).

There is enough evidence on music therapy's benefits on individuals with autism based on the preference, responsivity and predisposition of this group to music stimuli. Musical perception in individuals with autism is characterized by superior identification and labelling of pitch, enhanced sensitivity for pitch direction and enhanced detection of changes in pitch contours (Simpson and Keen, 2011). Whipple reported that music was effective as an intervention with individuals with autism irrespective of the age of participants, type of intervention, treatment, methodology and profession of the music provider (Whipple, 2004).

Carol Goldstein first reported the use of a percussion instrument as one of the many interventions done on an 8-year-old autistic girl. Goldstein states that by letting the child play a percussion instrument, the idea was to add "color to the sound and provided the child with a constructive outlet for her aggression" (Goldstein, 1964). Another percussion instrument by the name of "bongo drums" have also been used as a musical bridge that could tap out communication, messages and emotions in children with autism (Warwick, 1984).

The musical instrument used in our study was the Tabla, another percussion instrument. Sound production in this instrument is entirely by the way the fingers hit the drums. Fine motor skills can be refined through playing such rhythmic instruments which can further refine and appropriately time finger, hand and arm movements (Srinivasan and Bhat, 2013). Toothbrushing involves the sequential utilization of muscles of the hand which can help in effective mechanical plaque control. In our study, these muscles of the hand were targeted through training in percussion music instrument like the Tabla that targets the fine and gross motor skills of the upper limbs.

Flexor pollicis brevis, flexor pollicis longus, flexor carpi radialis, pronator teres, biceps brachii and deltoid are the commonly utilized muscles while using a toothbrush (Uenoyama and Inada, 1990). A computer software analyzed the action of various muscles when subjects resorted to bass, modified stillman, scrubbing and rolling techniques. The most important muscles that generated action potential during toothbrushing are flexor carpi radialis, flexor pollicis longus, biceps brachii and thumb flexor (Endo et al., 2003). Kono and Inada in 1995 compared the grip strength in school children and adults. The range of motion of upper limbs and the muscles involved were closely studied. They concluded that the grip pressure relies entirely on the thumb and index finger. Muscles like flexor digitorum brevis, root flexor, pronator biceps and deltoid muscles along with flexion of the metacarpophalangeal joint of second finger are most commonly used during toothbrushing. Flexion of the wrist, radius and ulna along with elbow joint flexion are the most important motions during toothbrushing (Kono and Inada, 1995). These motions were utilized while playing the beats on the Tabla during the course of the music therapy sessions (Table 1).

In this study, motor skills and social skills are a physiological, psychological or neurological response to music. They are connected with an analogous non-musical response in the form of oral health. There is growing evidence that music therapy can enhance the motor and social skills of children with autism (Boso et al., 2007; Zarafshan et al., 2017; Weitlauf et al., 2017; Damm and Workman, 2017). Hence, the objective of this study was to enhance the oral health of the children with autism by improving their mechanical plaque control skill, which required apt motor and social skills. However, in order to achieve the needed results, the method of training the children in playing the instrument should be in a structured and meticulous manner.

At the end of the training sessions, the experimental group showed an improvement in all three domains that were put to test – motor skills, social skills and oral health status.

ASD, Music & Oral Health Status

According to Ferrazzano et al, children with ASD may have a major risk of developing caries, periodontal lesions and alteration of the oral microbiome. The authors add that because of their hyperactivity and their stereotypical and self-injurious attitudes, these children have a

greater probability of having oral trauma. All these diseases can be reduced, if not eliminated, by personalised preventive approaches and a correct personalised educational model for the ASD patient (Ferrazzano et al., 2020). In our knowledge there is no previous study that aimed to see the effect of a musical therapy intervention on the oral health of children with autism.

The intragroup results of our study show that following the intervention, the experimental group showed a significant reduction in the plaque index score (Table 2). There was also a reduction in the mean scores of both gingival and plaque index in the intergroup comparisons (Table 3). However, these results were not statistically significant. The reason for this can be attributed to many reasons. Firstly, the significant reduction in plaque index score can be because of a significant increase in the motor skills of the participants at the end of the training duration. However, this cannot be the sole reason influencing the results of oral health status. Even if the participants had an enhancement in motor skills, it is still noteworthy that they take a longer time to adapt to their new skills (Matson et al., 1990). Children with autism display oral sensitivity and often show behavioural tantrums during toothbrushing (Du et al., 2018; Smith and Belcher, 1985; Popple et al., 2016; Subramanium and Gupta, 2011). Moreover, because of their low cognitive functioning, there is a need to instruct them repeatedly with proper instructions (Pilebro and Backman, 2005).

Three more factors which can influence the periodontal condition of children with autism are their irregular dietary habits, ongoing medications and the type of tool they use for plaque control (electric or manual) (Shapira et al., 1989; Ferrazzano et al., 2020). These are vital because salivary pH and buffering capacity are lower in children with autism. Moreover, microbiological studies have revealed an increased prevalence of Hemophilus in saliva and Streptococcus in saliva in patients of autism. Thus, these periodontal factors, which are difficult to control outside the experimental environment can assert their effects on the outcome of this study.

ASD, Music & Motor Skills

In the present study, the Quality of Upper Extremity Skills Test (QUEST) was used to evaluate the motor skills of the children with autism. The motor skills improved significantly in the experimental group in both intergroup and intragroup comparisons (Table 2 and Table 3). The findings of this study agree with the findings of two other studies where the researchers evaluated the effect of music instrument playing on children with Down's Syndrome. Down's Syndrome also causes developmental delays in motor skills due to chromosomal abnormalities. In the first study the effect of 1 month of Tabla training was observed on the motor skills of children between 6 to 12 years of age with Down's Syndrome. The results of the study showed that there was a significant change in the hand functioning of the children after the intervention (Maqbool and Rajaguru, 2015). The second study evaluated the effect of self-playing the drums on their motor development. After 6 months of training, the participants showed a significant improvement in the motor development of children with Down's Syndrome (Taufiq et al., 2018).

The involvement of the hand-motor component in Tabla playing served two functions apart from promoting the motor activity and capture the child's interest in the therapy. Firstly, the simultaneous engagement of a number of sensorimotor systems while playing the instrument has the potential to strengthen the connections between auditory and motor regions. Secondly, the act of music making itself has the potential to facilitate social communication and interaction in children with autism because it exploits their strong interest in music as well as

their positive response to it (Wan and Schlaug, 2010). Since sound production in Tabla takes place through the fingers hitting the drums, it is safe to assume that deep pressure technique (firm touch pressure providing calming input) is also delivered through it. Moreover, instrument exploration and feeling of vibrations of the sound produced by the instrument can also help in sensory stimulation (Baranek, 2002). A PET scan of a neurological study showed that finger tapping led to the activation of those areas of the brain that are responsible for motor skills, social skills and music perception (Aoki et al., 2009).

ASD, Music & Social Skills

Improper social functioning is the defining feature of autism. Social participation, social reciprocation and social behaviour in a given setting are reflective of a child's cognitive development. Social, behavioural and cultural factors like poor family stability, lack of parents' knowledge on oral health, low family income, improper eating habits, have been associated with increased caries prevalence in children with autism (Ferrazzano et al., 2016).

Impaired motor development can derail the development of social communication. This is because timed gesture and gaze-following are the building blocks of joint attention (Chukoskie et al., 2013). Furthermore, playing drums (another percussion instrument) led to an increase in the social skills of children with autism in areas concerned with co-operation, self-control and imitation (Yoo and Kim, 2018). In fact, Hans Asperger (discoverer of Asperger syndrome) believed that it was impossible to tease apart motor clumsiness from lack of social understanding and believed that the two deficits were in fact linked.

Social skills were evaluated using Autism Social Skills Profile which considered Social Reciprocation, Social Participation and Detrimental Social Behaviour. Social reciprocation improved significantly in the experimental group in the intragroup comparisons (Table 2). Social participation showed a significant enhancement in both intergroup and intragroup comparisons. Detrimental Social Behavior was decreased in the experimental group, but the results were not significant (Table 2 and Table 3).

The results of social skills in this study agree with the study by Lagasse in 2014 who showed a significant improvement in social skills of 17 children with autism between the age of 6 to 9 years who were given music therapy group intervention. The same study also demonstrated initial support for the use of music therapy social groups to develop joint (LaGasse, 2014). The enhancement in social participation and social reciprocation agrees with the findings of a systematic review that showed the effect of music therapy on improving the social outcomes (communication, participation, joint-attention, frequency of responses) in children and adults with ASD (Boster et al., 2021). Our study was conducted for a period of 12 weeks and the results showed an enhancement in social participation and social reciprocation skills. This change is certainly possible as confirmed by a neurological study that showed the improvement in social communication and brain-connectivity following a music therapy intervention for 8-12 weeks in children with autism between the age of 6-12 years (Sharda et al., 2018).

Limitations

This study has shown that oral health status, social skills and motor skills were improved in the experimental group following a music therapy intervention. However, factors like dietary habits, mode of plaque control, ongoing medications and behaviour during toothbrushing sessions were not monitored. Even though these factors can affect the oral health-based

outcomes of the study, the effect of music therapy in enhancing social and motor skills cannot be denied.

The motor skills in this study were assessed by Quality of Upper Extremity Skills Test (QUEST). This test was primarily developed for children with cerebral palsy between the age of 18 months to 8 years. However, based on the recommendations of the International Handbook of Autism and Pervasive Developmental Disorders, the QUEST can be used for children with autism (Hilton, 2011). Moreover, the QUEST specifically focuses on the motor skills assessment of upper limbs which is appropriate for the current study. The results of motor skills obtained through QUEST in this study shows the potential of Tabla as a musical instrument for improving the motor skills in children with developmental disabilities.

CONCLUSION

Music Therapy is one of those approaches which directly affects the neural networking of the brain of children with Autism. The present study lays down the foundation of a possible link between rhythm-based music, pediatric dentistry and autism. This intervention is more desirable in individuals with ASD as it has a neurological effect in areas of the brain concerned with motor and social skills. Within the limitations of this study, the following conclusions can be drawn:

- Poor upper limb co-ordination is a major factor for detrimental oral health in children with autism.
- Oral health status improved following the music therapy intervention.
- Motor skills and social skills scores showed an enhancement after music therapy. sessions. An interplay between these variables affects the oral health of children with autism.
- A correlation can be appreciated between the similarities in the muscles used during the act of toothbrushing and playing the Tabla.

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Conflict of Interest

The author declared no conflict of interest.

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