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Theoretical Exploration of TCM Herbal Foot Bath as an Adjunctive Treatment for Short Stature in Children

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Abstract: This paper systematically explores the application potential and theoretical basis of the traditional Chinese medicine (TCM) foot bath in the adjuvant treatment of short stature in children. Currently, the primary treatment for short stature is recombinant human growth hormone (rhGH), but it faces challenges such as high costs, variable responses, and safety concerns. Traditional Chinese Medicine emphasizes syndrome differentiation and holistic regulation. Against this backdrop, the TCM foot bath, as a safe and convenient external TCM therapy, demonstrates unique advantages. The theoretical foundation of the TCM foot bath is rooted in the holistic concept and meridian theory of TCM, with its mechanisms of action including thermal stimulation, percutaneous absorption of medicinal components, and regulation through the neuro-endocrine-immune network, producing analgesic, anti-inflammatory, and immunomodulatory effects. These mechanisms are highly compatible with the pathogenesis of short stature. Despite the advantages of the TCM foot bath, such as simplicity, convenience, effectiveness, affordability, and good compliance among children, there is still a lack of high-quality clinical research evidence, and the safety and standardized protocols for pediatric use remain to be improved. Future research needs rigorous randomized controlled trials to deepen mechanism exploration and standardize clinical practice.

Keywords: Traditional Chinese medicine foot bath; Short stature; Mechanism of action; Transdermal drug delivery

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1. Preface

Pediatric short stature is a common growth and developmental disorder in pediatric clinical practice, defined as a child's height being more than 2 standard deviations (-2 SD) below the average height of individuals of the same race, age, and gender, or falling below the 3rd percentile. The etiology is complex, encompassing conditions such as growth hormone deficiency, idiopathic short stature, genetic syndromes, and chronic systemic diseases [1]. Currently, Western medicine primarily employs recombinant human growth hormone (rhGH) for replacement or growth-promoting therapy, which, while effective in enhancing growth rate, still faces challenges such as high treatment costs, suboptimal responses in some children, concerns regarding long-term safety, and apprehensions among some

parents about the use of "hormones" [2]. Therefore, the exploration of safe, effective, and well-tolerated adjuvant or alternative therapies has become an urgent clinical research need.

Traditional Chinese medicine (TCM) boasts a long history and unique advantages in promoting children's growth and development. According to TCM theory, height growth is closely related to the functions of the kidneys (which store essence and govern bone and marrow production), the spleen (which is the foundation of postnatal constitution and governs transportation and transformation, as well as muscles and limbs), and the liver (which governs the smooth flow of qi and regulates the body's vital energy). Short stature is often attributed to basic pathogenic mechanisms such as spleen and kidney deficiency, qi and blood insufficiency, and liver stagnation with spleen deficiency [3]. Clinical practice has demonstrated that TCM therapies, including oral herbal medicine, pediatric tuina (massage), and acupoint application, exhibit good potential in improving children's appetite, sleep, and constitution, thereby promoting height growth [4]. This provides a theoretical basis for a comprehensive intervention model that combines traditional Chinese and Western medicine and employs both internal and external treatments. As an important branch of external treatment methods in traditional Chinese medicine, the Chinese herbal footbath is widely used in the management of various pediatric and chronic diseases due to its safety, simplicity, non-invasiveness, and high acceptance among children. Its theoretical foundation stems from the holistic concept and meridian theory of traditional Chinese medicine. The feet are the starting and ending points of the three yin meridians of the foot and the three yang meridians of the foot, and are dotted with numerous acupoints, such as Yongquan and Sanyinjiao, which are closely related to the qi and blood of the internal organs. By soaking the feet in warm medicinal liquid, it can not only promote the circulation of qi and blood with the help of water temperature but also enable the effective components of the herbs to be absorbed through the skin and stimulate specific acupoints, thereby harmonizing yin and yang, unblocking meridians, and regulating the functions of the internal organs [5]. Modern research has confirmed that Chinese herbal footbath can effectively improve local and systemic microcirculation, regulate neuroendocrine function, and demonstrate significant effects in improving sleep disorders, relieving fatigue, promoting gastrointestinal function recovery, and other aspects [6–8]. Given that good sleep, strong appetite, and normal digestion and absorption are the cornerstones of children's growth and development, the Chinese herbal footbath, by improving these key aspects, is expected to open up new avenues for the adjuvant treatment of short stature.

2. Understanding and current treatment status of short stature in traditional Chinese and Western medicine

2.1. Understanding of traditional Chinese and Western medicine

The etiology of short stature in Western medicine is complex and diverse, with its core attributed to growth axis dysfunction, primarily including growth hormone deficiency (GHD) and idiopathic short stature (ISS). Meanwhile, hereditary factors such as chromosomal abnormalities and gene defects, chronic organic diseases, and psychosocial factors can all lead to growth retardation by affecting endocrine, nutritional, or metabolic pathways [9].

In traditional Chinese medicine (TCM), short stature is classified under categories such as "five delays", "fetal weakness", and "deficiency fatigue", with its theoretical foundation rooted in the core visceral doctrines that "the kidneys are the foundation of prenatal constitution and govern bones and marrow production" and "the spleen is the foundation of postnatal constitution and governs transportation, transformation, and the generation of qi and blood." TCM posits that height growth results from the collaborative efforts of the viscera (with particular emphasis on the spleen and kidneys), qi and blood, and meridians. The core pathological mechanism is often characterized by a

combination of root deficiency and branch excess, with spleen and kidney deficiency as the root cause. Congenital kidney essence deficiency leads to inadequate nourishment of the bones, while acquired spleen and stomach weakness result in insufficient production of qi and blood, preventing the muscles from becoming robust, both of which collectively contribute to growth retardation. On this basis, conditions such as qi and blood deficiency, manifested as sallow complexion, fatigue, and liver stagnation with spleen deficiency, often emerge as concurrent syndromes [10].

2.2. Current treatment status

The current first-line treatment for short stature is recombinant human growth hormone (rhGH) therapy. Numerous clinical studies have confirmed that rhGH effectively stimulates the proliferation of chondrocytes in the growth plates of bones, significantly increasing the growth rate and improving the final adult height in children with growth hormone deficiency (GHD) and idiopathic short stature (ISS) [11]. However, this therapy faces challenges such as high treatment costs, difficulties in long-term adherence management, and concerns about potential safety issues.

Based on its understanding of the pathological mechanisms, TCM emphasizes syndrome differentiation and treatment, which involves administering personalized prescriptions based on the specific combination of syndromes in each child. Common clinical syndromes and their corresponding treatments include: spleen and kidney deficiency syndrome, treated by invigorating the spleen and qi, and replenishing the kidneys and essence to strengthen the foundation; spleen qi deficiency syndrome, treated by invigorating the spleen and qi, and aiding transportation and appetite to boost the postnatal constitution; and spleen deficiency with liver hyperactivity syndrome, treated by invigorating the spleen and soothing the liver, harmonizing qi and blood, and simultaneously regulating emotions and digestion [12]. Currently, the clinical field increasingly advocates the “integrated traditional Chinese and Western medicine” model, which involves using rhGH to promote growth while combining traditional Chinese medicine for holistic conditioning. This model is expected to not only enhance growth rate but also mitigate the potential side effects of rhGH, improve the quality of life for children, and achieve an organic integration of “addressing symptoms” and “treating root causes,” representing an important direction for future comprehensive interventions.

3. Theoretical foundations of the traditional Chinese medicine foot bath

Traditional Chinese medicine foot bath, historically known as “foot fumigation” or “foot washing”, is a form of external treatment in traditional Chinese medicine. Its origins can be traced back to the pre-Qin period, with records in the “Book of Rites” stating, “If there is a sore on the head, wash the hair; if there is an ulcer on the body, take a bath.” Although these records do not specifically refer to the feet, they already contain the embryonic form of the principle that “the rationale of external treatment is the same as that of internal treatment.” In the Jin Dynasty, Ge Hong explicitly recorded in his “Handbook of Prescriptions for Emergencies” the method of soaking the feet in a decoction made from willow bark, angelica, and other herbs to treat foot diseases, which can be regarded as an early practice of medicinal bathing. By the Tang Dynasty, the renowned physician Sun Simiao systematically summarized the health preservation concept of “keeping the feet warm” in his “Essential Formulas for Emergencies Worth a Thousand Pieces of Gold”, emphasizing that “washing the feet before going to bed in winter prevents cold diseases”, elevating foot bathing from a therapeutic practice to a preventive and health-preserving measure, which became widely popular in both the imperial court and among the general populace. The “Taiping Huimin Heji Ju Fang” of the Song Dynasty recorded various fumigation and washing formulas, marking its entry into a standardized stage. During the Ming and Qing dynasties, with the rise of the school of warm diseases and the maturation of external treatment theories, the application scope of foot bathing greatly expanded. In the Liyue Pianwen (Parallel Prose on External

Treatments) written by Wu Shangxian in the Qing Dynasty, it was proposed that "the methods of external treatment are essentially the same as those of internal treatment." He systematically expounded on the principle of treating systemic diseases through the administration of medication via the feet, elevating traditional Chinese medicine (TCM) foot baths from a folk remedy to a mature external treatment technique in TCM. This method has been widely used to treat rheumatism, insomnia, colds, and various gynecological conditions.

The theoretical foundation of TCM foot baths is rooted in the holistic concept, with its core being the full utilization of the physiological characteristics of the feet as "the convergence point of the starting and ending points of meridians." The three yin meridians of the foot originate here, while the three yang meridians of the foot terminate here. Through continuous immersion in warm medicinal liquid, heat energy synergizes with the medicinal properties to effectively stimulate the meridian qi at acupoints, thereby dredging the meridians and promoting the circulation of qi, blood, and body fluids throughout the body. When qi and blood flow smoothly, essential substances can be transported, providing the fundamental energy and material basis for the growth and development of bones and muscles. On this basis, the stimulation of specific acupoints by foot baths produces targeted regulatory effects: stimulating the Yongquan acupoint can directly nourish the kidneys and replenish essence, strengthening the innate foundation; stimulating the Sanyinjiao acupoint can comprehensively regulate qi and blood, invigorating the spleen, soothing the liver, and tonifying the kidneys. This targeted regulation directly addresses the core pathogenesis of "deficiency of both the spleen and kidneys" in dwarfism. Meanwhile, under the influence of warmth, the pores and capillaries in the feet open, allowing effective components such as alkaloids and flavonoids in the medicinal liquid to be absorbed through the skin into the systemic circulation, bypassing the "first-pass effect" of the gastrointestinal tract and liver, and directly exerting systemic pharmacological effects [13]. Therefore, through the integrated mechanisms of meridian conduction, acupoint stimulation, and transdermal absorption, TCM foot baths achieve the goal of treating internal diseases through external methods.

4. Mechanism of action of the traditional Chinese medicine foot bath

The fundamental effect of traditional Chinese medicine (TCM) foot baths lies in the combination of thermal stimulation and transdermal drug absorption, with its mechanism not being a single pathway but rather a collaborative regulatory process involving multiple targets and levels. Thermal stimulation can rapidly dilate blood vessels in the lower extremities, significantly improving local microcirculation and hemorheological status, thereby laying the foundation for drug absorption [14]. Simultaneously, as a benign physical signal, thermal stimulation can reflexively regulate autonomic nervous function by stimulating the abundant nerve endings in the feet, producing relaxation and calming effects, and consequently improving sleep disorders [15].

Transdermal drug absorption is a crucial chemical pathway for producing specific pharmacological effects. The skin, as the largest organ in the human body, possesses multiple functions, including defense, protection, penetration, and absorption [16]. Studies have shown that an increase in temperature leads to greater fluidity of the lipid layer on the skin surface, thereby enhancing drug penetration. Moreover, the drug penetration rate through the skin of the feet is 3–5 times higher than that of the forearm [17]. Therefore, when the heated medicinal solution comes into contact with the legs and feet, the active ingredients of TCM can penetrate the skin stratum corneum and superficial layers into the extracellular fluid, lymphatic microcirculation, and even the bloodstream at a constant rate over an extended period, facilitated by the pressure and heat of the water [18]. This enables different drugs in the foot bath formula, tailored to the disease pathogenesis, to exert their inherent pharmacological activities, similar to oral decoctions. For instance, adding drugs such as *Ligusticum chuanxiong* and *Salvia miltiorrhiza* to the foot bath formula allows

their active components, including ligustrazine and tanshinone, to enter the systemic circulation through hair follicle channels, inhibiting platelet P-selectin expression while upregulating mRNA expression of VEGF and its receptor Flk-1, thereby promoting collateral circulation establishment [19]. The addition of spleen-invigorating and dampness-drying traditional Chinese medicines such as *Atractylodis rhizoma* can also indirectly improve gastrointestinal blood supply by regulating gastrointestinal hormone levels [20]. The inclusion of Poria can calm the mind and promote sleep. The triterpenoids, polysaccharides, and other components in Poria may exert sedative and hypnotic effects by regulating the levels of monoamine neurotransmitters (such as serotonin) in the brain [21].

In addition, the regulatory effect of traditional Chinese medicine foot bath on the neuro-endocrine-immune network is also one of the core mechanisms underlying its effectiveness. When the warm liquid stimulates the skin on the soles of the feet, mechanoreceptors such as Merkel cells and Pacinian corpuscles are activated, transmitting signals to the dorsal horn of the spinal cord via Aβ and C nerve fibers [22]. Secondary neurons here then transmit the signals via the spinothalamic tract to the paraventricular nucleus (PVN) of the hypothalamus, activating its large-cell neurons [23]. As an integration center for the autonomic nervous system and the endocrine system, the PVN, on the one hand, regulates the hypothalamic-pituitary-adrenal (HPA) axis by releasing corticotropin-releasing hormone (CRH), promoting the overexpression of β-endorphin synthase, ultimately leading to an increase in plasma β-endorphin levels. As an endogenous opioid peptide, β-endorphin inhibits the release of substance P in the dorsal horn of the spinal cord by binding to μ receptors, blocking the transmission of pain signals, a process that can explain the decrease in VAS pain scores [24]. On the other hand, acetylcholine (ACh) released from vagus nerve endings binds to α7 nicotinic receptors on macrophages, inhibiting nuclear translocation of NF-κB and subsequently downregulating the transcription of pro-inflammatory cytokines such as IL-6 and TNF-α [25]. β-endorphin can also directly act on opioid receptors on T lymphocytes, enhancing IL-10 secretion from CD4+ T cells and promoting a shift in the Th1/Th2 balance towards an anti-inflammatory direction [24]. This bidirectional neuro-immune regulatory mechanism manifests, in relevant studies such as those involving post-operative patients with adenomyosis, as a decrease in serum IL-6 levels and an increase in the CD4+/CD8+ ratio, confirming that foot baths possess a triple effect of "analgesia-anti-inflammation-immune homeostasis reconstruction" [26].

5. Potential application of traditional Chinese medicine foot baths in the adjuvant treatment of short stature

5.1. High compatibility between the mechanism of action of traditional Chinese medicine foot baths and the pathogenesis of short stature

Based on theoretical and mechanistic research on traditional Chinese medicine foot baths, they demonstrate unique value in the prevention and treatment of short stature. The core of their application lies in prescription compatibility and matching with syndrome types, with their mechanism of action showing a high degree of compatibility with the Chinese and Western medical pathogenesis of short stature. The core of short stature lies in dysfunction of the growth hormone-insulin-like growth factor-1 (GH-IGF-1) axis, nutritional absorption disorders, and sleep disturbances. Traditional Chinese medicine foot baths achieve targeted intervention through the following means: (1) Improving nutritional metabolism: By stimulating the Spleen Meridian of Foot-Taiyin (such as the Sanyinjiao acupoint) and leveraging the spleen-strengthening effects of the herbs, they enhance gastrointestinal motility and digestive fluid secretion, thereby improving appetite and nutritional absorption efficiency. (2) Optimizing sleep: The warming effect of the foot bath and the sedative herbs can prolong deep sleep duration and improve sleep quality, with deep sleep being a key trigger for peak GH secretion, thus improving the physiological secretion of growth hormone [6]. (3)

Enhancing immunity: The warming effect of traditional Chinese medicine foot baths and the medicinal components (such as polysaccharides and saponins found in *Astragalus membranaceus* and *Glycyrrhiza uralensis*) can be absorbed through the skin and regulated via the neuro-endocrine system, helping to reduce the body's chronic low-grade inflammation levels. Moderate foot bath intervention can regulate the levels of pro-inflammatory factors such as TNF-α and IL-6 in serum, improving immune homeostasis [27]. A stable immune environment creates a more favorable physiological internal environment for growth.

Traditional Chinese medicine (TCM) posits that the fundamental pathogenesis of short stature lies in deficiency of both the spleen and kidney, often accompanied by qi-blood stagnation. Herbal foot baths can utilize herbs such as astragalus and eucommia, which are absorbed through acupoints on the foot-shaoyin kidney meridian (Yongquan acupoint) and the foot-taiyin spleen meridian (Sanyinjiao acupoint) and transmitted along the meridians, allowing the medicinal properties to directly reach the affected areas and exert effects such as invigorating the spleen and replenishing qi, as well as tonifying the kidney and replenishing essence, addressing the underlying "deficiency of both spleen and kidney" [28]. Meanwhile, the warm stimulation and blood-activating herbs (such as safflower and cassia twig) can significantly improve microcirculation in the feet and throughout the body, unblocking qi and blood, resolving the pathological state of stagnation caused by deficiency, ensuring that the vital substances of qi and blood can smoothly reach all limbs and bones, nourishing the skeletal system [29].

5.2. Analysis of prescription medication patterns

An effective foot bath prescription for short stature is not a simple accumulation of herbs but an organic combination that adheres to the principles of TCM theory, methodology, prescriptions, and medications. Commonly used herbs can be categorized into three types: (1) Tonifying the spleen and kidney, strengthening the foundation, and replenishing vital essence: This is the core of the prescription, aiming to "replenish deficiencies." Commonly used herbs include astragalus, codonopsis, and atractylodes to invigorate the spleen and replenish qi; eucommia, cyathula, and dipsacus to tonify the kidney and strengthen bones; and dioscorea and polygonatum to nourish both the spleen and kidney yin. This combination directly targets the fundamental pathogenesis of short stature, "deficiency of both spleen and kidney," providing the primary driving force for growth. (2) Promoting blood circulation and unblocking meridians, ensuring smooth flow of qi and blood: This is the key to the prescription, aiming to "unblock stagnation." Commonly used drugs such as safflower, *Ligusticum chuanxiong*, and *Caulis spatholobi* are employed to promote blood circulation and remove blood stasis; cassia twig and folium artemisiae argyi are used to warm the meridians and restore yang. These drugs can significantly improve the local microcirculation of foot baths and extend the "unblocking" effect to the whole body, ensuring the smooth delivery of subtle substances and growth factors to the bone growth plate. (3) Calming the mind and stabilizing the will, harmonizing yin and yang: This serves as an important adjunct aimed at "regulating the vital spirit." Commonly used drugs such as *Poria cocos* (with host wood) and *Caulis polygoni multiflori* are used to calm the heart and soothe the mind; *Cortex albiziae* and *Polygala tenuifolia* are used to relieve depression and calm the mind. Calming the mind and improving sleep are crucial for ensuring the nocturnal pulsatile secretion of growth hormone.

5.3. Compatibility principles and dosage characteristics

Studies have shown that the compatibility of foot bath prescriptions emphasizes "combining tonification with unblocking, and balancing activity with stillness" [5]. The core structure often takes "tonic drugs" and "drugs that promote blood circulation and unblock the meridians" as the basic framework, and then supplements with drugs that calm the mind and stimulate appetite based on the specific symptoms of the child, such as poor sleep and loss of

appetite. In terms of dosage, the amount of drugs used in foot baths is usually several times that of oral decoctions. The common dosage for adult prescriptions is mostly 30–60 grams per drug, while for children, the dosage can be appropriately reduced to 15–30 grams to ensure that the foot bath solution has a sufficient effective concentration [29].

5.4. Precautions and contraindications

To ensure the safety and effectiveness of adjuvant therapy for children, it is essential to strictly adhere to operational standards and pay attention to relevant contraindications. Contraindications include skin damage, infection, ulcers, or severe eczema on the feet; severe cardiovascular and cerebrovascular diseases, bleeding disorders, or being in the acute phase of high fever [30]. Meanwhile, it is important to note that Traditional Chinese Medicine (TCM) syndrome differentiation should be conducted before treatment, and the prescription needs to be adjusted for those with yin deficiency and excessive fire or excessive internal heat. The water temperature should be maintained at around 40°C, and the duration should be 15–20 minutes. It is advisable to avoid performing the foot bath immediately after meals. After treatment, the feet should be dried immediately, and attention should be paid to keeping warm.

In summary, Chinese herbal foot bath, through the multidimensional mechanism of "improving circulation — regulating endocrine — optimizing sleep" verifiable by modern pharmacology, corroborates with its effects in TCM theory of "dredging meridians, harmonizing qi and blood, and calming the mind," jointly forming the scientific basis for its adjuvant intervention in short stature and improvement of the internal growth environment.

6. Conclusion

Although the Chinese herbal foot bath shows promising application prospects, its clinical promotion still faces several challenges. The current evidence mostly comes from small-sample clinical observations or experience summaries, lacking high-quality, large-sample randomized controlled trials (RCTs) to provide strong evidence of efficacy. Moreover, there is a lack of in-depth exploration of the mechanisms at the molecular biology level. Additionally, as children are a special population, the percutaneous absorption rate, long-term safety, and standard dosage of external medications for children have not been established, and there is a significant deficiency in the safety database for pediatric medications. Future research should focus on constructing a more scientific evidence system and clinical practice protocols. Design and conduct rigorous multi-center, large-sample RCT studies to obtain high-level evidence of efficacy.

Based on the holistic concept of traditional Chinese medicine (TCM) and modern pharmacological mechanisms, Chinese herbal footbath offers a "simple, convenient, effective, and affordable" new approach for the adjuvant treatment of short stature through the combined effects of thermal stimulation, transdermal drug absorption, and regulation of meridians and acupoints. It ingeniously aligns with the TCM pathogenesis of "deficiency in both spleen and kidney" and the Western medical pathological link of "growth axis disorder", offering the advantages of holistic regulation and good patient compliance. Although currently limited by the depth of research and the level of evidence, its application potential is immense. By deepening mechanistic research, standardizing clinical protocols, and exploring individualized treatment approaches, the Chinese herbal footbath has the potential to become a model of integrated traditional Chinese and Western medicine in the field of children's healthy growth.

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Disclosure statement

The authors declare no conflict of interest.

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