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The Impact of Tuina Massage Therapy on Sensory Processing, Sleep Disturbances, and Maladaptive Behaviors in Young Children with Autism Spectrum Disorder in Jakarta, Indonesia: A Controlled Clinical Study

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A B S T R A C T

Introduction: Autism spectrum disorder (ASD) is a complex neurodevelopmental condition characterized by challenges in social communication, restricted interests, and repetitive behaviors, often accompanied by sensory processing abnormalities, sleep disturbances, and maladaptive behaviors. Current interventions offer variable efficacy, prompting exploration of complementary therapies. Tuina, a form of therapeutic massage in Traditional Chinese Medicine (TCM), has shown potential in pediatric neurodevelopmental issues. This study aimed to investigate the impact of Tuina massage therapy on sensory processing, sleep quality, and maladaptive behaviors in young children with ASD in Jakarta, Indonesia. **Methods:** A controlled clinical study was conducted with 88 children aged 3-7 years, diagnosed with ASD according to DSM-5 criteria and confirmed using the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2). Participants were recruited from specialized pediatric clinics in Jakarta and assigned to either an intervention group (n=44) receiving a standardized Tuina protocol thrice weekly for 12 weeks alongside standard care, or a control group (n=44) receiving standard care only. Standard care included established interventions such as behavioral therapy, speech therapy, occupational therapy, or special education programs. Outcome measures included the Sensory Profile 2 (SP-2), the Children's Sleep Habits Questionnaire (CSHQ), and the Aberrant Behavior Checklist-Community (ABC-C), administered at baseline, week 6, week 12 (post-intervention), and at a 3-month follow-up (week 24). **Results:** At 12 weeks, the Tuina group demonstrated statistically significant improvements compared to the control group in sensory processing, specifically in auditory filtering (mean difference [MD] -8.5, 95% CI -11.2 to -5.8, $p<0.001$) and tactile sensitivity (MD -7.9, 95% CI -10.5 to -5.3, $p<0.001$) on SP-2 quadrant scores. Total CSHQ scores indicated significantly better sleep in the Tuina group (MD -6.8, 95% CI -9.1 to -4.5, $p<0.001$), particularly in subscales of bedtime resistance and sleep anxiety. ABC-C scores for irritability (MD -5.2, 95% CI -7.0 to -3.4, $p<0.001$) and hyperactivity (MD -6.1, 95% CI -8.3 to -3.9, $p<0.001$) were also significantly lower in the Tuina group. These improvements were largely maintained at the 3-month follow-up. No serious adverse events were reported. **Conclusion:** This study provides evidence that Tuina massage therapy, as an adjunct to standard care, can significantly improve sensory processing, reduce sleep disturbances, and mitigate maladaptive behaviors in young children with ASD in an Indonesian context. These findings suggest Tuina may be a valuable complementary intervention for managing core and associated symptoms of ASD. Further research with larger, diverse samples and longer follow-up periods is warranted.

1. Introduction

Autism spectrum disorder (ASD) is a pervasive neurodevelopmental condition characterized by persistent deficits in social communication and social interaction across multiple contexts, coupled with restricted, repetitive patterns of behavior, interests, or activities.[1] These core symptoms manifest early in development, typically within the first three years of

life, and lead to clinically significant impairment in social, occupational, or other important areas of current functioning.[2] The global prevalence of ASD has been steadily increasing, with estimates from the World Health Organization suggesting approximately 1 in 100 children has ASD,[3] though rates vary considerably across studies and geographic regions. In Indonesia, while comprehensive national epidemiological data remains nascent, awareness and diagnosis of ASD are growing, highlighting an urgent need for effective and accessible intervention strategies.[4]

The social communication deficits in ASD are multifaceted, encompassing challenges in social-emotional reciprocity, nonverbal communicative behaviors used for social interaction such as eye contact, facial expressions, and gestures, and developing, maintaining, and understanding relationships.[1] Restricted and repetitive behaviors (RRBs) form the second core diagnostic criterion and include stereotyped or repetitive motor movements, use of objects, or speech; insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior; highly restricted, fixated interests that are abnormal in intensity or[4] focus; and hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment. The heterogeneity in the presentation and severity of these core symptoms is a hallmark of ASD, necessitating individualized approaches to treatment and support.[6]

Beyond the core diagnostic criteria, children with ASD frequently experience a constellation of associated challenges that significantly impact their quality of life and that of their families. Among these, sensory processing abnormalities, sleep disturbances, and maladaptive behaviors are particularly prevalent and often intertwined. Sensory processing refers to the neurological process of receiving, organizing, and responding to sensory information from one's own body and the environment. A vast majority of individuals with ASD, estimated between 70-96%, experience atypical sensory processing. These abnormalities can manifest as hyperreactivity (over-responsiveness), hyporeactivity (under-responsiveness), or sensory seeking across various modalities, including auditory, tactile, visual, olfactory, gustatory, vestibular, and proprioceptive systems.[9] Such sensory sensitivities can lead to distress, avoidance of certain environments or stimuli, or an intense craving for specific sensory inputs, all of which can interfere with daily activities, learning, and social engagement.[10] For instance, a child with auditory hyperreactivity might find typical classroom noise overwhelming, leading to withdrawal or meltdowns, while a child with tactile defensiveness might resist physical contact or specific clothing textures.

Sleep disturbances are another common comorbidity in ASD, affecting an estimated 40-80% of children with the disorder, a rate significantly higher than in typically developing children or those with other developmental disabilities.[11,12] These disturbances encompass a wide range of issues, including difficulties initiating sleep (prolonged sleep latency), maintaining sleep (frequent night awakenings), short sleep duration, irregular sleep-wake patterns, bedtime resistance, and sleep-related anxiety.[13] The etiology of sleep problems in ASD is likely multifactorial, involving genetic predispositions, abnormalities in melatonin regulation, heightened anxiety levels, co-occurring medical conditions, particularly gastrointestinal issues, and sensory sensitivities that interfere with the ability to settle and sleep.[14,15] Poor sleep quality in children with ASD has been consistently linked to exacerbation of core ASD symptoms, increased daytime irritability, poorer learning outcomes, and diminished parental well-being.[16]

Maladaptive behaviors, including irritability, aggression, self-injurious behavior, hyperactivity, and tantrums, are also frequently observed in children with ASD and present significant challenges for families and educators.[17] These behaviors are often conceptualized as responses to internal or external stressors that the child struggles to manage or

communicate effectively. There is a strong bidirectional relationship between sensory processing issues, sleep disturbances, and maladaptive behaviors. For example, sensory overload can trigger meltdowns or aggressive outbursts[18], while chronic sleep deprivation can lower the threshold for frustration and increase irritability and hyperactivity.[19] Addressing these associated symptoms is therefore crucial for improving the overall well-being and adaptive functioning of children with ASD.

The current standard of care for ASD typically involves a multidisciplinary approach, including behavioral interventions such as Applied Behavior Analysis (ABA), speech and language therapy, occupational therapy (often addressing sensory issues), educational support, and, in some cases, pharmacological treatments for co-occurring conditions like ADHD, anxiety, or severe irritability.[20,21] While these interventions have demonstrated benefits for many children, their efficacy can vary widely, and significant challenges remain. Access to high-quality, intensive early intervention services can be limited by cost, geographical location, and availability of trained professionals, particularly in developing countries like Indonesia.[22]

Furthermore, pharmacological interventions for ASD primarily target associated symptoms rather than core deficits and often come with a risk of side effects. There is a growing recognition of the limitations of existing approaches and a corresponding increase in parental interest in complementary and alternative medicine (CAM) therapies. Families often seek CAM interventions to address symptoms not fully managed by conventional treatments, to pursue more "natural" options, or to improve their child's overall well-being. However, the evidence base for many CAM therapies in ASD is still emerging, and rigorous research is needed to establish their safety and efficacy.

Traditional Chinese Medicine (TCM) offers a holistic framework for understanding health and disease, emphasizing the balance of Qi (vital energy), Blood, Yin, and Yang, and the harmonious functioning of the Zang-Fu organs. From a TCM perspective, neurodevelopmental conditions like ASD can be understood as manifestations of imbalances in these fundamental substances and organ systems, particularly involving the Heart (governing Shen/Mind and Spirit), Spleen (governing digestion, transformation, and influencing cognitive function and muscle development), Liver (governing the smooth flow of Qi, and related to emotional regulation and motor control), and Kidney (governing essence, brain development, and constitutional strength).

Tuina, meaning "push-grasp," is a therapeutic massage system that forms an integral part of TCM. It involves applying various manual techniques to acupoints, meridians (channels through which Qi flows), and specific body regions to regulate Qi and Blood, restore balance to Yin and Yang, and promote the healthy functioning of Zang-Fu organs. Pediatric Tuina (Xiao Er Tuina) is a specialized branch that utilizes gentle, specific techniques tailored to the unique physiological and energetic characteristics of children. It is widely used in China and other parts of Asia for a variety of pediatric conditions, including digestive issues, respiratory problems, and, increasingly, neurodevelopmental and behavioral concerns.

In the context of ASD, TCM theory suggests that Tuina may help to: Calm the Shen (Mind/Spirit): Techniques applied to acupoints on the head, chest, and upper back, including DU20 Baihui, PC6 Neiguan, and HT7 Shenmen, are believed to pacify the Heart and Liver, thereby reducing anxiety, agitation, and improving sleep; Strengthen the Spleen and Stomach: Massaging acupoints related to the digestive system, such as ST36 Zusanli and CV12 Zhongwan, and techniques like massaging the abdomen can improve digestion and absorption, which TCM theory links to better nutrient supply for brain development and a reduction in "phlegm" or "dampness" that can cloud the mind and senses; Regulate Qi Flow and Open Orifices: Techniques along meridians and on the back, focusing on the Bladder and Du meridians, can facilitate the smooth flow of Qi and Blood, potentially

improving sensory processing and communication by "opening the orifices" (eyes, ears, nose, mouth, mind); Balance Yin and Yang: The rhythmic and patterned touch of Tuina can have a grounding and organizing effect, helping to balance hyperactivity (Yang excess) with calmness (Yin).

Preliminary research and anecdotal reports have suggested potential benefits of massage therapy, including Tuina, for children with ASD, such as reduced anxiety, improved social relatedness, and decreased touch aversion. However, most studies have been small, lacked rigorous control groups, or focused on general massage rather than specific TCM-based Tuina protocols tailored for ASD symptomatology. Indonesia, with its rich tradition of indigenous healing practices, presents a unique context for exploring the integration of CAM therapies like Tuina into ASD care. There is a cultural openness to massage-based therapies, and Tuina, while originating from China, shares some conceptual similarities with local massage traditions in its hands-on approach. Given the aforementioned challenges in accessing comprehensive ASD services in Jakarta, a relatively low-cost, non-invasive intervention like Tuina, if proven effective, could offer a valuable adjunctive therapy. Recognizing the profound impact of sensory dysregulation, sleep difficulties, and challenging behaviors on children with autism spectrum disorder (ASD) and their families, and the pressing need for culturally congruent, accessible interventions in diverse settings like Jakarta, Indonesia, this pioneering study aimed to rigorously investigate a novel therapeutic avenue. The principal aim was to determine the efficacy of a standardized, 12-week pediatric Tuina massage therapy program, rooted in Traditional Chinese Medicine, as an adjunctive treatment to improve sensory processing capabilities, alleviate burdensome sleep disturbances, and mitigate maladaptive behaviors in young Indonesian children (aged 3-7 years) with ASD.

2. Methods

This study employed a controlled clinical trial design with parallel groups. Participants were assigned to either an intervention group (Tuina massage therapy plus standard care) or a control group (standard care only). Assessments were conducted at baseline (T0), mid-intervention (T1 - week 6), immediately post-intervention (T2 - week 12), and at a 3-month follow-up (T3 - week 24).

The study protocol was approved by the CMHC Research Center, Indonesia. All procedures were conducted in accordance with the Declaration of Helsinki and its later amendments. Written informed consent was obtained from the parents or legal guardians of each participating child prior to any study-related procedures. Assent was also obtained from children who were capable of understanding the basic procedures, using age-appropriate language and visual aids. Confidentiality and anonymity of participants were maintained throughout the study.

Participants were recruited from three specialized pediatric developmental clinics and ASD intervention centers in Jakarta, Indonesia, between May 2024 and August 2024. Recruitment strategies included referrals from pediatricians, child neurologists, psychologists, and therapists working at these centers, as well as informational flyers distributed at the clinics and presentations to parent support groups.

Children were eligible for inclusion if they met all the following criteria: Aged between 3 years 0 months and 7 years 11 months at the time of enrollment. This age range was chosen as it represents a critical period for early intervention in ASD; A confirmed diagnosis of autism spectrum disorder according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria, made by a qualified child psychiatrist; Diagnosis further confirmed by the study team using the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) administered by a trained and reliable researcher. A minimum severity score was not mandated to capture a broader spectrum, but scores were recorded; Willingness of the

parent/guardian to participate in all aspects of the study, including attending Tuina sessions (for the intervention group) and completing all assessment measures; Stable standard care interventions for at least 3 months prior to enrollment and willingness to maintain these interventions throughout the study period. Standard care included established interventions such as behavioral therapy (utilizing ABA-based approaches), speech therapy, occupational therapy, or special education programs; Residing in the Greater Jakarta area to ensure feasibility of attending sessions.

Children were excluded if they met any of the following criteria: Presence of diagnosed genetic syndromes known to be associated with autistic features, such as Fragile X syndrome, Rett syndrome, or Tuberous Sclerosis, as these conditions might have different underlying pathophysiologies and responses to intervention; Significant sensory impairments, including severe uncorrected visual or hearing impairment, that would preclude meaningful participation in assessments or therapy; Presence of severe, unstable medical conditions such as uncontrolled epilepsy, severe cardiac conditions, or active dermatological conditions that would contraindicate massage; Current or recent (within the past 4 weeks) initiation or change in dosage of psychotropic medications that could affect the outcome variables, including stimulants, antipsychotics, anxiolytics, or anticonvulsants used for mood stabilization. Children on stable doses for at least 3 months were permitted; Previous systematic exposure to Tuina massage therapy specifically for ASD symptoms within the past 6 months; Concurrent participation in another clinical trial investigating interventions for ASD.

Following baseline assessment and confirmation of eligibility, participants were assigned to either the Tuina intervention group or the control group using a block randomization method (block sizes of 4 and 6) to ensure balanced group sizes over time. The randomization sequence was generated by an independent statistician using a computer program and concealed in sequentially numbered, opaque, sealed envelopes. The study coordinator, who was not involved in outcome assessment, opened the envelopes and informed the parents of the group allocation.

Due to the nature of the intervention, blinding of participants, their parents, and the Tuina therapists was not feasible. However, outcome assessors (psychologists and trained research assistants responsible for administering and scoring the standardized measures) were blinded to group allocation. Efforts were made to maintain this blinding throughout the study, including instructing parents not to disclose their child's group assignment to the assessors and conducting assessments in a neutral location separate from the therapy rooms. The success of blinding was informally assessed post-study by asking assessors to guess group allocation. Data analysts were also blinded to group allocation until primary analyses were completed.

Children in the intervention group received Tuina massage therapy in addition to their ongoing standard care. Tuina Protocol: A standardized pediatric Tuina protocol was developed by a panel of experienced TCM practitioners specializing in pediatrics and ASD, based on TCM principles for addressing common patterns of imbalance seen in ASD, specifically Liver Qi Stagnation, Heart Fire, Spleen Qi Deficiency, and Kidney Essence Insufficiency. The protocol was designed to be gentle, rhythmic, and calming, focusing on improving sensory modulation, promoting relaxation, and enhancing digestive function. The core techniques included: Head and Face: Gentle rubbing/kneading of Yintang (EX-HN3), Taiyang (EX-HN5), DU20 (Baihui), and GB20 (Fengchi). Light stroking of the forehead and temples; Back: Pushing along the Du Meridian (spine) from top to bottom (30-50 times). Kneading and plucking paravertebral muscles along the Bladder Meridian, focusing on Back Shu points associated with Zang-Fu organs like BL13 Feishu, BL15 Xinshu, BL18 Ganshu, BL20 Pishu, and BL23 Shenshu (5-7 times each side); Abdomen: Circular clockwise massage around the umbilicus (CV8 Shenque) to regulate Spleen and Stomach Qi (5-

10 minutes). Press-kneading CV12 (Zhongwan), ST25 (Tianshu). Limbs: Kneading and stroking along the major meridians of the arms and legs. Specific acupoints included PC6 (Neiguan) for calming Shen, HT7 (Shenmen) for calming Heart and improving sleep, LI4 (Hegu) for general regulation, ST36 (Zusanli) for Spleen/Stomach Qi, SP6 (Sanyinjiao) for harmonizing Liver, Spleen, Kidney. Gentle joint rotations; Specific Techniques for Children (Xiao Er Tuina): Specific Techniques for Children (Xiao Er Tuina) incorporated into the protocol included Qing Gan Jing (clearing Liver Channel), Bu Pi Jing (tonifying Spleen Channel), and Rou Ban Men (kneading Ban Men point for digestion). Therapists: The Tuina therapy was delivered by three certified Tuina therapists, each with at least 5 years of experience in pediatric Tuina. All therapists underwent an additional 20 hours of training on the specific study protocol, including theory relevant to ASD from a TCM perspective, safety considerations, and rapport-building techniques for children with ASD. Regular meetings were held to ensure treatment fidelity and consistency. A detailed manual outlining the techniques, sequence, duration, and pressure for each step was provided; Dosage and Duration: Each Tuina session lasted approximately 30-40 minutes. Sessions were conducted three times per week for 12 consecutive weeks, totaling 36 sessions. Therapy took place in quiet, comfortable rooms at the participating clinics, with a parent present if desired by the child or therapist; Standard Care: Children in this group continued to receive their pre-existing standard care interventions as prescribed by their primary healthcare providers. Types and intensity of standard care were documented at baseline and monitored for changes during the study.

Children in the control group received only their ongoing standard care interventions. They did not receive Tuina massage therapy during the 12-week study period. To control for the attention and time commitment involved in the intervention, parents in the control group were offered general educational materials about ASD and healthy lifestyle practices for children, covering topics such as nutrition and play, at three time points corresponding to approximate therapy contact times (baseline, week 6, week 12). After the completion of the 24-week study (including the follow-up period), children in the control group were offered a complimentary 6-week course of Tuina massage therapy as an ethical consideration. Types and intensity of standard care were also documented and monitored as in the intervention group.

A battery of standardized, validated assessment tools was used to measure outcomes. Parents/primary caregivers completed the questionnaires. Primary Outcome Measures: Sensory Profile 2 (SP-2) - Child Version (Parent Report): The SP-2 (37) is a widely used, standardized parent questionnaire designed to evaluate a child's sensory processing patterns in everyday life. It assesses responses to auditory, visual, tactile, movement, body position, and oral sensory processing, as well as behavioral and socioemotional responses associated with sensory processing. We focused on Quadrant Scores (Seeking, Avoiding, Sensitivity, Registration) and Sensory System Scores, particularly Auditory and Tactile scores. Raw scores are converted to standardized scores. Lower scores on Sensitivity and Avoiding, and scores moving towards "Typical Performance" range on Seeking and Registration were considered improvements; Children's Sleep Habits Questionnaire (CSHQ): The CSHQ (38) is a parent-report questionnaire designed to screen for common sleep problems in children. It consists of 33 items rated on a 3-point scale, yielding a total score and eight subscale scores: Bedtime Resistance, Sleep Onset Delay, Sleep Duration, Sleep Anxiety, Night Wakings, Parasomnias, Sleep Disordered Breathing,[8] and Daytime Sleepiness. Higher[9] scores indicate more sleep problems; thus, a decrease in scores indicates improvement. A total score of 41 or higher is often used as a clinical cutoff for identifying a sleep problem; Aberrant Behavior Checklist-Community (ABC-C): The ABC-C (39) is a 58-item informant-rated scale used to assess maladaptive behaviors in individuals with developmental disabilities. It yields scores on five subscales: Irritability/Agitation, Lethargy/Social

Withdrawal, Stereotypic Behavior, Hyperactivity/Noncompliance, and Inappropriate Speech. Items are rated on a 4-point Likert scale (0=not a problem to 3=problem is severe). Lower scores indicate fewer maladaptive behaviors and are thus considered improvements. Secondary Outcome Measure: Childhood Autism Rating Scale, Second Edition (CARS2-ST): The CARS2-ST (40) is a 15-item behavior rating scale used to identify children with ASD and distinguish them from those with other developmental disorders. It also provides a measure of autism symptom severity. While primarily used for diagnostic confirmation and baseline severity assessment, changes in total CARS2-ST scores were explored as a secondary outcome to gauge overall changes in ASD-related symptom severity. Scores were completed by trained clinicians based on observation and parental report. Other Measures: Demographic and Clinical Information: A baseline questionnaire collected data on the child's age, gender, parental education, socioeconomic status (approximated by monthly household income categories), age at ASD diagnosis, types and intensity of current therapies, and medical history including medication use; Treatment Adherence and Adverse Events: Attendance at Tuina sessions was logged. Therapists documented any observed reactions or difficulties during sessions. Parents were provided with a diary to record any potential adverse events such as skin irritation, discomfort, or changes in behavior potentially related to therapy and were contacted weekly by the study coordinator to inquire about adverse events.

Data were collected at four time points: Baseline (T0): Prior to randomization. Included demographic questionnaire, ADOS-2 (if not recently available), CARS2-ST, SP-2, CSHQ, and ABC-C; Mid-intervention (T1 - Week 6): SP-2, CSHQ, ABC-C were re-administered to assess early treatment effects; Post-intervention (T2 - Week 12): Immediately after completion of the 12-week intervention period. SP-2, CSHQ, ABC-C, and CARS2-ST were re-administered; Follow-up (T3 - Week 24): 3 months after cessation of the Tuina intervention (or 3 months after T2 for the control group). SP-2, CSHQ, ABC-C, and CARS2-ST were re-administered to assess maintenance of effects.

Parents completed the questionnaires (SP-2, CSHQ, ABC-C) either in paper format or via a secure online platform, with assistance from trained research staff if needed to ensure understanding of items. Clinician-rated scales (ADOS-2, CARS2-ST) were completed by trained study personnel who had established inter-rater reliability (Intraclass Correlation Coefficient > 0.85). The sample size was calculated based on detecting a clinically meaningful difference in one of the primary outcome measures, the ABC-C Irritability subscale, using data from previous massage therapy studies in ASD. Assuming a mean difference of 4.0 points (SD=6.0) on the ABC-C Irritability subscale, with an alpha of 0.05 and power of 80%, approximately 36 participants per group would be required. To account for an anticipated attrition rate of around 20% (common in longitudinal ASD studies), we aimed to recruit 44 participants per group, for a total sample size of 88 children.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 27.0 (Armonk, NY, IBM Corp). An intention-to-treat (ITT) approach was used for all primary analyses, with missing data handled using multiple imputation techniques where appropriate, based on the pattern of missingness. A per-protocol analysis was also conducted as a sensitivity analysis: Descriptive Statistics: Means, standard deviations (SD), medians, interquartile ranges (IQR), frequencies, and percentages were used to describe baseline demographic and clinical characteristics of the participants in both groups, as well as outcome scores at all time points; Baseline Comparisons: Independent samples t-tests, Mann-Whitney U tests, and Chi-square tests or Fisher's exact tests were used to compare baseline characteristics and outcome scores between the Tuina group and the control group to check the success of randomization; Primary Efficacy Analyses: The primary analytic strategy involved using mixed-effects models for repeated measures (MMRM) for each primary outcome (SP-2 quadrant scores, CSHQ total score, ABC-C

subscale scores). The model included fixed effects for treatment group (Tuina vs. control), time (T0, T1, T2, T3), and the group-by-time interaction. Baseline score for the respective outcome was included as a covariate. Subject was entered as a random effect to account for the correlation of repeated measurements within individuals. The primary endpoint for comparison was the difference between groups at T2 (12 weeks). Secondary comparisons were made at T1 and T3. Effect sizes (Cohen's d for between-group differences at specific time points, and partial eta-squared for interaction effects) were calculated; Secondary Outcome Analysis: Changes in CARS2-ST total scores were analyzed using a similar MMRM approach; Subgroup Analyses (Exploratory): If sufficient variability existed and numbers permitted, exploratory subgroup analyses were planned based on baseline ASD severity (categorized as mild-moderate versus severe on CARS2-ST) or age group (specifically 3-5 years versus 6-7 years) to see if treatment effects differed; Adverse Events: Frequencies and types of adverse events were tabulated and compared descriptively between groups.

A two-tailed p-value of < 0.05 was considered statistically significant for all analyses. Bonferroni correction was considered for multiple primary outcomes or multiple comparisons where appropriate to control for Type I error inflation, though the primary focus was on pre-specified primary outcomes. Treatment fidelity for the Tuina intervention was monitored through several mechanisms: (a) initial intensive training and provision of a detailed manual, (b) random session observations (approximately 5% of sessions) by an independent TCM expert using a fidelity checklist, and (c) weekly meetings with therapists to discuss challenges and adherence to the protocol. Adherence by participants was defined as completion of ≥80% (at least 29 out of 36) of the scheduled Tuina sessions. Reasons for missed sessions were documented.

3. Results

A total of 152 children were screened for eligibility between May 2024 and August 2024. Of these, 105 were assessed for eligibility, and 88 met the inclusion criteria and were randomized: 44 to the Tuina intervention group and 44 to the control group (standard care only). During the 12-week intervention phase, 3 participants (6.8%) from the Tuina group dropped out (2 due to family relocation, 1 due to scheduling conflicts with other therapies). In the control group, 2 participants (4.5%) were lost to follow-up before the T2 assessment (1 due to family relocation, 1 declined further participation). Thus, 41 participants in the Tuina group and 42 in the control group completed the T2 assessment. For the 3-month follow-up (T3), an additional 1 participant from the Tuina group and 2 from the control group were lost, resulting in 40 and 40 participants respectively completing the T3 assessment. All 88 participants were included in the intention-to-treat analysis using multiple imputation for missing post-baseline data points.

Baseline demographic and clinical characteristics of the participants are presented in Table 1. The mean age of the children was 5.2 years (SD=1.3) in the Tuina group and 5.4 years (SD=1.4) in the control group. The majority of participants were male (Tuina: 81.8%; Control: 79.5%), consistent with known gender ratios in ASD. There were no statistically significant differences between the two groups at baseline in terms of age, gender, parental education level, socioeconomic status (approximated by monthly household income categories), age at ASD diagnosis, baseline CARS2-ST severity scores, or types and intensity of standard care therapies being received, including hours per week of ABA, speech therapy, and occupational therapy. Baseline scores on the primary outcome measures (SP-2, CSHQ, ABC-C) were also comparable between the groups (all $p > 0.05$), indicating successful randomization.

Table 1. Baseline demographic and clinical characteristics of participants.

Characteristic	Tuina Group (n=44)	Control Group (n=44)	Total Sample (N=88)	Statistic	p-value
Demographic characteristics					
Age (years), Mean (SD)	5.2 (1.3)	5.4 (1.4)	5.3 (1.3)	t=-0.55	0.580
Gender, n (%)				x^2=0.07	0.790
Male	36 (81.8%)	35 (79.5%)	71 (80.7%)		
Female	8 (18.2%)	9 (20.5%)	17 (19.3%)		
Parental education level, n (%)				x^2=0.42	0.935
High School or less	5 (11.4%)	6 (13.6%)	11 (12.5%)		
Diploma/Vocational	10 (22.7%)	9 (20.5%)	19 (21.6%)		
Bachelor's Degree	20 (45.5%)	21 (47.7%)	41 (46.6%)		
Master's/Doctoral Degree	9 (20.5%)	8 (18.2%)	17 (19.3%)		
Monthly Household Income (IDR), n (%)				x^2=0.28	0.963
5,000,000	7 (15.9%)	8 (18.2%)	15 (17.0%)		
5,000,000 - 10,000,000	15 (34.1%)	14 (31.8%)	29 (33.0%)		
10,000,001 - 20,000,000	13 (29.5%)	14 (31.8%)	27 (30.7%)		
> 20,000,000	9 (20.5%)	8 (18.2%)	17 (19.3%)		
Clinical characteristics					
Age at ASD Diagnosis (years), Mean (SD)	3.1 (0.8)	3.2 (0.9)	3.1 (0.8)	t=-0.53	0.598
ADOS-2 Calibrated Severity Score (1-10), Mean (SD)	7.2 (1.1)	7.0 (1.3)	7.1 (1.2)	t=0.78	0.437
CARS2-ST Total Score (Baseline), Mean (SD)	35.5 (4.2)	35.1 (4.5)	35.3 (4.3)	t=0.45	0.650
Standard care therapies (hours/week), Mean (SD)					
Applied behavior analysis (ABA)	9.8 (4.1)	9.5 (3.8)	9.7 (3.9)	t=0.35	0.725
Speech therapy	2.1 (1.0)	2.3 (1.1)	2.2 (1.0)	t=-0.88	0.381
Occupational therapy	2.5 (1.2)	2.4 (1.0)	2.4 (1.1)	t=0.40	0.690
Baseline outcome measure scores, mean (SD)					
Sensory profile 2 (SP-2) quadrant scores					
Sensory sensitivity	125.5 (15.1)	124.8 (16.3)	125.1 (15.7)	t=0.20	0.840
Sensation avoiding	128.2 (14.8)	127.5 (15.5)	127.8 (15.1)	t=0.21	0.833
Low registration	120.3 (13.5)	119.9 (14.0)	120.1 (13.7)	t=0.13	0.895
Sensation seeking	115.6 (16.0)	116.2 (15.2)	115.9 (15.6)	t=-0.17	0.863
Sensory profile 2 (SP-2) sensory system scores (Selected)					
Auditory processing	130.1 (14.5)	129.5 (15.8)	129.8 (15.1)	t=0.18	0.855
Tactile processing	127.8 (16.2)	128.3 (15.9)	128.1 (16.0)	t=-0.14	0.888
Movement processing	122.4 (13.8)	121.9 (14.4)	122.2 (14.1)	t=0.16	0.873
Children's Sleep Habits Questionnaire (CSHQ)					
Total score	53.2 (7.1)	52.8 (7.5)	53.0 (7.3)	t=0.25	0.801
Bedtime resistance	8.5 (2.2)	8.3 (2.4)	8.4 (2.3)	t=0.39	0.697
Sleep onset delay	2.8 (0.9)	2.7 (0.8)	2.7 (0.8)	t=0.53	0.597
Sleep anxiety	5.1 (1.8)	5.0 (1.7)	5.0 (1.7)	t=0.26	0.792
Night wakings	3.3 (1.1)	3.2 (1.0)	3.2 (1.0)	t=0.43	0.666
Aberrant Behavior Checklist-Community (ABC-C) subscale scores					
Irritability/Agitation	15.8 (4.5)	15.5 (4.9)	15.6 (4.7)	t=0.29	0.770
Lethargy/Social withdrawal	10.2 (3.8)	9.9 (4.0)	10.0 (3.9)	t=0.36	0.720
Stereotypic behavior	8.5 (3.1)	8.2 (2.9)	8.3 (3.0)	t=0.46	0.648
Hyperactivity/Noncompliance	22.3 (6.5)	21.9 (6.9)	22.1 (6.7)	t=0.27	0.788
Inappropriate speech	4.1 (2.0)	3.9 (1.8)	4.0 (1.9)	t=0.48	0.630

In the Tuina intervention group (n=44), the mean number of sessions attended by those who did not drop out was 34.2 out of 36 (SD=1.8), representing a 95% adherence rate (Table 2). Thirty-nine out of 41 participants (95.1%) who completed the intervention phase attended ≥80% of the sessions. Reasons for missed sessions were typically minor childhood illnesses or unavoidable family commitments. Treatment fidelity checks conducted by the independent TCM expert indicated high adherence (average >90%) to the prescribed Tuina protocol by all therapists.

Table 2. Treatment adherence (Tuina Intervention Group) and therapist fidelity.

Parameter	Details / Value
Participant adherence to Tuina sessions (Intervention Group)	
Initial participants randomized to Tuina group	44
Participants completing 12-week intervention	41 (93.2% of initial)
Participants discontinuing intervention	3 (6.8% of initial)
Reasons for discontinuation:	
Family relocation	2
Scheduling conflicts	1
Total scheduled sessions per participant	36
For participants completing intervention (n=41):	
Mean (SD) sessions attended	34.2 (1.8)
Median (Range) sessions attended	35 (27 - 36)
Overall adherence rate (Mean % of scheduled sessions attended)	95.0%
Participants attending ≥80% of sessions (≥29 sessions), n (%)	39 (95.1%)
Participants attending 100% of sessions (36 sessions), n (%)	18 (43.9%)[1]
Total scheduled sessions for completers	1476
Total attended sessions by completers	1402
Total missed sessions by completers	74
Reasons for Missed Sessions by Completers (among 74 missed sessions):	
Minor child illness (cold, fever)	45 (60.8%)
Unavoidable family commitments (travel, non-study appointments)	20 (27.0%)
Inclement weather / Transportation issues	5 (6.8%)
Other (temporary scheduling conflict)	4 (5.4%)
Therapist fidelity to standardized Tuina protocol	
Number of certified Tuina therapists delivering intervention	3
Training on study-specific protocol	20 hours per therapist
Method of fidelity assessment	Direct observation by independent TCM expert using a pre-defined fidelity checklist (25 items)
Frequency of fidelity checks	Random 5% of total intervention sessions (approx. 70 sessions observed across all therapists)
Mean (SD) fidelity score across observed sessions	92.5% (3.5%)
Range of fidelity scores observed	85% - 98%
Key domains assessed for fidelity by checklist:	
Correct acupoint location and selection	High adherence (>90%)
Accurate application of specified Tuina techniques (push, knead, press)	High adherence (>90%)
Adherence to the prescribed duration for each component of the massage	High adherence (>90%)
Correct sequence of massage techniques as per protocol	Very high adherence (>95%)
Appropriate pressure and gentleness for pediatric application	High adherence (>90%)
Management of the child's comfort and rapport building	Consistently positive
Regular therapist meetings for consistency	Weekly

Notes: Abbreviations: SD, Standard Deviation; TCM, Traditional Chinese Medicine.

Mixed-effects model analyses revealed significant group-by-time interaction effects for several SP-2 quadrant and sensory system scores. At T2 (12 weeks), compared to the control group, the Tuina group showed significantly greater improvements (lower scores indicating fewer problems, or scores moving towards typical ranges) in: Sensory Sensitivity Quadrant: Mean difference (MD) in change from baseline -7.9 (95% CI -10.5 to -5.3), $p < 0.001$; Cohen's d = 0.88; Sensation Avoiding Quadrant: MD -8.2 (95% CI -11.0 to -5.4), $p < 0.001$; Cohen's d = 0.91; Low Registration Quadrant: MD -6.5 (95% CI -9.2 to -3.8), $p < 0.001$; Cohen's d = 0.75 (indicating fewer missed cues); Sensation Seeking Quadrant: While both groups showed slight increases, the difference was not statistically significant, MD 1.5 (95% CI -1.8 to 4.8), $p = 0.370$. Specific sensory system scores showing significant improvement in the Tuina group included; Auditory Processing: MD -8.5 (95% CI -11.2 to -5.8), $p < 0.001$ (indicating reduced over-responsiveness or distress from sounds); Tactile Processing: MD -7.2 (95% CI -9.8 to -4.6), $p < 0.001$ (indicating reduced tactile defensiveness); Movement Processing**:** MD -5.9 (95% CI -8.4 to -3.4), $p < 0.001$ (indicating better modulation of vestibular input). At T3 (3-month follow-up), these improvements in sensory processing scores in the Tuina group were largely maintained, though with a slight attenuation for some scores; for instance, the Sensitivity MD at T3 was -6.8 (95% CI -9.7 to -3.9, $p < 0.001$). The group-by-time interaction remained significant across the study duration (T0 to T3) for these measures.

A significant group-by-time interaction effect was found for the CSHQ total score ($p < 0.001$). At T2 (12 weeks), the Tuina group showed a significantly greater reduction in total sleep problems compared to the control group: CSHQ Total Score: MD -6.8 (95% CI -9.1 to -4.5), $p < 0.001$; Cohen's d = 0.95. The mean CSHQ total score in the Tuina group decreased from 53.2 (SD=7.1) at baseline to 42.5 (SD=6.8) at T2, while in the control group it changed from 52.8 (SD=7.5) to 49.1 (SD=7.0). The proportion of children scoring above the clinical cutoff of 41 decreased from 88.6% to 56.1% in the Tuina group, versus from 86.4% to 76.2% in the control group. Significant improvements in the Tuina group were also observed for the following CSHQ subscales at T2: Bedtime Resistance: MD -1.8 (95% CI -2.7 to -0.9), $p < 0.001$; Sleep Onset Delay: MD -1.1 (95% CI -1.7 to -0.5), $p = 0.001$; Sleep Anxiety: MD -1.5 (95% CI -2.2 to -0.8), $p < 0.001$; Night Wakings: MD -0.9 (95% CI -1.5 to -0.3), $p = 0.004$. No significant between-group differences were observed for Sleep Duration, Parasomnias, or Sleep Disordered Breathing subscales. At T3 (3-month follow-up), the improvements in CSHQ total score (MD -5.7, 95% CI -8.2 to -3.2, $p < 0.001$) and key subscales (Bedtime Resistance, Sleep Anxiety) remained statistically significant in favor of the Tuina group, indicating good maintenance of effect.

Significant group-by-time interaction effects were found for several ABC-C subscale scores. At T2 (12 weeks), the Tuina group demonstrated significantly greater reductions in the following maladaptive behaviors compared to the control group: Irritability/Agitation Subscale: MD -5.2 (95% CI -7.0 to -3.4), $p < 0.001$; Cohen's d = 0.98; Hyperactivity/Noncompliance Subscale: MD -6.1 (95% CI -8.3 to -3.9), $p < 0.001$; Cohen's d = 0.92; Lethargy/Social Withdrawal Subscale: MD -3.5 (95% CI -5.1 to -1.9), $p < 0.001$; Cohen's d = 0.78; Stereotypic Behavior Subscale: MD -2.1 (95% CI -3.5 to -0.7), $p = 0.003$; Cohen's d = 0.55. No significant between-group difference was observed for the Inappropriate Speech subscale (MD -0.8, 95% CI -2.0 to 0.4, $p = 0.180$). At T3 (3-month follow-up), the reductions in Irritability (MD -4.5, 95% CI -6.5 to -2.5, $p < 0.001$) and Hyperactivity (MD -5.0, 95% CI -7.4 to -2.6, $p < 0.001$) remained robust and statistically significant in the Tuina group. Improvements in Lethargy also persisted significantly, while the effect on Stereotypic Behavior was somewhat diminished but still trended favorably.

Table 3. Primary outcome measures at baseline, week 6, week 12 (post-intervention), and week 24 (follow-up).

Outcome measure / Subscale	Group	Baseline (T0) Mean (SD)	Week 6 (T1) Mean (SD)	Week 12 (T2) Mean (SD)	Week 24 (T3) Mean (SD)	Between-Group Comparison: Change T0-T2 (Week 12) Mean Diff (95% CI)	Cohen's d	p-value	Between-Group Comparison: Change T0-T3 (Week 24) Mean Diff (95% CI)	p-value
Sensory profile 2 (SP-2) quadrant scores										
Sensory sensitivity	Tuina	125.5 (15.1)	119.2 (14.5)	116.8 (14.0)	118.0 (14.2)	-7.9 (-10.5 to -5.3)	0.88	0.001	-6.8 (-9.7 to -3.9)	<0.001
	Control	124.8 (16.3)	124.0 (16.0)	124.0 (15.8)	123.5 (15.9)					
Sensation avoiding	Tuina	128.2 (14.8)	122.0 (14.0)	119.1 (13.5)	120.5 (13.8)	-8.2 (-11.0 to -5.4)	0.91	0.001	-7.0 (-10.1 to -3.9)	<0.001
	Control	127.5 (15.5)	126.8 (15.2)	126.6 (15.0)	126.0 (15.1)					
Low registration	Tuina	120.3 (13.5)	115.1 (13.0)	113.0 (12.8)	114.2 (12.9)	-6.5 (-9.2 to -3.8)	0.75	0.001	-5.5 (-8.5 to -2.5)	<0.001
	Control	119.9 (14.0)	119.5 (13.8)	119.1 (13.5)	118.8 (13.6)					
Sensation seeking	Tuina	115.6 (16.0)	117.0 (15.5)	117.5 (15.0)	117.2 (15.2)	1.5 (-1.8 to 4.8)	0.18	0.370	1.2 (-2.2 to 4.6)	0.485
	Control	116.2 (15.2)	116.0 (15.0)	115.8 (14.8)	115.5 (14.9)					
Sensory profile 2 (SP-2) sensory system scores (Selected)										
Auditory processing	Tuina	130.1 (14.5)	123.5 (13.8)	120.6 (13.2)	122.0 (13.5)	-8.5 (-11.2 to -5.8)	0.93	0.001	-7.2 (-10.2 to -4.2)	<0.001
	Control	129.5 (15.8)	128.8 (15.5)	128.5 (15.2)	128.0 (15.3)					
Tactile processing	Tuina	127.8 (16.2)	122.1 (15.5)	119.9 (15.0)	121.0 (15.2)	-7.2 (-9.8 to -4.6)	0.82	0.001	-6.1 (-9.0 to -3.2)	<0.001
	Control	128.3 (15.9)	127.6 (15.7)	127.4 (15.5)	126.8 (15.6)					
Movement processing	Tuina	122.4 (13.8)	118.0 (13.2)	115.8 (12.8)	117.0 (13.0)	-5.9 (-8.4 to -3.4)	0.70	0.001	-4.8 (-7.5 to -2.1)	<0.001
	Control	121.9 (14.4)	121.3 (14.1)	121.0 (13.9)	120.6 (14.0)					
Children's Sleep Habits Questionnaire (CSHQ)										
Total score	Tuina	53.2 (7.1)	46.5 (6.9)	42.5 (6.8)	44.0 (6.9)	-6.8 (-9.1 to -4.5)	0.95	0.001	-5.7 (-8.2 to -3.2)	<0.001
	Control	52.8 (7.5)	51.0 (7.3)	48.9 (7.0)	48.5 (7.2)					
Bedtime resistance	Tuina	8.5 (2.2)	7.2 (2.0)	6.5 (1.9)	6.8 (2.0)	-1.8 (-2.7 to -0.9)	0.73	<0.001	-1.5 (-2.5 to -0.5)	0.002
	Control	8.3 (2.4)	8.1 (2.3)	8.1 (2.2)	8.0 (2.3)					
Sleep onset delay	Tuina	2.8 (0.9)	2.0 (0.7)	1.7 (0.6)	1.9 (0.7)	-1.1 (-1.7 to -0.5)	0.68	0.001	-0.9 (-1.6 to -0.2)	0.010
	Control	2.7 (0.8)	2.6 (0.8)	2.6 (0.7)	2.5 (0.8)					
Sleep anxiety	Tuina	5.1 (1.8)	4.0 (1.6)	3.5 (1.5)	3.8 (1.5)	-1.5 (-2.2 to -0.8)	0.76	<0.001	-1.2 (-2.0 to -0.4)	0.003
	Control	5.0 (1.7)	4.8 (1.6)	4.8 (1.6)	4.7 (1.6)					
Night wakings	Tuina	3.3 (1.1)	2.7 (0.9)	2.4 (0.8)	2.6 (0.9)	-0.9 (-1.5 to -0.3)	0.60	0.004	-0.7 (-1.3 to -0.1)	0.021
	Control	3.2 (1.0)	3.1 (1.0)	3.1 (0.9)	3.0 (1.0)					
Aberrant Behavior Checklist-Community (ABC-C) Subscale Scores										
Irritability/Agitation	Tuina	15.8 (4.5)	12.0 (4.0)	10.1 (3.8)	10.8 (3.9)	-5.2 (-7.0 to -3.4)	0.98	0.001	-4.5 (-6.5 to -2.5)	<0.001
	Control	15.5 (4.9)	15.0 (4.8)	14.8 (4.6)	14.7 (4.7)					
Lethargy/Social withdrawal	Tuina	10.2 (3.8)	7.8 (3.5)	6.5 (3.2)	7.0 (3.3)	-3.5 (-5.1 to -1.9)	0.78	0.001	-2.9 (-4.6 to -1.2)	0.001
	Control	9.9 (4.0)	9.6 (3.9)	9.7 (3.8)	9.5 (3.9)					
Stereotypic behavior	Tuina	8.5 (3.1)	7.0 (2.8)	6.2 (2.5)	6.8 (2.6)	-2.1 (-3.5 to -0.7)	0.55	0.003	-1.5 (-3.0 to -0.1)	0.045
	Control	8.2 (2.9)	8.0 (2.8)	8.0 (2.7)	7.9 (2.8)					
Hyperactivity/Noncompliance	Tuina	22.3 (6.5)	17.5 (6.0)	15.5 (5.8)	16.5 (5.9)	-6.1 (-8.3 to -3.9)	0.92	<0.001	-5.0 (-7.4 to -2.6)	<0.001
	Control	21.9 (6.9)	21.2 (6.7)	21.2 (6.5)	20.8 (6.6)					
Inappropriate speech	Tuina	4.1 (2.0)	3.5 (1.8)	3.2 (1.7)	3.4 (1.7)	-0.8 (-2.0 to 0.4)	0.25	0.180	-0.6 (-1.9 to 0.7)	0.355
	Control	3.9 (1.8)	3.8 (1.7)	3.8 (1.7)	3.7 (1.7)					

Notes: Abbreviations: SD, Standard Deviation; CI, Confidence Interval; SP-2, Sensory Profile 2; CSHQ, Children's Sleep Habits Questionnaire; ABC-C, Aberrant Behavior Checklist-Community.

A significant group-by-time interaction effect was observed for the CARS2-ST total score (p = 0.002). At T2 (12 weeks), the Tuina group showed a significantly greater reduction in CARS2-ST total scores compared to the control group: CARS2-ST Total Score: MD -2.8 (95% CI -4.5 to -1.1), p = 0.001; Cohen's d = 0.60. The mean CARS2-ST total score in the Tuina group decreased from 35.5 (SD=4.2) at baseline to 31.2 (SD=3.8) at T2. In the control group, scores changed from 35.1 (SD=4.5) to 33.9 (SD=4.1). At T3 (3-month follow-up), this difference remained statistically significant (MD -2.3, 95% CI -4.1 to -0.5, p = 0.012), suggesting some sustained impact on overall ASD symptom severity as measured by this scale.

Table 4. Secondary outcome measure – Childhood autism rating scale, second edition (CARS2-ST) total score.

Group	Baseline (T0) Mean (SD)	Week 12 (T2) Post-Intervention Mean (SD)	Week 24 (T3) Follow-up Mean (SD)	Between-Group Comparison: Change T0-T2 (Week 12) Mean Difference (95% CI)	Cohen's	p-value	Between-Group Comparison: Change T0-T3 (Week 24) Mean Difference (95% CI)	p-value
Tuina intervention group (n=44)	35.5 (4.2)	31.2 (3.8)	31.7 (3.9)	-2.8 (-4.5 to -1.1)	0.60	0.001	-2.3 (-4.1 to -0.5)	0.012
Control group (n=44)	35.1 (4.5)	33.9 (4.1)	33.6 (4.2)					

Notes: Abbreviations: SD, Standard Deviation; CI, Confidence Interval; CARS2-ST, Childhood Autism Rating Scale, Second Edition - Standard Form.

No serious adverse events related to the Tuina intervention were reported during the study. Minor, transient adverse events reported in the Tuina group included: mild skin redness at the site of massage in 2 children, which resolved within an hour and did not prevent subsequent sessions; temporary irritability or restlessness immediately following the first one or two sessions in 3 children, which parents reported subsided by the third session; and one child experienced slight drowsiness after sessions, which parents viewed positively as it correlated with improved nighttime sleep. These were comparable to minor reactions sometimes seen with any new tactile or physical intervention in sensitive children. No participants discontinued the Tuina intervention due to adverse events. Parents generally reported that their children became more comfortable and accepting of the massage over time, with many appearing to enjoy the sessions.

Exploratory analyses stratifying by baseline ASD severity (CARS2-ST mild-moderate [score <37] vs. severe [score ≥37]) suggested that children in both severity categories in the Tuina group showed improvements. However, children with severe ASD at baseline appeared to show slightly larger magnitudes of change on the ABC-C Irritability and Hyperactivity subscales, although these subgroup analyses were underpowered and should be interpreted with caution. No clear differential effects were observed based on age group (3-5 years vs. 6-7 years).

Table 5. Exploratory subgroup analyses of treatment effects on key outcomes (Mean change from baseline to week 12).

Subgroup category	Subgroup stratum	Outcome measure	N (Tuina / Control)	Tuina group change T0-T2 Mean (SD)	Control group change T0-T2 Mean (SD)	Between-Group MD for Stratum (95% CI)	p-value for interaction (Subgroup × Treatment)
Baseline ASD severity (CARS2-ST)	Mild-Moderate (CARS2-ST 37)	ABC-C Irritability/Agitation	24 / 25	-4.7 (3.1)	-0.6 (2.7)	-4.1 (-6.1 to -2.1)	0.235
	Severe (CARS2-ST ≥ 37)	ABC-C Irritability/Agitation	20 / 19	-5.9 (3.3)	-0.5 (2.9)	-5.4 (-7.7 to -3.1)	
	Mild-Moderate (CARS2-ST 37)	ABC-C Hyperactivity/Noncompliance	24 / 25	-5.4 (4.2)	-0.8 (3.3)	-4.6 (-7.1 to -2.1)	0.198
	Severe (CARS2-ST ≥ 37)	ABC-C Hyperactivity/Noncompliance	20 / 19	-7.1 (4.3)	-0.7 (3.5)	-6.4 (-9.2 to -3.6)	
Age group (years)	3 – 5	SP-2 Sensory Sensitivity	26 / 24	-8.6 (5.1)	-0.9 (4.6)	-7.7 (-10.4 to -5.0)	0.810
	6 – 7	SP-2 Sensory Sensitivity	18 / 20	-8.4 (5.3)	-0.7 (4.8)	-7.7 (-10.9 to -4.5)	
	3 – 5	CSHQ Total Score	26 / 24	-10.1 (5.3)	-3.6 (5.1)	-6.5 (-9.3 to -3.7)	0.723
	6 – 7	CSHQ Total Score	18 / 20	-10.6 (5.6)	-3.8 (5.3)	-6.8 (-10.0 to -3.6)	
	3 – 5	ABC-C Irritability/Agitation	26 / 24	-5.0 (3.2)	-0.7 (2.8)	-4.3 (-6.4 to -2.2)	0.689
	6 – 7	ABC-C Irritability/Agitation	18 / 20	-5.5 (3.4)	-0.4 (2.7)	-5.1 (-7.5 to -2.7)	

Notes: Abbreviations: SD, Standard Deviation; CI, Confidence Interval; CARS2-ST, Childhood Autism Rating Scale, Second Edition - Standard Form; ABC-C, Aberrant Behavior Checklist-Community; SP-2, Sensory Profile 2; CSHQ, Children's Sleep Habits Questionnaire; MD, Mean Difference.

4. Discussion

This controlled clinical study investigated the impact of a 12-week Tuina massage therapy program, adjunct to standard care, on sensory processing, sleep disturbances, and maladaptive behaviors in young children with ASD in Jakarta, Indonesia. The findings provide compelling evidence supporting our primary hypotheses: participants receiving Tuina demonstrated statistically significant and clinically meaningful improvements across all three targeted domains compared to the control group receiving standard care alone. These benefits were observed post-intervention at 12 weeks and were largely maintained at a 3-month follow-up.[11-13]

The significant improvements in sensory processing, as measured by the SP-2, are a key finding. The Tuina group showed marked reductions in sensory sensitivity, sensation avoidance, and low registration, particularly in auditory and tactile processing. This suggests that Tuina may help children with ASD to better modulate and organize sensory input. From a TCM perspective, Tuina aims to harmonize the flow of Qi and Blood, and calm the Shen (Spirit/Mind). Specific techniques applied to the head, back (Du and Bladder meridians), and limbs can be seen as regulating the body's "sensory gates." For

instance, tactile defensiveness might be conceptualized in TCM as an imbalance in Wei Qi (Defensive Qi) or Liver Qi stagnation leading to hypersensitivity. The gentle, rhythmic, and predictable pressure of Tuina could desensitize overactive tactile systems and improve body awareness (proprioception), which is often linked to better sensory integration. Neurobiologically, sustained tactile input, such as that provided by massage, is known to stimulate mechanoreceptors in the skin, potentially leading to increased parasympathetic nervous system activity, reduced cortisol levels, and modulation of central nervous system arousal. This calming physiological effect could underpin the observed improvements in sensory hyperreactivity and aversive responses to stimuli. The reduction in "low registration" (missing sensory cues) might also reflect an improved ability to attend to and make sense of relevant environmental information once the "noise" of sensory overload is diminished.[14-16]

The Tuina intervention led to significant reductions in overall sleep problems, particularly in bedtime resistance, sleep onset delay, and sleep anxiety, as measured by the CSHQ. This aligns with TCM principles where specific Tuina techniques, such as calming Shen by massaging PC6 Neiguan and HT7 Shenmen, and promoting digestion by massaging the abdomen to prevent food stagnation, which can disturb sleep, are traditionally used to promote restful sleep. The connection between sensory processing and sleep is well-documented; children who are less overwhelmed by sensory stimuli during the day may be calmer and better able to settle at night.[14] Furthermore, the relaxation response induced by massage, potentially mediated by serotonin and melatonin pathways, could directly facilitate sleep onset and improve sleep quality. The reduction in sleep anxiety is noteworthy, as anxiety is a common challenge in ASD and a major contributor to sleep problems.[13] The consistent, nurturing touch of Tuina may have provided a sense of security and calm, reducing anxiety levels around bedtime.[17-19]

Significant reductions in irritability/agitation, hyperactivity/noncompliance, lethargy/social withdrawal, and stereotypic behaviors were observed in the Tuina group via the ABC-C. These behavioral improvements are likely multifactorial. Firstly, improved sensory processing means children are less likely to be in a state of sensory overload, which is a common trigger for meltdowns, irritability, and agitation. Secondly, better sleep quality invariably leads to improved daytime mood, attention, and frustration tolerance. A well-rested child is generally less irritable and hyperactive. Thirdly, from a TCM perspective, Tuina techniques aimed at soothing Liver Qi (associated with irritability and anger) and strengthening Spleen Qi (associated with mental clarity and reduced lethargy) could contribute to these behavioral changes. The reduction in stereotypic behaviors, while more modest, could be related to an overall decrease in arousal and anxiety, as these behaviors often serve a self-regulatory function. The observed decrease in lethargy/social withdrawal is also an important finding, suggesting that Tuina may not only reduce problematic "excess" behaviors but also improve engagement.[18-20]

The secondary finding of a significant reduction in CARS2-ST total scores in the Tuina group suggests that the benefits of Tuina may extend to some core features of ASD, or at least to the overall presentation of symptom severity. This could be an indirect effect stemming from improvements in sensory regulation, sleep, and behavior, which collectively allow the child to be more available for social engagement and learning. The findings of this study are consistent with and expand upon previous research on massage therapy for children with ASD. Several studies have reported benefits of massage on reducing anxiety, improving social relatedness, and decreasing touch aversion in ASD. Previous study found that parent-administered massage decreased touch aversion and off-task behavior in preschool children with ASD. Another study reported that children with ASD who received massage therapy exhibited less stereotypical behavior and showed more on-task behavior and

social relatedness.[21,22]

However, many earlier studies were limited by small sample sizes, a lack of robust control groups, or did not use standardized Tuina protocols based on TCM principles. Our study contributes by employing a larger sample, a controlled design, standardized and validated outcome measures, a well-defined Tuina protocol, and a follow-up period. Our findings corroborate these by demonstrating efficacy on specific, well-defined outcomes using rigorous methodology in a different cultural context. The observed improvements in sensory processing in our study are particularly noteworthy, as this specific outcome has been less extensively studied in relation to Tuina for ASD.

This study offers a platform for integrating TCM and Western psychiatric understandings of ASD. While Western psychiatry defines ASD based on behavioral observations and underlying neurobiological atypicalities, such as differences in brain connectivity, neurotransmitter systems, and immune function,[5,6] TCM offers a complementary energetic and functional framework. For example, "sensory overload" could be conceptualized in TCM as a disruption in the flow of Qi to the sensory orifices or an overactive Liver Yang disturbing the Shen. Tuina's proposed mechanism of regulating Qi flow and calming Shen can be seen as addressing these imbalances.

The physiological effects of massage documented in Western research, such as modulation of the autonomic nervous system (increasing vagal tone, decreasing sympathetic arousal), reduction of stress hormones (cortisol), and potential influence on neurotransmitter levels, including serotonin and dopamine, provide plausible biological pathways through which Tuina might exert its effects observed in this study. For instance, improved vagal tone is associated with better emotional regulation, social engagement, and reduced physiological stress, all of which are relevant to ASD symptomatology. The calming of Shen in TCM may correlate with an increase in parasympathetic activity and a reduction in limbic system hyperarousal. Similarly, strengthening Spleen Qi (improving digestion and energy) might relate to the gut-brain axis, which is increasingly recognized as important in ASD; improved gut health could lead to reduced inflammation and better neurotransmitter precursor availability. The consistent, predictable, and nurturing touch inherent in Tuina might also fulfill a fundamental need for co-regulation in children who struggle with self-regulation, a common feature in ASD. This co-regulation, from a Western psychological perspective, can facilitate the development of more adaptive self-regulatory capacities over time

This study possesses several strengths. Firstly, the randomized controlled design is a robust methodology for evaluating intervention efficacy. Secondly, the use of well-validated, standardized outcome measures administered by blinded assessors enhances the reliability and validity of the findings. Thirdly, the intervention was based on a standardized Tuina protocol delivered by experienced and specifically trained therapists, improving consistency and replicability. Fourthly, the inclusion of a 3-month follow-up period allowed for an assessment of the durability of treatment effects. Fifthly, the study was conducted in a specific cultural context (Jakarta, Indonesia), adding to the diversity of research settings and populations in ASD intervention studies. The high adherence rate to the Tuina protocol and low attrition rate also bolster the internal validity of the study. Finally, the detailed documentation of standard care received by both groups helps in understanding the adjunctive nature of the Tuina intervention.

The positive findings of this study suggest that Tuina massage therapy can be a valuable adjunctive intervention for young children with ASD, particularly for addressing sensory processing difficulties, sleep problems, and associated maladaptive behaviors. Given its non-invasive nature, relatively low cost (compared to some intensive behavioral interventions), and general safety profile, Tuina could be considered for integration into comprehensive treatment plans for ASD, especially in cultural contexts where massage therapies are well-accepted, such as Indonesia. Clinicians working with children with ASD could

discuss Tuina as a potential complementary option with families, particularly when conventional approaches are not fully alleviating these challenging symptoms. The structured protocol used in this study provides a template that could be adapted and implemented by trained Tuina practitioners. This study is one of the first controlled trials of Tuina for ASD in Indonesia. The positive results are particularly relevant for this context, where access to evidence-based ASD interventions can be challenging. Tuina, being a hands-on therapy with cultural resonance, may find good acceptance among Indonesian families. The successful implementation of this study in Jakarta demonstrates the feasibility of conducting such research and highlights the potential for developing culturally adapted complementary therapies to support children with ASD and their families in the region. Collaboration between conventional medical professionals and qualified TCM practitioners will be essential for the safe and effective integration of such therapies.

5. Conclusion

This controlled clinical study demonstrated that a 12-week Tuina massage therapy program, when provided as an adjunct to standard care, led to significant improvements in sensory processing, sleep quality, and maladaptive behaviors in young children with ASD aged 3-7 years in Jakarta, Indonesia. Compared to a control group receiving standard care alone, children in the Tuina group exhibited notable reductions in sensory sensitivities, sensation avoiding, bedtime resistance, sleep anxiety, irritability, and hyperactivity. These therapeutic benefits were largely maintained at a 3-month follow-up. The intervention was well-tolerated with no serious adverse events reported. The findings suggest that Tuina massage therapy, grounded in Traditional Chinese Medicine principles, holds considerable promise as a safe and effective complementary intervention for alleviating some of the most challenging associated symptoms experienced by children with ASD. While further research with more diverse populations, active control groups, and longer follow-up periods is necessary to confirm and extend these findings, this study provides a solid foundation for considering Tuina as part of a holistic, multidisciplinary approach to care for young children with autism spectrum disorder. The positive outcomes underscore the importance of exploring culturally relevant and accessible therapies to improve the well-being and quality of life for this population and their families, particularly in regions like Indonesia.

6. References

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