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Research Progress of Acupuncture in Treating Sleep Disorders in Children with Autism Spectrum Disorder

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Abstract: This paper comprehensively reviews the current research on the use of acupuncture for treating sleep disorders in children with Autism Spectrum Disorder (ASD). Firstly, it delves deep into the possible pathogenesis, carefully analyzing how neurological factors (such as abnormal neural pathways related to sleep - wake regulation in the brain), genetic factors, social factors, and gut - related factors interact intricately. Then, it thoroughly explores modern medical treatments, like the use of sedative - hypnotic medications and the implementation of structured behavioral therapy programs, and compares these with traditional Chinese medicine therapies that emphasize holistic balance. The paper also elaborates on the remarkable progress of acupuncture treatment, including diverse techniques such as filiform needle insertion and electro - acupuncture, elaborate acupoint selection strategies based on meridian theory, and the optimal treatment frequency determined by clinical trials. Overall, this paper aims to provide systematic reference materials for clinical practice and research in this field, and earnestly hopes to promote the wider application of acupuncture, as it can significantly improve the sleep quality and overall well - being of children with ASD, bringing new hope and a brighter future to them and their families.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that usually begins in early childhood. The core symptoms are significant social communication disorders, communication disorders, narrow interests, and stereotyped behaviors, and most children are accompanied by intellectual developmental delays [1]. Among the much comorbidity, sleep disorders are particularly prominent. A regional survey in China shows that the incidence of sleep disorders in children with ASD is as high as 70% [2]. Sleep disorders not only exacerbate children's social, cognitive, and repetitive behavior problems, hinder their normal growth and development, but also greatly increase the psychological burden on caregivers, bringing heavy pressure to families and society. In recent years, acupuncture treatment has been more widely used in improving sleep disorders associated with ASD. Given its advantages such as relatively simple operation and small

side effects, in-depth research on its treatment effects and mechanisms has important clinical significance and social value. This paper reviews it in detail.

2. Pathogenesis

2.1. Research on the Pathogenesis in Modern Medicine

Neurotransmitters and Genetic Factors: The hypothalamic-pituitary-adrenal (HPA) axis plays a crucial role in regulating the body's physiological rhythms and sleep-wake cycles. Sleep disorders in children with ASD may be closely related to HPA axis dysfunction. This dysfunction can lead to disorders in the metabolic pathways of sleep-related neurotransmitters such as melatonin. Melatonin is mainly produced by the pineal gland in the brain and plays an important role in regulating sleep and relieving anxiety under the fine regulation of the suprachiasmatic nucleus. When genes encoding melatonin receptors are abnormal or the functions of enzymes metabolizing melatonin are impaired, the secretion and function of melatonin are disrupted, thereby triggering sleep disorders[3]. In addition, GABAergic neurons in different brain regions participate in the regulation of the sleep-wake system through complex neural pathways, and their abnormal functions may lead to sleep rhythm imbalance. Studies have also found that 5-HT, MT, and brain functional connectivity play an important role in the neurobiological mechanism of the association between sleep behavior problems and autistic behavior in preschool children. Heterozygous CT genotypes and CT and TT gene combinations participate in the regulation of sleep-wake rhythms through a feedback mechanism[4]. Mutations in the CLOCK gene (especially the regulator 1 - PER1) can affect the biological clock of ASD patients, resulting in abnormal melatonin secretion. The rs3762836 variation on the CLOCK gene only appears in ASD patients, further indicating the key role of genetic factors in the pathogenesis of sleep disorders associated with ASD[5].

Social and Intestinal Factors:Many studies [6]have shown that social factors such as maternal depression during pregnancy, children's age, the severity of ASD symptoms, and the time of using electronic screens before going to bed can significantly affect the sleep status of preschool children with ASD. Whether mothers take vitamin D during pregnancy is also related to sleep problems in children with ASD[7]. In the intestine, the abundances of Faecalibacterium and Agathobacter, which mainly produce butyric acid in the gut microbiota of children with ASD and sleep problems, decrease, and the levels of 3-hydroxybutyric acid and melatonin in gut metabolites decrease, while the level of 5-hydroxytryptamine increases. These changes in gut microbiota and metabolites are closely related to the core symptoms of children with ASD, suggesting that the gut microecological environment may affect children's sleep and neural development through the neuro-endocrine-immune network. However, the specific mechanism still needs further exploration and verification[8].

2.2. Research on the Pathogenesis in Traditional Chinese Medicine

Although there is no clear record of the disease names "autism" or "autism spectrum disorder" in ancient Chinese medical books, through the study and collation of ancient medical books, descriptions such as "childish stupor", "mania", "lack of wisdom", "language retardation", "five retardations", "fetal weakness", "sight without emotion", "eyes without emotion", "loss of spirit", and "aphasia" are found to be similar to the symptoms of ASD, indicating that traditional Chinese medicine has long observed and recorded the symptoms of this disease. Most physicians believe that the cause of ASD is due to congenital deficiency, deficiency of kidney essence, or weakness of the spleen and stomach, resulting in deficiency of qi and blood, insufficiency of the sea of marrow, malnutrition of the meridians, and malnutrition of the mind. The pathogenesis is mainly deficiency of

the five zang-organs, and the disease location is in the brain, closely related to the five zang- organs. For the theoretical research on ASD combined with sleep disorders, modern physicians mainly treat it from the perspectives of nourishing the brain marrow and regulating the spirit mechanism, such as the heart-spleen, intestine-spirit, and heart-liver. Zhang Ningbo [9] believes that from the perspective of the heart, excessive heart fire, confusion of the mind, or malnutrition of the mind, and restlessness of the spirit can lead to yang excess and yin deficiency and yin-yang imbalance. The disease location is in the heart and is closely related to the spleen, liver, and kidney. Zhang Lili[10] believes that from the acquired aspect, the "intestine" can absorb the refined substances after digesting food and water to nourish the brain marrow, so that the spirit can be nourished and have a place to rely on, achieving the function of regulating the qi mechanism of the whole body, calming the mind and soothing the heart, and adjusting the "mind". Therefore, the "intestine" can be regulated to calm the "spirit" and help sleep. Cheng Yanran [11] and others treat sleep disorders in children with ASD from the liver. They believe that the disease of insomnia originates from the liver. "The liver stores blood, and the blood houses the soul." When the soul is in the eyes, it can perceive external things. When the soul is stored in the liver, the mind is calm and sleep is peaceful, as shown in Table 1.

Table 1: The pathogenesis of traditional Chinese medicine for ASD comorbid with sleep disorders

Pathogenesis	Related Zang-Fu Organs	Relationship with Sleep Disorders
Excessive Heart Fire	Heart	Excessive heart fire leads to confusion of the mind, yang excess and yin deficiency, and yin-yang imbalance. It affects the generation of brain marrow, resulting in emptiness of the sea of marrow and influencing the neural regulation related to sleep.
Heart Malnutrition	Heart, Spleen	The spleen and stomach are the foundation of the acquired constitution and the source of qi and blood production. Weakness of the spleen and stomach leads to malnutrition of the heart, restlessness of the spirit, and thus causes sleep disorders.
Intestinal Dysfunction	Intestine	Intestinal dysfunction causes the adjustment of "consciousness", inability to nourish the heart and spirit, resulting in restlessness of the mind and sleep problems such as insomnia and excessive dreaming.
Liver Qi Stagnation	Liver	Liver qi stagnation leads to poor qi movement, stagnation of liver qi transforming into fire, disturbing the heart and spirit, resulting in insomnia and irritability.

3. Treatment Methods

3.1. Treatment in Modern Medicine

In the intervention of sleep disorders in children with ASD, there are mainly two methods: drug intervention and behavior intervention. Considering that family and social factors that affect the sleep of healthy children may also cause sleep disorders in children with ASD, and parents are often cautious about drug treatment, parental education and behavior intervention are usually the preferred treatment options. Parental education is of great significance in improving children's sleep. By teaching parents sleep knowledge and behavior management skills, helping parents establish a

good sleep environment and regular routine, and guiding children to develop healthy sleep habits, it has been included in the basic treatment category by many clinical studies[12]. Specific behavior interventions include cultivating good bedtime habits, such as maintaining a quiet and comfortable sleep environment and avoiding excitement and stimulation before going to bed; reasonably adjusting the sleep time to ensure that children get enough sleep; implementing sleep restriction to prevent children from sleeping too long during the day and affecting sleep at night. According to relevant treatment guidelines, it is necessary to comprehensively evaluate children's sleep status in advance and formulate a personalized behavioral sleep plan, and integrate it into daily life to effectively improve sleep behavior. For example, methods such as response interruption and cost strategy are used to correct children's bad sleep behaviors[13]. Studies have shown that intensive behavior intervention can effectively adjust the sleep patterns of children with ASD, and good sleep intervention can alleviate the daytime behavioral symptoms of children with ASD and reduce the burden on family caregivers. Therefore, comprehensive rehabilitation training has become the main method for clinical treatment of sleep disorders in children with ASD[14,15]. In addition, physical intervention methods such as light and sound physical factors are also used to improve children's sleep quality. The light factor uses the circadian rhythm characteristics of melatonin secretion to promote the normal secretion of melatonin at night by adjusting the light time and intensity, thereby improving sleep[16]. The sound factor stimulates the human body to secrete various hormones, reduces the activity frequency of the sympathetic nervous system, relaxes the child's body, and then improves sleep quality[17]. Repetitive transcranial magnetic stimulation[18], melatonin and other treatment methods [19]are also used to some extent to relieve sleep disorders in children with ASD.

3.2. Treatment in Traditional Chinese Medicine

At present, there are relatively few studies on traditional Chinese medicine for ASD with sleep disorders. Most of them observe the improvement of comorbidities such as sleep disorders in the process of treating the core symptoms of ASD. In terms of traditional Chinese medicine treatment, modern physicians mainly start from the heart-spleen or heart-liver perspectives. For example, in Lan Sheng's study[20], children with ASD and sleep disorders were divided into four traditional Chinese medicine syndromes: deficiency of both the heart and spleen, disharmony between the heart and spirit, disharmony of the stomach qi, and internal disturbance of phlegm-heat, and treated with traditional Chinese medicine combined with foot massage. The clinical cure rate reached 54.4%. Chou Yiqian [21]believes that spleen deficiency is the root cause of such children. Spleen deficiency leads to food stagnation and heat generation, which disturbs the mind and causes sleep problems such as difficulty falling asleep or waking up early. She emphasizes that on the basis of spleen-centered treatment, attention should be paid to the simultaneous treatment of the liver and spleen. The use of traditional Chinese medicine for strengthening the spleen and replenishing qi and soothing the liver and regulating the wood has achieved certain curative effects. Cheng Yanran[11]. treat from the liver. Based on the theory of "the liver stores blood, and the blood houses the soul", they believe that when the soul is stored in the liver, the mind is calm and sleep is peaceful. By soothing and regulating the liver, the effect of calming the mind and improving sleep can be achieved. In addition, ear acupoint embedding needles[22] can regulate the function of the central nervous system and the excitability of the cerebral cortex, moderate to high-intensity physical activities[23], rTMS[24], ketogenic diet therapy[25], and sufficient courses of washed microbiota transplantation[26] can also promote the sleep quality of children with ASD to a certain extent. Acupuncture therapy is widely used in the treatment of sleep disorders associated with ASD in

clinical practice because of its advantages such as direct stimulation of acupoints, simple operation, low cost, definite curative effect, and small side effects, as shown in Table 2.

Table 2: Treatment measures for ASD comorbid with sleep disorders

Classification	Modern Medical Treatment Methods	Traditional Chinese Medical Treatment Methods
Drug Intervention	Melatonin, etc.	Chinese herbs for strengthening the spleen and replenishing qi, Soothing the liver and regulating qi
Behavioral Intervention	Parental education, cultivating good bedtime habits, reasonably adjusting sleep time, sleep restriction, using response interruption and cost strategy to correct bad sleep behaviors	Ear acupoint embedding needles, acupuncture, ketogenic diet therapy, gut microbiota transplantation
Physical Intervention	Light factors, sound factors, repetitive transcranial magnetic stimulation (rTMS)	Moderate to high-intensity physical activities

4. Current Research Status of Acupuncture Treatment

4.1. Principles of Acupuncture Treatment

In recent years, the research on the principles of acupuncture treatment has been continuously deepened. Studies have shown that acupuncture can activate dormant neural structures. The mechanism may be related to the regulation of the expression and activity of specific proteins, thereby promoting axon regeneration and repair. At the cellular and molecular levels, acupuncture helps to repair the structure and function of damaged synapses and enhance the efficiency of information transmission between neurons[27]. At the same time, acupuncture can also regulate the excitability of the cerebral cortex, inhibit the overexcited neuronal activity, reduce the damage and fatigue of nerve cells, and thus play a role in protecting neurons, providing a neurobiological basis for acupuncture treatment of sleep disorders associated with ASD[28].

4.2. Clinical Application

Zhu Xiangmei[29] proposed using the acupuncture method of combining the back-shu and front-mu points to treat sleep disorders associated with ASD. By regulating yin and yang and balancing the qi and blood functions of the zang-fu organs, the spirit can return to its position, thus effectively improving the core symptoms and sleep disorders of ASD, providing a new idea for acupuncture point selection. Liu Zihui[30] treated 120 children with ASD and sleep disorders for three courses. They used the method of scalp acupuncture combined with acupoint application. The results showed that this therapy could significantly improve the children's sleep conditions, such as shortening the sleep latency, reducing the number of night awakenings, and prolonging the sleep duration. At the same time, it also had a certain positive impact on the children's daytime behaviors, improving the children's quality of life and family satisfaction. Huang Longsheng[31] used the "Jin's three needles" therapy to treat sleep disorders in children with ASD. By stimulating specific acupoints, the sleep resistance of the children was effectively reduced, sleep anxiety was improved, and the sleep quality of the children was significantly improved, providing an effective empirical reference for clinical acupuncture treatment. Hu Yijia[32] treated sleep disorders in autistic patients based on psychological and behavioral intervention therapy and the principle of calming the mind and fixing the spirit. They used the method of acupuncture combined with ear acupoint pressure.

The research results showed that this combined therapy could significantly improve the sleep structure of the patients, increase the deep sleep time, reduce the abnormal activities in the light sleep and rapid eye movement sleep stages, and also relieve the emotional and behavioral symptoms of the patients to a certain extent, improving the overall rehabilitation effect of the patients. Zhang Ningbo[9] studied sleep disorders associated with ASD by a comprehensive treatment method of combining acupuncture and medicine with behavior intervention. They found that this method not only had a certain curative effect on sleep disorders, but also could alleviate the core symptoms such as social disorders and repetitive stereotyped behaviors in children with ASD, and promote the neuropsychological development of the children, reflecting the advantages and potential of comprehensive treatment in the treatment of ASD.

4.3. Rules of Acupuncture Point Selection

According to the "Clinical Practice Guidelines for Pediatrics of Traditional Chinese Medicine - Autism Spectrum Disorder (Formulation)"[1], the "Expert Consensus on Integrated Traditional Chinese and Western Medicine Intervention for Children with Autism Spectrum Disorder", and a large number of literature studies, the commonly used acupoints for acupuncture treatment of ASD cover multiple parts, as shown in Table 3.

Table 3: Common Acupoints in Acupuncture Treatment of ASD Comorbid with Sleep Disorders

Region	Commonly Used Acupoints	Acupoint Functions
Scalp	Language Areas 1, 2, 3	Closely related to the regulation of language function, helpful to improve speech expression and communication disorders in children with ASD, and promote the functional recovery of the language center in the brain.
Scalp	Baihui, Yintang, Naohu	Baihui can refresh the brain, open the orifices, raise yang and lift the sinking, and is crucial for regulating the overall function of the brain and improving the mental state of children. Yintang has the effect of calming the mind and relieving mental tension and abnormal emotions in children. Naohu can enrich the essence and marrow, refresh the brain and calm the spirit, and is of great significance for nourishing the brain marrow and regulating nerve function.
Limbs	Neiguan, Shenmen, Yongquan, Xuanzhong, Sanyinjiao	Neiguan and Shenmen can calm the mind, regulate qi, and relieve chest tightness, and have a significant effect on improving sleep and stabilizing emotions. Yongquan and Xuanzhong can nourish yin, tonify the kidney, calm the liver and extinguish wind, and communicate the heart and kidney, which are important for regulating the yin- yang balance of the human body, improving sleep and nerve function disorders. Sanyinjiao can strengthen the spleen, remove dampness, tonify the liver and kidney, regulating the overall function of the zang-fu organs and the production of qi and blood.nourish blood and calm the spirit, and plays a key role in.
Trunk	Xinshu, Shenshu	Xinshu can nourish the heart and calm the spirit, regulate the heart function and mental state. Shenshu can tonify the kidney yang, enrich the essence and fill the marrow, and nourish the kidney qi to nourish the brain marrow.
Specific Acupoint Combinations	Sishenzhen, Dingshenzhen, Nie Sanzhen, Nie Shang Sanzhen, Zhisanzhen, Naosanzhen, She	Mostly selected according to the theory of traditional Chinese medicine meridians and clinical experience. By stimulating the corresponding acupoints, the operation of qi and blood in the meridians is regulated, and the brain function is improved, thus playing a role in treating the core symptoms and sleep disorders of children with ASD.

	Sanzhen, Xingshenzhen, Zuzhizhen, etc.	

In acupuncture operation, after the skin of the acupoints is disinfected routinely, a 0.25 mm × 25 mm acupuncture needle is usually selected. For the acupoints on the limbs and back, according to the characteristics of the acupoints and the deficiency or excess of the disease, the method of straight or oblique insertion of 0.5 - 1 inch is used to reach an appropriate depth of stimulation and stimulate the qi. The scalp acupoints are inserted horizontally 1 - 1.5 inches to avoid damaging the skull and allow the needling sensation to conduct along the meridians. The acupuncture manipulation mostly adopts the even reinforcing-reducing method to regulate qi and blood and balance yin and yang. In terms of the retention time of the needles, the needles are retained for no more than 0.5 h in the trunk and limbs to prevent discomfort or accidents caused by long-term retention of the needles. The needles are retained for 0.5 - 2 h in the head. Because the acupoints on the head play a significant role in regulating brain function, appropriately prolonging the retention time of the needles helps to enhance the acupuncture effect. However, the rules of acupuncture point selection for treating sleep disorders associated with ASD have not been completely unified. It is still necessary to carry out large-sample, multi-center clinical studies, combined with modern medical imaging, neuroelectrophysiology and other technologies, to deeply explore the correlation between acupoints and brain nerve function areas, optimize the acupoint selection scheme, improve the accuracy and effectiveness of acupuncture treatment, and provide more scientific and standardized guidance for clinical treatment.

5. Conclusion

Acupuncture treatment of sleep disorders associated with ASD has shown certain positive effects and application potential in clinical practice. Its unique treatment advantages provide a new way to improve the sleep and overall symptoms of children with ASD. However, there are still some deficiencies in current research, such as the lack of standardization of acupuncture prescriptions and the incomplete elucidation of the mechanism of action. Future research should focus on integrating modern medical technology and traditional Chinese medicine theory, deeply exploring the neurobiological mechanism of acupuncture treatment, conducting high-quality clinical trials, optimizing the acupuncture scheme, standardizing the operation process, and strengthening multidisciplinary collaboration. Thus, the wide application and development of acupuncture therapy in the field of ASD treatment can be promoted, bringing more hope and well-being to children with ASD and their families, promoting social attention and support for the ASD group, and improving their quality of life and social integration.

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