


To Evaluate the Effect of Pediatric Massage Combined with Comprehensive Management on Growth Parameters and Biochemical Indicators in Children with Short Stature

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Purpose: To investigate the effect of pediatric massage combined with comprehensive management on height improvement in children with short stature.

Patients and Methods: This retrospective analysis included medical records of 80 children diagnosed with short stature, who received treatment at Wuhu Hospital of Traditional Chinese Medicine between April 2022 and April 2023. According to the recorded treatment modalities, patients were divided into two groups: the control group received standard comprehensive management (including psychological health guidance, diet, sleep, exercise), while the massage group received additional pediatric syndrome-based massage therapy alongside comprehensive treatment. Relevant clinical indicators—including height, weight, BMI (body mass index), IGF-1 (insulin-like growth factor-1), BA (bone age), 25(OH)D (25-hydroxyvitamin D), annual growth velocity (GV), TCM (Traditional Chinese Medicine) symptom scores, as well as cortisol, luteinizing hormone (LH), and growth hormone (GH) levels—were extracted from the medical records and compared between the two groups at baseline and after the recorded treatment period.

Results: When comparing both groups of patients before and after the intervention, significant improvements were observed in height, weight, IGF-1, bone age index (BAI), 25(OH)D levels, GV, and TCM symptom scores ($P < 0.05$). Notably, the massage group showed significantly greater improvements in height, weight, BAI, IGF-1, and GV compared to the control group ($P < 0.05$). Furthermore, massage therapy was associated with a reduction in serum cortisol levels and an increase in LH and GH levels, indicating potential endocrine benefits.

Conclusion: Pediatric massage combined with comprehensive management effectively promotes improvements in height, weight, and annual growth velocity (GV) among children with short stature.

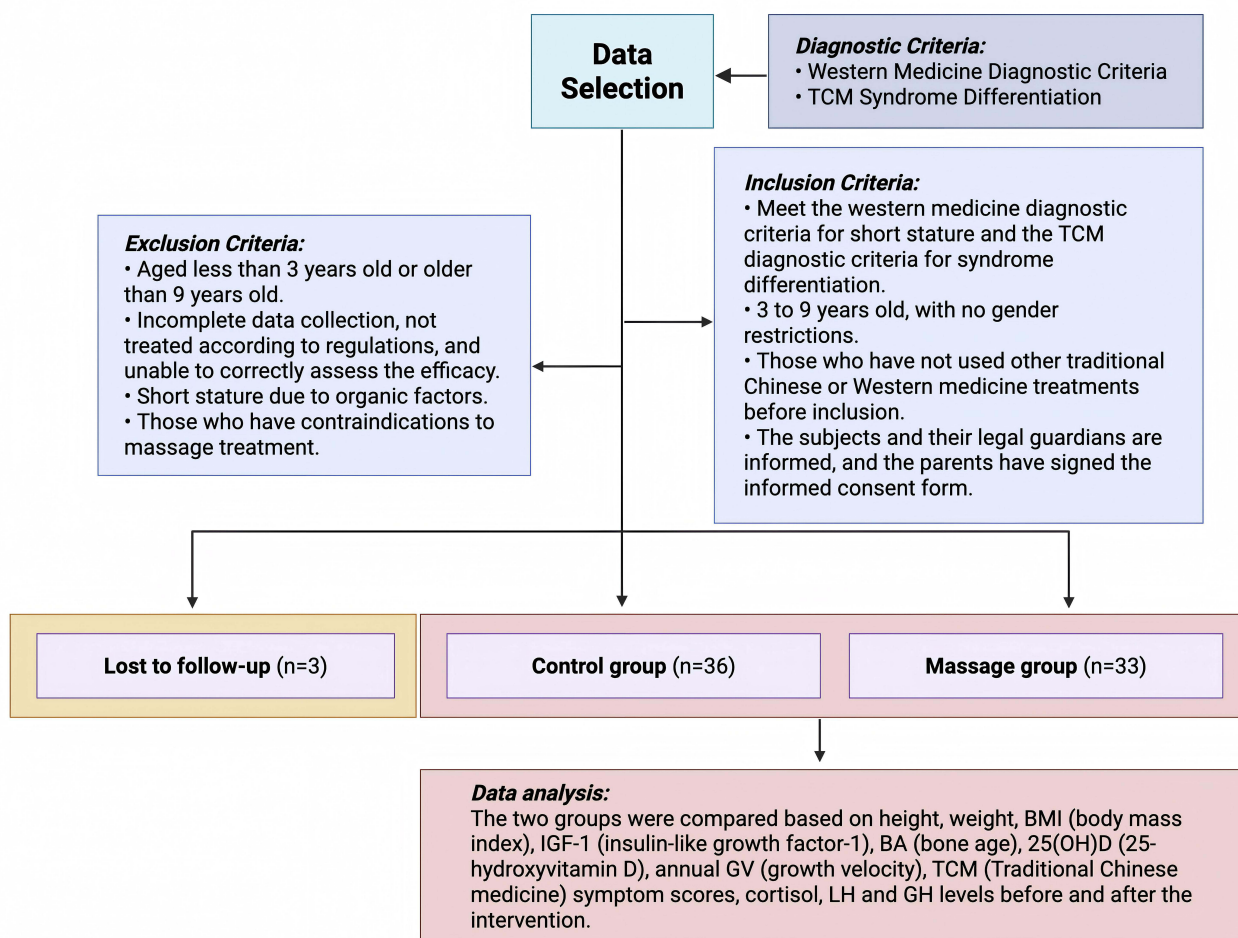
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Introduction

Short stature is a common pediatric problem worldwide, affecting an estimated 150 million children¹ Short stature refers to a height significantly below the normal standard for children of the same age, sex, and ethnicity. Clinically, it is commonly defined as a height more than two standard deviations (-2 SD) below the mean height for the same age and sex, or below the 3rd percentile.^{2,3} The prevalence of short stature among children in China has been increasing annually and continues to rise.⁴ If timely intervention is not provided, short stature may progress to dwarfism, further induce psychological and social problems as well as reduced educational and employment opportunities in adulthood¹ Currently, recombinant human growth hormone is commonly used in Western medicine to treat dwarfism; however, its indications are strictly defined, and routine administration is not recommended for children whose height does not meet the diagnostic criteria for dwarfism.⁵ Moreover, it is costly, its efficacy is uncertain, and it may cause side effects.⁶



Graphical Abstract



Against this background, the concept of “preventive treatment” in traditional Chinese medicine (TCM) underscores the importance of early TCM intervention to promote height growth in children. In addition to herbal medicines, external therapeutic methods such as acupoint plastering, auricular therapy, and massage play significant roles in comprehensive interventions, offering advantages of minimal side effects and ease of application.^{7,8} Therefore, people have begun to explore alternative therapies such as traditional Chinese massage, Chinese medicine, and acupuncture, which can stimulate specific acupoints to promote the secretion of growth hormone (GH) and IGF-1.^{6,9,10} Recently, more studies have focused on the advantages of TCM in treating children,¹¹⁻¹³ particularly highlighting its significant effectiveness in managing idiopathic short stature and emphasizing the importance of external treatment methods in TCM for this condition.⁶

To evaluate the effectiveness of traditional Chinese massage in promoting height gain, hormone levels in children were measured in this study. Serum GH, luteinizing hormone (LH), and cortisol are key components of the endocrine system, reflecting the overall hormonal health and function of the body.¹⁴⁻¹⁶ These hormones play essential roles in physiological processes, including growth, metabolism, sexual development, and stress response.

Therefore, based on the principle of “preventive treatment of disease” in TCM, this retrospective study aims to evaluate the clinical effectiveness of individualized pediatric massage combined with comprehensive management in promoting growth and development among children with short stature. By reviewing these clinical data, we seek to

explore whether this integrative approach may help prevent progression to short stature and provide evidence-based support for optimizing treatment strategies in clinical practice.

Materials and Methods

Participant Selection

From April 2022 to April 2023, 72 children (age between 3 to 9 years old) with short stature who visited the outpatient department of Wuhu Hospital of Traditional Chinese Medicine were selected. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethical Committee, Wuhu Hospital of Traditional Chinese Medicine (No. KY-2023-026). Informed consent was waived due to the study's retrospective nature, and all patient data were anonymized to maintain confidentiality throughout the research.

Study Design

Estimating the sample size (n) using the formula: $n = \frac{[\Pi_1(100\% - \Pi_1)]^{(\alpha, \beta)}}{(\Pi_1 - \Pi_2)^2}$ in medical statistics, α and β represent the probabilities of Type I and Type II statistical errors, respectively. Typically, α is set to 0.05 and β to 0.10. By consulting tables, it is found that the value is $^{(\alpha, \beta)} = 10.5$. Reviewing relevant literature and analyzing the effectiveness rates of the treatment group and the control group, denoted as Π_1 and Π_2 , respectively, the sample size is calculated to be 60 cases. Considering a dropout rate of 20%, the final determined sample size is 72 cases.

A total of 72 children diagnosed with short stature who received treatment at Wuhu Hospital of Traditional Chinese Medicine between April 2022 and April 2023 were included in this retrospective study. Based on the recorded treatment modalities in their medical records, 36 children received standard comprehensive management (control group), while 36 children additionally received pediatric syndrome-based massage therapy (massage group). Due to incomplete records, 3 cases in the massage group were excluded, resulting in 33 children in the massage group and 36 in the control group. Baseline characteristics between the two groups showed no statistically significant differences ($P > 0.05$), indicating comparability (see Tables 1 and 2).

Data Collection

Western Medicine Diagnostic Criteria

According to the “China Guidelines for the Diagnosis and Treatment of Short Stature in Children”¹⁷ and the “China Recommendations for the Clinical Application of Recombinant Human Growth Hormone in Pediatrics”,¹⁸ along with the standardized growth curves for height and weight of children and adolescents,^{19,20} the diagnostic criteria established in this study are as follows:

(1) For individuals of the same race, gender, and age, the height is between one standard deviation below the average height ($-1SD$) and two standard deviations below the average height ($-2SD$) of the normal population (growth hormone

Table 1 Baseline Characteristics of Study Participants

	Gender	Number of Children	Age (years)	Height (cm)	Weight (kg)	BA (years)	BMI	BAI	IGF1 (ng/mL)	25(OH)D (ng/mL)
Massage Group	Male	22	5.80±1.69	109.40±10.19	18.62±3.66	5.53±1.75	15.39±0.47	0.95±0.05	119.03±10.25	28.74±5.31
	Female	11								
Control Group	Male	25	5.79±1.25	107.51±7.39	17.73±2.51	5.45±1.29	15.35±0.27	0.94±0.05	115.51±9.9	29.17±5.95
	Female	11								
t			0.028	0.875	1.168	0.198	0.428	0.74	1.431	0.317
P			0.978	0.385	0.248	0.84	0.67	0.63	0.83	0.752

Abbreviations: BA, Bone age; BMI, Body mass index; BAI, Bone age index; IGF-1, Insulin-like growth factor-1; 25(OH)D, 25-Hydroxyvitamin D.

Table 2 Comparison of TCM Symptom Scores at Baseline Between Two Groups

	Massage Group	Control Group	z	P
Poor complexion	2(2,2)	2(2,2)	-1.068	0.286
Lethargy	2(2,2)	2(1,25,2)	-1.009	0.313
Poor appetite	2(2,2)	2(1,2)	-1.215	0.224
Poor sleep	1(1,2)	1(1,2)	-0.797	0.425
Spontaneous sweating	1(1,2)	1(1,2)	-0.938	0.348
Irregular bowel movements	1(1,2)	1(1,2)	-0.565	0.572
Pale tongue with white coating	1(1,2)	1(1,2)	-0.297	0.767
Total score of TCM symptoms	12(11,12.5)	11(10,12)	-1.904	0.057

stimulation test may be performed if necessary). (2) At birth, the length was within the normal range for the same gestational age, and the weight was normal. (3) Normal findings in related examinations such as cranial and pituitary magnetic resonance imaging. (4) Exclusion of other diseases that may cause short stature in children (including endocrine diseases, chromosomal diseases, etc).

TCM Syndrome Differentiation

The TCM diagnostic criteria for lung and spleen Qi deficiency syndrome in children with short stature are established as follows:

Main symptoms: Short stature, slow growth.

Secondary symptoms: poor complexion, lethargy, poor appetite, poor sleep, loose stools/constipation, spontaneous sweating, pale tongue with white coating.

Inclusion and Exclusion Criteria

Inclusion Criteria

- (1) Meet the above western medicine diagnostic criteria for short stature and the TCM diagnostic criteria for syndrome differentiation.
- (2) Aged between 3 to 9 years old, with no gender restrictions.
- (3) Those who have not used other traditional Chinese or Western medicine treatments before inclusion.
- (4) The subjects and their legal guardians are informed.

Exclusion Criteria

- (1) Aged less than 3 years old or older than 9 years old.
- (2) Incomplete data collection, not treated according to regulations, and unable to correctly assess the efficacy.
- (3) Short stature due to organic factors.
- (4) Those who have contraindications to massage treatment.

Methods

Control Group

Conventional comprehensive management is provided, with specific measures including:

- (1) Psychological health guidance: Strengthen education for children and parents. Mainly explain to parents the possible causes of short stature and the necessity of increasing attention, while also enhancing parent-child relationships and maintaining a relaxed and pleasant family atmosphere.

(2) Diet: Based on physical characteristics, body mass index (BMI), dietary preferences, etc., children in the group are required to be fed reasonably and have a balanced diet. Encourage regular meals, chew food thoroughly during meals, and avoid picky eating and excessive intake of junk food.

(3) Sleep: Ensure sleep quality on the premise of a good sleep environment, requiring children in the group to maintain sufficient sleep time. It is recommended that children aged 3–5 years sleep for 11–14 h per day, and children aged 6–8 years sleep for 10–13 h per day.

(4) Exercise: On the premise of ensuring safety, adjust the exercise plan according to age. Children aged 3–5 years in the group are ensured to have enough sunlight exposure and appropriate outdoor activities daily. Encourage children aged 6–8 years to engage in simple aerobic exercises such as jumping rope and jogging daily, with a recommended exercise time of about 30 min per day. Adjust dynamically according to the actual situation of the child, with a treatment course of 3 months, followed by regular follow-up visits, totaling 6 months.

Massage Group

Children in massage group received supplemental massage treatment in addition to the control group's regimen. Massage Protocol: Techniques are tailored after syndrome differentiation, including tonifying the spleen and lung meridians, activating the inner and outer Bagua (Eight Extraordinary Vessels), externally rubbing the Labor Palace, pushing through the Three Passes, massaging Tan Zhong, and point rubbing at Baihui, Zhongwan, Zusanli, Feishu (Lung Shu), Pishu (Spleen Shu), and Shenshu (Kidney Shu). Moxibustion is applied to the abdomen and spine manipulation is performed.

Each course of treatment includes 14 massage sessions, scheduled 2–3 times per week, with a total of three courses administered. The duration of each massage session be adjusted according to age: 20 min for preschool children (3–5 years) and 20–30 min for school-age children (6–9 years). Moreover, the duration should be adjusted appropriately based on the child's condition. Massage techniques, duration, and pressure are adjusted according to the child's symptoms and tolerance levels. Following the completion of the massage treatments, regular follow-up visits are scheduled over a period of six months.

Massage Standardization Protocol

Intensity and Frequency

Intensity: The core principle is to ensure the massage is within the child's tolerance level.

The technique should be “gentle but not superficial, firm but not forceful” meaning the applied pressure must be even—sufficient to stimulate the acupoints without causing pain or resistance.

Practitioners are instructed to monitor the child's response during the session: crying or physical resistance may indicate excessive force, while an absence of visible skin redness or sensation may suggest insufficient stimulation.

Frequency: Approximately 100–150 strokes per minute. Techniques such as linear or lateral pushing should be performed in a continuous and rhythmic manner using the finger pulp or palm surface, ensuring consistent pressure and avoiding abrupt speed changes.

Recommended session durations by age: Preschool children (3–5 years): 20 min, School-age children (6–9 years): 20–30 min. The duration may be adjusted based on the child's individual condition.

Therapist Training and Certification

Credentialing: Therapists must hold a Pediatric Tuina Practitioner Certificate issued by the National Administration of TCM. All practitioners must complete a standardized 60-hour in-house training program (40 h of theory + 20 h of hands-on practice) and pass a qualification exam with a score of $\geq 90\%$ before participating in the study.

Observational Indicators

- (1) Height, weight, BMI, GV (Growth Velocity), and TCM symptom scores.
- (2) Laboratory and imaging examinations: IGF-1 (Insulin-like Growth Factor-1), 25(OH)D (25-Hydroxyvitamin D), BA (Bone Age). IGF-1 and 25(OH)D levels were measured through standard laboratory blood tests, BA was assessed using hand and wrist X-ray imaging.

- (3) Safety indicators: Complete blood count, urine routine, liver and kidney function. Here, monitor adverse reactions during the study period, and if any discomfort occurs, immediately discontinue the intervention and provide symptomatic treatment.
- (4) Height was measured at baseline (prior to intervention), and again at 3 and 6 months after the start of the intervention. Other indicators were measured at baseline and after 6 months of intervention.

Efficacy Assessment

Western Medicine Efficacy Evaluation

In this retrospective study, the efficacy of treatment was assessed based on established clinical criteria recorded in the patients' medical files. The evaluation indicators are developed as follows:

- (1) Marked effect: Height increase of ≥ 1 SD or annual GV ≥ 6.5 cm.
- (2) Effective: Height increase of ≥ 0.5 SD but < 1 SD or annual GV of ≥ 5 cm but < 6.5 cm.
- (3) Ineffective: Height increase of < 0.5 SD or annual GV of < 5 cm or no significant growth. Annual growth velocity (AGV, cm/year) = [Height increase (cm)/Number of months] * 12

Total efficacy rate = (Number of cases with marked effect + Number of effective cases)/Total number of cases * 100%.

TCM Efficacy Evaluation

TCM was assessed based on symptom score records documented in accordance with the Guiding Principles for Clinical Research of New Chinese Medicines (Trial) issued by the State Administration of Traditional Chinese Medicine. The scoring criteria were as follows:²¹

Cure: Symptoms basically disappear, with a reduction in symptom score of $\geq 90\%$.

Marked effect: Symptoms significantly improved, with a reduction in symptom score of $\geq 65\%$ and $< 90\%$.

Effective: Symptoms somewhat improved, with a reduction in symptom score of $\geq 30\%$ and $< 65\%$.

Ineffective: No improvement in symptoms, with a reduction in symptom score of $< 30\%$.

The calculation formula (Nimodipine method) is: Reduction in score after treatment = (Pre-treatment score - post-treatment score)/Pre-treatment score * 100%.

Enzyme-Linked Immunosorbent Assay (ELISA)

Serum levels of cortisol, LH, and peak GH were measured based on laboratory test results recorded in the patients' medical records. All assays were originally performed using standardized ELISA kits according to manufacturer protocols at the time of treatment.

Statistical Methods

Experimental data are processed using the SPSS 27.0 statistical software. This study applied Bonferroni correction to all relevant statistical analyses. The Shapiro–Wilk test was used to assess the normality of data distribution for all continuous variables. Normally distributed quantitative data are compared using the *t*-test and expressed as $\bar{x} \pm s$, non-normally distributed quantitative data are compared using the rank sum test and expressed as M (P25, P75). Categorical data are compared using the chi-square (χ^2) test and expressed as percentages. A P-value of less than 0.05 indicates a statistically significant difference. For comparisons between two time points within the same group (eg, before treatment vs after treatment), paired *t*-tests were used for normally distributed variables, and Wilcoxon signed-rank tests were used for non-normally distributed variables. For comparisons involving three time points (eg, before treatment, 3 months later, and 6 months later), repeated measures ANOVA was applied for normally distributed data.

Table 3 Comparison of Weight and BMI Before and After Treatment ($\bar{x} \pm s$)

	Group	Before Treatment	After Treatment	t	P
Weight	Massage Group	18.62±3.66	19.94±3.38	12.94	<0.001 (****)
	Control Group	17.73±2.51	18.52±2.44	-7.089	<0.001 (****)
	t/P	1.178/0.243(ns)	2.004/0.049(*)	-	-
BMI	Massage Group	15.39±0.47	15.39±0.43	-0.03	0.976
	Control Group	15.35±0.28	15.48±0.50	-1.59	0.121
	t/P	0.422/0.674(ns)	0.838/0.405(ns)	-	-

Note: Significant differences between before and after treatment are marked with P < 0.05. ns means "no significance", * denotes P<0.05, **** denotes P<0.0001.

Abbreviation: BMI, Body mass index.

Results

Comparison of Height, Weight, and BMI After Treatment

After treatment, the height, weight, and BMI of children in both groups were confirmed to follow a normal distribution both before and after intervention. A *t*-test revealed significant improvements in height and weight in both groups post-treatment. As illustrated in Table 3, Figure 1A and B, 6-month mark as the primary post-treatment endpoint, children who received massage therapy exhibited greater improvements in height and weight compared to the control group. Moreover, no significant changes in BMI were observed (Table 3 and Figure 1C), which suggested that massage therapy supports balanced growth without causing excessive or unhealthy weight gain.

Comparison of BA and BAI After Treatment

Upon examination, the BA and BAI levels of children in both groups were found to follow a normal distribution before and after treatment. According to Table 4, significant differences were observed in both BA and BAI after massage therapy. Despite variability in BA within the control group, the BAI showed no significant changes. Figure 2A illustrates that the BAI in the massage therapy group significantly increased compared to the control group.

Comparison of IGF-1, 25(OH)D, and GV After Treatment

Upon examination, the IGF-1, 25(OH)D and GV levels of children in both groups were found to follow a normal distribution before and after treatment. In contrast, GV did not conform to a normal distribution, so a rank-sum test was

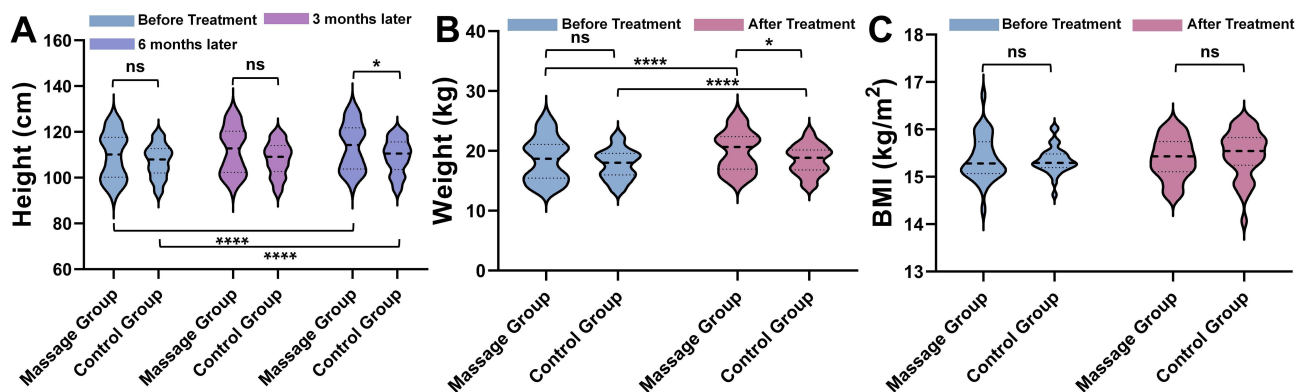


Figure 1 Comparison of Height, Weight, and BMI between the two groups before and after treatment. (A) Height at baseline, 3 months, and 6 months after treatment. (B) Weight. (C) BMI. Statistical analysis was performed using repeated measures ANOVA and Student's *t*-test. Data are presented as mean ± SD. Significant differences between before and after treatment are marked with P < 0.05. ns means "no significance", * denotes P < 0.05, **** denotes P < 0.0001.

Table 4 Comparison of BA and BAI Before and After Treatment ($\bar{x} \pm s$)

	Group	Before Treatment	After Treatment	t	P
BA (years)	Massage Group	5.53±1.75	6.25±1.71	18.88	<0.001(***)
	Control Group	5.45±1.29	6.08±1.29	32.36	<0.001(***)
	t/P	0.198/0.844(ns)	0.460/0.088(ns)	–	–
BA/CA (BAI)	Massage Group	0.95±0.05	0.97±0.04	2.874	0.007(**)
	Control Group	0.94±0.05	0.95±0.04	2.351	0.024(*)
	t/P	0.74/0.63(ns)	2.514/0.014 (*)	–	–

Note: Significant differences between before and after treatment are marked with $P < 0.05$. ns means “no significance”, * denotes $P < 0.05$, ** denotes $P < 0.01$, *** denotes $P < 0.001$.

Abbreviations: BA, Bone age; BAI, Bone age index.

used. Children after receiving massage therapy improved in both groups compared to baseline, with the massage group achieving significantly greater improvements in GV (Table 5) and IGF-1 (Table 6 and Figure 2B) level. IGF-1 is a key biomarker that promotes the growth of bones and soft tissues. Massage therapy significantly increased IGF-1 levels, suggesting that massage may enhance children’s growth potential by stimulating the secretion or utilization of IGF-1. Both groups showed an increase in 25(OH)D levels (Table 6 and Figure 2C) before and after testing, with no significant differences between the groups.

TCM Symptom Scores

After examination, the TCM syndrome integral of children in both groups before and after treatment did not follow a normal distribution, necessitating the use of the rank sum test. Aside from lethargy, where improvements were comparable, the massage group demonstrated superior efficacy in all other aspects (Table 7 and Table 8), showing a more pronounced reduction in TCM symptom scores compared to the control group. As shown in Table 9, a significant difference in the effectiveness rate between the two groups further verifies the efficacy of massage therapy.

Comparison of Serum Cortisol, LH and GH Levels After Massage Treatment

To account for variations in serum cortisol levels at different times of the day, blood samples for all children were collected between 8:00 AM and 10:00 AM. Figure 3 illustrates that there were no significant differences in serum

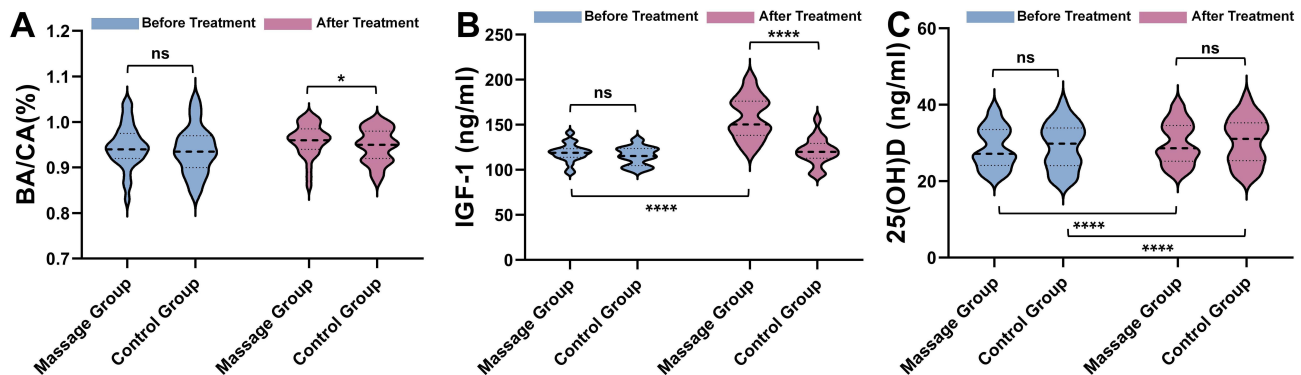


Figure 2 Comparison of BA/CA (BAI), IGF-1, and 25(OH)D between the two groups before and after treatment. (A) BAI. (B) IGF-1. (C) 25(OH)D. Statistical analysis was performed using Student’s *t*-test. Data are presented as mean ± SD. Significant differences between before and after treatment are marked with $P < 0.05$. ns means “no significance”, * denotes $P < 0.05$, **** denotes $P < 0.0001$.

Table 5 Comparison of GV Between the Two Groups After Treatment ($\bar{x} \pm s$)

	GV	z	P
Massage Group	8.55(7.06,9.48)	-5.827	<0.001
Control Group	4.12(2.08,5.11)		

Note: Statistical analysis was performed using a rank-sum test.

Abbreviation: GV, Growth Velocity.

Table 6 Comparison of IGF-I and 25(OH)D Before and After Treatment ($\bar{x} \pm s$)

	Group	Before Treatment	After Treatment	t	P
IGF-I (ng/mL)	Massage Group	119.03±10.25	158.04±22.88	12.88	<0.0001 (****)
	Control Group	115.51±9.9	120.66±14.91	2.256	0.03 (*)
	t/P	1.431/0.8324(ns)	7.983/<0.0001 (****)	-	-
25(OH)D (ng/mL)	Massage Group	28.74±5.23	29.92±5.33	25.867	<0.0001 (****)
	Control Group	29.17±5.87	30.48±5.95	25.095	<0.0001 (****)
	t/P	0.315/0.754(ns)	0.409/0.684(ns)	-	-

Note: Significant differences between before and after treatment are marked with $P < 0.05$. ns means "no significance", **** denotes $P < 0.0001$.

Abbreviation: BMI, Body mass index.

Table 7 Comparison Between the Two Groups of TCM Syndrome Integral After Treatment (M [P25, P75])

	Massage Group	Control Group	z	P
Poor complexion	1(0,1)	1.5(1,2)	-4.99	<0.001
Lethargy	1(0,1)	1(0.25,2)	-1.350	0.177
Poor appetite	0(0,1)	2(1,2)	-5.523	<0.001
Poor sleep	1(0,1)	1(0,2)	-2.125	0.034
Spontaneous sweating	1(1,1)	1.5(1,2)	-2.529	0.011
Irregular bowel movements	0(0,1)	1(0,2)	-2.424	0.015
Pale tongue with white coating	1(0,1)	1(1,2)	-2.679	0.007
Total score of TCM symptoms	4(4,6)	8(7,10.75)	-6.117	<0.001

Table 8 Comparison of Two TCM Syndrome Groups After Treatment (M [P25, P75])

		Poor Complexion	Lethargy	Poor Appetite	Poor Sleep	Spontaneous Sweating	Irregular Bowel Movements	Pale Tongue with White Coating	Total Score of TCM Symptoms
Massage Group	Before	2(2,2)	2(2,2)	2(2,2)	1(1,2)	1(1,2)	1(1,2)	1(1,2)	12(11,12.5)
	After	1(0,1)	1(0,1)	0(0,1)	1(0,1)	1(1,1)	0(0,1)	1(0,1)	4(4,6)
Control Group	Before	2(2,2)	2(1.25,2)	2(1,2)	1(1,2)	1(1,2)	1(1,2)	1(1,2)	11(10,12)
	After	1.5(1,2)	1(0.25,2)	2(1,2)	1(0,2)	1.5(1,2)	1(0,2)	1(1,2)	8(7,10.75)

(Continued)

Table 8 (Continued).

	Poor Complexion	Lethargy	Poor Appetite	Poor Sleep	Spontaneous Sweating	Irregular Bowel Movements	Pale Tongue with White Coating	Total Score of TCM Symptoms
z/P Massage	-5.052	-4.362	-5.035	-4.894	-4.536	-4.823	-4.077	-5.034
	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
z/P Control	-2.837	-3.805	-2.055	-2.093	-1.468	-2.306	-2.043	-4.416
	0.005	<0.001	0.04	0.036	0.142	0.021	0.041	<0.001

Table 9 Comparison of Clinical Efficacy Between the Two Groups

Group	Number of Cases	Marked Effective	Effective	Ineffective	Effective-ness Rate	χ^2	P
Massage Group	33	19	13	1	96.97%	11.650	<0.001
Control Group	36	2	21	13	63.89%		

cortisol, LH, and GH levels between the groups prior to treatment. Compared to the control group, serum cortisol levels in the massage group were on the lower end of the normal range for children of this age group.

Discussion

From a Western medicine perspective, short stature is associated with growth hormone deficiency and also related to congenital genetic disorders.²² Previous study has shown that although growth hormone therapy is generally associated with minimal side effects,²³ many parents remain concerned about its safety.²⁴ TCM may serve as a complementary or alternative approach that alleviates parental concerns regarding treatment-related adverse effects. TCM offers its unique insights. With a history spanning thousands of years, TCM treatments exert direct effects on specific areas of the body while also indirectly modulating the nervous system and bodily fluids.^{25,26}

In TCM, children are often considered to have an inherently weak spleen due to their incomplete development. If postnatal care is inappropriate, the spleen’s function becomes abnormal, the muscles, limbs, and bones are not adequately nourished, leading to slow growth and development. At the same time, the lungs are delicate and easily injured by

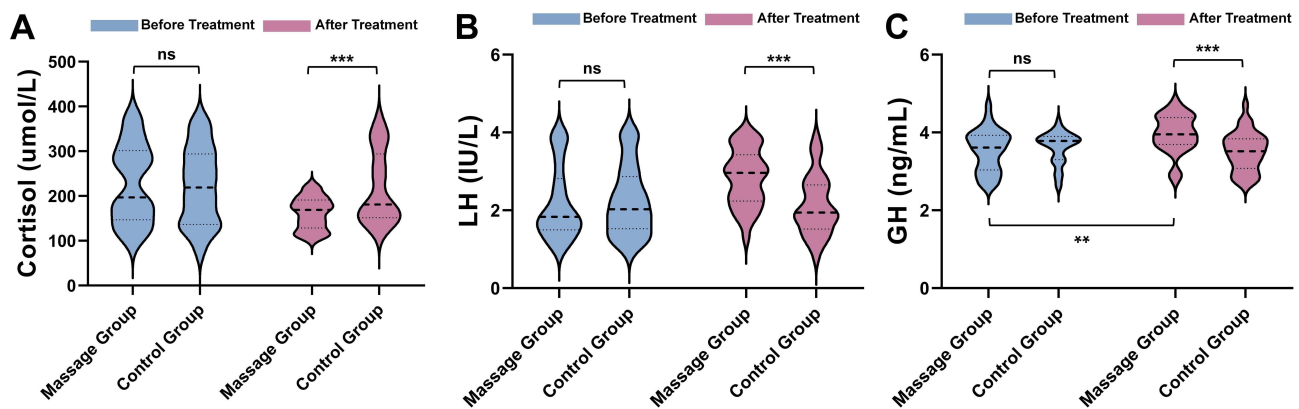


Figure 3 Comparison of Cortisol, LH, and GH between the two groups before and after treatment. (A) Cortisol. (B) LH. (C) GH. Statistical analysis was performed using Student’s t-test. Data are presented as mean \pm SD. Significant differences between before and after treatment are marked with P < 0.05. ns means “no significance”, ** denotes P < 0.01, *** denotes P < 0.001.

external pathogens. Children often have an excess of liver energy, which also affects the spleen's transformative function. Therefore, in this study, the pediatric massage techniques focus on strengthening the spleen, supplemented by regulating the lung, liver, and kidney, to achieve a balance of yin and yang, thus eliminating diseases on its own.

Massage, as a non-invasive treatment method, has significant advantages. Since it does not require medication or surgical intervention, it causes no harm to the skin, tissues, or organs, making it extremely safe, especially for children, the elderly, and individuals with weak constitutions.²⁷ By stimulating the body's meridians, acupoints, and muscle tissues, massage activates the body's self-regulatory and restorative abilities, improves blood and qi circulation, and balances yin and yang, aligning with the principles of natural therapy. At the same time, massage is simple to perform, easy to learn, and does not require complex equipment, making it highly acceptable to patients and convenient for application in a home setting.²⁷ This makes it an economical and accessible treatment option. Its ability to quickly relieve pain, relax muscles, and reduce fatigue has made it highly praised for improving physical comfort and enhancing quality of life.^{28,29} Furthermore, massage benefits not only the body but also promotes relaxation, reduces stress, improves mood, and helps alleviate anxiety and depression, playing a unique role in maintaining mental health.³⁰ Therefore, due to its safety, natural approach, convenience, and wide range of benefits, which may underlie the observed improvements in growth-related outcomes, massage has become an ideal auxiliary treatment and health management method.

As a key physiological indicator directly linked to height and development, the pathogenesis of dwarfism is primarily attributed to dysfunction of the growth hormone-insulin-like growth factor-1 (GH-IGF-1) axis and deficiencies in vitamin.^{31,32} IGF-1, a critical regulatory factor for bone, influences the proliferation and differentiation of osteoblasts.³³ Meanwhile, 25(OH)D, the predominant form of vitamin D in the human body, plays a vital role in calcium and phosphorus metabolism. Moreover, there is a positive correlation between 25(OH)D levels and height.³⁴ Deficiencies in either IGF-1 or 25(OH)D can significantly impact children's skeletal development to varying degrees.

The evaluation of serum cortisol, LH, and GH levels serves as a critical approach to understanding the physiological impacts of massage therapy, particularly its role in modulating stress responses and promoting growth and development in children. Cortisol, as a key biomarker of stress, reflects the activity of the hypothalamic-pituitary-adrenal (HPA) axis. Elevated cortisol levels are commonly associated with stress, while lower levels within the normal range suggest a reduction in stress and an improved state of physiological balance.²⁷ LH and GH, on the other hand, are central to growth and endocrine regulation. LH influences gonadal development and hormone production, while GH is essential for bone growth and metabolic functions, making these markers indispensable for assessing the therapeutic effects of massage in pediatric populations.^{35,36}

To ensure the validity of the research conclusions, we conducted statistical tests on the main baseline indicators (including height, weight, BMI, bone age, IGF-1, 25(OH)D, hormone levels, etc.) of the two groups before the intervention. **Table 1** showed that there were no statistically significant differences ($p > 0.05$), suggesting that the two groups were comparable before the treatment. Therefore, the significant improvement shown by the massage group after the treatment can be reasonably attributed to the intervention itself, rather than the initial differences. Our study demonstrated that pediatric massage combined with comprehensive management significantly improved serum IGF-1 and 25(OH)D levels in children, thereby promoting an increase in AGV. Both the height and weight of children in the massage group and the control group showed significant improvements after treatment, with the massage group exhibiting clear advantages over the control group. Similarly, the BAI, IGF-1, 25(OH)D, and GV of both groups improved significantly, with the massage group outperforming the control group in enhancing BAI, IGF-1 levels and GV. These results suggest that pediatric massage, when combined with comprehensive management, can effectively support height growth, weight gain, increased BAI, GV, and elevated serum IGF-1 levels in children with short stature. Additionally, post-treatment findings indicated that serum cortisol levels in the massage group were on the lower end of the normal range for children of this age, which aligns with previous reports.^{37,38} Additionally, massage was found to enhance the levels of LH and GH within the normal range for this age cohort.³⁷ This suggests that massage therapy may contribute to stress reduction by modulating cortisol levels. Moreover, massage was found to enhance LH and GH levels within the normal range for this age group, reflecting its potential to regulate endocrine function and promote growth-related hormonal activity. Although the BMI, and 25(OH)D levels of both groups increased after treatment, the

differences between the groups were not significant. These findings underscore the multifaceted benefits of pediatric massage as an adjunct therapy for promoting growth and development in children with short stature.

This study utilized a retrospective design, which still has non-negligible limitations. Retrospective study may be subject to selection bias, confounding factors, and variability in data completeness and quality. Our findings, while encouraging, should be interpreted with caution and need to be validated in future prospective studies. In addition, the relatively small sample size in this study may have limited its statistical power. Therefore, future studies with larger sample sizes and prospective randomized controlled trial (RCT) designs are warranted to further validate the reliability and generalizability of our findings.

Conclusion

This retrospective analysis suggests that pediatric massage, when combined with comprehensive management (including psychological health guidance, diet, sleep, exercise), may be a beneficial adjunct therapy for children with short stature. Our study highlighted the potential of pediatric massage, combined with comprehensive management, as a safe and effective adjunct therapy for managing short stature in children. This method may hold potential for future clinical application, particularly in pediatric endocrinology and TCM settings, which pending validation through prospective studies. Additionally, its non-invasive nature and long-term benefits suggest broader applications in preventive care and developmental support for children at risk of growth delays. Although retrospective studies have inherent limitations, they can still provide a valuable foundation for future prospective research.

In summary, the integration of pediatric massage with comprehensive management offers a proactive approach to mitigating the progression of existing conditions. This combination was associated with improvements in growth rate in children with short stature while improving their diet, sleep quality, and mental well-being. With its safety profile and benefits, this approach serves as a valuable reference for the clinical management of short stature and dwarfism.

Data Sharing Statement

The datasets for this article are not publicly available due to concerns regarding participant/patient anonymity. Requests to access the datasets should be directed to the corresponding author.

Ethics Statement

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethical Committee, Wuhu Hospital of Traditional Chinese Medicine (No. KY-2023-026). Informed consent was waived due to the study's retrospective nature, and all patient data were anonymized to maintain confidentiality throughout the research.

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We thank the patient and her parents for their cooperation in this study. All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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