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Analysis of the Efficacy of 3M Physical Therapy in Adolescent Female Patients with Hallux Valgus

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Abstract: *Objective:* To observe the clinical efficacy of safe and non-invasive 3M physical therapy on adolescent female patients with hallux valgus. *Methods:* From January 2024 to September 2025, 58 female hallux valgus patients aged 12–18 who received treatment at our hospital were selected and randomly divided into a treatment group and a control group, with 29 patients in each group. The treatment group received 3M physical therapy (including manual therapy, exercise therapy, and physical factor therapy); the control group received foot and toe function health education, requiring patients to improve their shoe-wearing and walking posture. After 8 weeks, hallux valgus angle (HVA), intermetatarsal angle (IMA), hallux valgus score American Orthopaedic Foot and Ankle Society (AO-FAS), and VAS scores were measured to evaluate rehabilitation effectiveness. *Results:* After 8 weeks, the VAS score in the control group was significantly lower compared to before treatment ($P < 0.05$); in the treatment group, HVA, IMA, and AO-FAS were significantly improved after 8 weeks compared to before treatment ($P < 0.05$), and the VAS score was decreased ($P < 0.01$); after 8 weeks of treatment, compared with the control group, HVA, IMA, and AO-FAS in the treatment group were significantly improved ($P < 0.05$), and the VAS score was decreased ($P < 0.01$). *Conclusion:* The application of 3M physical therapy in the treatment of adolescent female patients with hallux valgus can achieve significant therapeutic effects, significantly improve the hallux valgus angle, intermetatarsal angle, and pain, enhance the hallux valgus score level, and is suitable for the clinical rehabilitation treatment of adolescent female patients with hallux valgus.

Keywords: Hallux valgus; 3M physical therapy; Metatarsal

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1. Introduction

Hallux valgus is a common foot deformity primarily characterized by hallux valgus and subluxation or complete dislocation of the first metatarsophalangeal joint, with clinical manifestations including forefoot

pain, deformity, difficulty in wearing shoes, and functional impairment [1]. In clinical diagnosis, hallux valgus can be confirmed if the hallux valgus angle (HVA) exceeds 15° [2]. The incidence of this condition is significantly higher in females than in males, with a ratio of 15:1 for females to males [2]. Due to the deformity of the toes, pain, walking dysfunction, and abnormal gait, patients often experience significant physical and psychological stress. With the improvement of living standards and enhanced aesthetic awareness, an increasing number of adolescent females and their parents are actively seeking intervention due to the impact of hallux valgus on foot aesthetics and pain, a phenomenon that has garnered increasing attention in recent years. Although hallux valgus is not life-threatening, its impact on patients' daily quality of life cannot be overlooked. Currently, conservative clinical treatments for hallux valgus primarily focus on health education and orthotic appliances. However, health education content is often abstract, lacking systematic, quantitative training prescriptions and clear precautions, making it difficult for patients to effectively implement. Additionally, during the wearing of orthotic appliances, adolescent patients often experience poor compliance and significant discomfort, leading to suboptimal treatment outcomes and difficulty in achieving sustained improvement in deformities. Therefore, exploring a non-surgical therapy that is more operable, comprehensive, and acceptable to patients holds significant clinical importance.

3M physical therapy is a comprehensive rehabilitation intervention that integrates manual therapy, movement therapy, and modality therapy [3], aiming to correct hallux valgus deformities from both structural remodeling and functional reconstruction perspectives of the foot. This method has demonstrated favorable outcomes in the rehabilitation treatment of musculoskeletal system diseases. Currently, domestic clinical research on its application in hallux valgus treatment remains limited, particularly with insufficient evidence of its efficacy in adolescent females. Based on this, this study systematically evaluates the clinical efficacy of 3M physical therapy in improving hallux valgus in adolescent females, aiming to provide a scientific basis for clinical rehabilitation practice and lay the foundation for subsequent related research.

2. Materials and methods

2.1. Study subjects

A total of 58 adolescent females with hallux valgus who visited our hospital from January 2024 to September 2025 were selected as study subjects. They were randomly divided into a treatment group and a control group using a random number table method, with 29 cases in each group. The treatment group ranged in age from 12 to 18 years, with an average age of 13.83 ± 1.583; the control group ranged in age from 12 to 18 years, with an average age of 13.93 ± 1.668. There were no statistically significant differences in general information between the two groups ($P > 0.05$), indicating comparability and compliance with study requirements. All patients and their guardians thoroughly read and signed informed consent forms, voluntarily agreeing to receive treatment.

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Female patients with a disease duration of less than 3 years and aged between 12 and 18 years; (2) HVA ≥ 15°, intermetatarsal angle (IMA) ≥ 9°, Chippaux-Smirak index (CSI) > 45%, with the dominant foot included for observation; (3) Patients experiencing pain on the medial side of the toes but not affecting normal walking; (4) Patients and their guardians have no intention of undergoing surgery.

Exclusion criteria: (1) Individuals with leg length discrepancy, limping, or leg injuries that prevent

completion of the experiment; (2) Thumb deformities caused by fractures or other violent factors; (3) Hallux valgus deformities caused by other diseases such as clubfoot or foot hemangioma; (4) Patients with consciousness or comprehension disorders that prevent cooperation with treatment.

Exclusion and dropout criteria: (1) Failure to complete the full course of treatment as required due to subjective willingness or objective conditions; (2) Inability to tolerate treatment after the trial or the occurrence of adverse reactions during treatment; (3) Early withdrawal due to poor compliance or dissatisfaction with treatment outcomes, or loss of contact during follow-up (loss to follow-up).

2.3. Research methods

Both groups of patients maintained normal living environments, diets, and rest routines during the treatment period. The control group received health education on hallux valgus, with the following specific content:

(1) Patients were instructed to avoid prolonged local pressure on the toes during the trial period, and dance students (e.g., ballet) should cease relevant training.
(2) Avoid wearing pointed-toe shoes, high heels, overly tight canvas shoes, and flip-flops.
(3) Body weight should be controlled within the normal body mass index (BMI) range (18.5–23.9 kg/m²). For adolescent female patients who are overweight (24.0–27.9 kg/m²) or obese (≥28 kg/m²), they should be instructed to control their diet, engage in reasonable exercise, and be recommended aerobic exercises such as swimming.

The treatment group adopted 3M physical therapy on the basis of health education. For physical factor therapy, a low-frequency neuromuscular electrical stimulation therapy device (model: RH-SJSS-A) from Henan Ruihe Medical Equipment Co., Ltd. was used to provide electrical stimulation treatment to the abductor hallucis and peroneus longus muscles of patients. Manual therapy involved plucking and pressing the toe joints and adductor hallucis muscles, followed by the application of structural techniques to adjust the skin direction of the patients' lower limbs. Patients were placed in a prone position to release the quadriceps femoris, adjust the bone alignment of the feet, and reposition the talus. Exercise therapy involved comprehensive training of the intrinsic and extrinsic foot muscles: (1) Resistance training for ankle and toe flexion using elastic bands, including toe flexion and extension, ankle flexion and extension, and lateral ankle movements; (2) Training patients to use their hallux valgus toes to pick up objects such as small bamboo sticks, towels, and socks to exercise the functions of the extensor hallucis brevis and longus, abductor hallucis, flexor digitorum longus and brevis, dorsal interossei, and plantar fascia of the affected foot; (3) Modified TSO exercise training, which involved myofascial release along the direction of the peroneus longus muscle, followed by lifting all toes while keeping the metatarsal heads and heels on the floor. The little toe was placed on the ground first, then the big toe was pressed inward and downward, and finally, the fourth, third, and second toes were sequentially placed on the ground. Each exercise training session consisted of three sets of movements, with each set lasting for 3 minutes and a 1-minute rest between sets.

Both groups received treatment for 8 weeks.

2.4. Efficacy evaluation

The HVA, IMA, American Orthopaedic Foot and Ankle Society (AO-FAS) score, and pain level were compared between the control group and the treatment group before treatment and after 8 weeks of treatment.

AO-FAS score: It is an internationally recognized tool for evaluating foot and ankle function, encompassing three major dimensions: pain, function, and alignment, with a total score of 100 points. A

higher score indicates better function.

Pain level: The visual analogue scale (VAS) was used to assess patients' pain. It is a clinical assessment tool that quantifies pain intensity using a linear scale approximately 10 centimeters long, with "0 points" (painless) and "10 points" (excruciating pain) marked at both ends. Patients were asked to mark the corresponding position on the scale based on their subjective pain perception, and physicians measured the value at the marked point to obtain the pain score.

HVA: Measured using an anteroposterior radiograph of the foot, with a normal range of ≤15°. It represents the angle between the longitudinal axis of the first metatarsal bone and the longitudinal axis of the proximal phalanx, reflecting the degree of outward deviation of the big toe.

IMA: The angle between the longitudinal axes of the first and second metatarsal bones, with a normal range of ≤9°. An increased angle suggests metatarsus adductus.

2.5. Statistical analysis

All data were processed using SPSS 25.0 statistical software. Measurement data were expressed as mean ± standard deviation (SD). A normal distribution test was performed on the data. If the data conformed to a normal distribution, they were expressed as mean ± SD and analyzed using a *t*-test. If the data did not conform to a normal distribution, they were expressed as median and quartile points and analyzed using a rank-sum test. A P-value < 0.05 was considered statistically significant, and a P-value < 0.01 was considered highly statistically significant.

3. Results

There were no statistically significant differences in HVA, IMA, and AO-FAS scores between the control group before and after treatment ($P > 0.05$), while the VAS score significantly decreased after 8 weeks of treatment ($P < 0.05$). In the treatment group, after 8 weeks of treatment, HVA and IMA significantly decreased, the AO-FAS score increased ($P < 0.05$), and the VAS score significantly decreased ($P < 0.01$). There were no statistically significant differences in various indicators between the two groups before treatment ($P > 0.05$). After 8 weeks of treatment, the improvement in HVA, IMA, and AO-FAS scores in the treatment group was superior to that in the control group ($P < 0.05$), and the decrease in the VAS score was more significant ($P < 0.01$). See **Table 1**.

Table 1. Comparison of HVA, IMA, AO-FAS scores, and VAS scores in patients before and after treatment (mean ± SD)

Indicator	Before treatment	Before treatment	After 8 weeks	After 8 weeks
	Control group (n = 29)	Treatment group (n = 29)	Control group (n = 29)	Treatment group (n = 29)
HVA (degrees)	21.47 ± 4.44	21.98 ± 2.70	21.34 ± 4.56	16.94 ± 2.80$^{\circ\,\triangle}$
IMA angle (degrees)	11.23 ± 2.37	11.42 ± 1.13	11.17 ± 4.38	9.22 ± 3.24$^{\circ\,\triangle}$
AOFAS (points)	62.56 ± 9.79	64.89 ± 10.30	63.67 ± 9.78	79.22 ± 7.12$^{\circ\,\triangle}$
VAS score (points)	5.44 ± 1.42	5.33 ± 1.58	4.89 ± 1.27$^{\triangle}$	1.78 ± 1.20$^{\bullet\,\blacktriangle}$

Note: ○ indicates a comparison within each group before and after the experiment, with $P < 0.05$; ● indicates a comparison within each group before and after the experiment, with $P < 0.01$; △ indicates a comparison between the control group and the treatment group, with $P < 0.05$; ▲ indicates a comparison between the control group and the treatment group, with $P < 0.01$.

4. Discussion

The coordinated contraction of the intrinsic and extrinsic foot muscles is crucial for maintaining the dynamic stability of the foot arch. The tibialis anterior and tibialis posterior muscles maintain the height of the medial foot arch through traction, while the flexor digitorum longus, flexor hallucis longus, and intrinsic foot muscles work together to counteract the downward pressure and posterior tilt of the talus, preventing arch collapse [4–6]. When wearing inappropriate footwear for extended periods or having abnormal gait patterns, abnormal anterior displacement of plantar pressure can occur, leading to compensatory tension in the adductor hallucis and flexor hallucis brevis muscles, which in turn pulls the big toe outward, forming hallux valgus deformity. The skeletal and soft tissues of adolescents exhibit strong plasticity and respond better to physical stimuli than adults, providing a favorable physiological basis for conservative correction. However, research on non-surgical interventions for adolescent hallux valgus is relatively limited, with traditional conservative treatments focusing on passive measures such as health education and orthotic wear, lacking a systematic treatment regimen that actively corrects foot biomechanical imbalances. Therefore, exploring the efficacy of 3M physical therapy for treating adolescent hallux valgus holds significant clinical importance.

The results of this study show that after 8 weeks of 3M physical therapy intervention, the HVA and IMA significantly decreased, the AO-FAS score increased, and the VAS pain score significantly decreased ($P < 0.01$) in the treatment group of adolescent female patients with hallux valgus, while the control group only showed improvement in the VAS score ($P < 0.05$), with no significant changes in other indicators. After treatment, all indicators in the treatment group were significantly better than those in the control group ($P < 0.05$ or $P < 0.01$), indicating that 3M physical therapy has a definite corrective and analgesic effects on mild hallux valgus in adolescents. Compared to previous studies, the breakthrough of this study lies in: for the first time, integrating physical factor therapy, manual therapy, and exercise therapy into a systematic 3M physical therapy intervention regimen, focusing on adolescent females, a high-risk population. Firstly, physical factor therapy employs low-frequency electrical stimulation technology, precisely targeting the abductor hallucis and peroneus longus muscles. Electrical stimulation induces rhythmic muscle contractions, enhancing neuromuscular recruitment efficiency and improving muscle active contraction ability, thereby improving the dynamic motor function of hallux valgus [7]. Secondly, manual therapy focuses on the abductor hallucis muscle—the only intrinsic muscle on the medial side of the foot that directly counteracts hallux valgus deformity—effectively adjusting the positional relationship between the navicular bone and the first metatarsal bone, restoring the normal alignment and mechanical axis of the first metatarsophalangeal joint, and reducing abnormal stress at the medial bony prominence [8]. Finally, exercise therapy includes toe curling exercises, short foot exercises, and Tensor Fasciae Latae Strengthening Orthosis (TSO) exercises. Toe curling exercises activate the intrinsic plantar muscle group, short foot exercises emphasize actively shortening the foot arch length while keeping the heel and metatarsal heads grounded, and TSO exercises strengthen the eccentric and concentric control abilities of the intrinsic foot muscles through specific postures

and loads. These exercises work together to maximize the activation of the abductor hallucis muscle's active stability function [9]. The synergistic effect of the above 3M physical therapy can rebuild the balance between the intrinsic and extrinsic foot muscle groups, improve foot arch support, and thereby delay or partially correct deformity progression from a biomechanical perspective. The clinical guidance value of this study lies in: for mild hallux valgus patients with immature skeletons, a comprehensive conservative treatment regimen combining active muscle group training with passive manual therapy and physical factors should be prioritized, rather than passive deformity correction or premature consideration of surgical intervention. It is particularly emphasized that adolescent skeletons are not yet fully mature, and the epiphyseal plate still has growth potential, with the plasticity of foot soft tissues being superior to that of adults. Therefore, 3M physical therapy can leverage this physiological characteristic to guide the normal development of foot structure, holding significant early intervention value. Compared to previous studies, most conservative treatments only focus on a single aspect, such as using night splints or silicone toe separators alone, which can temporarily relieve symptoms but fail to fundamentally correct muscle imbalances and joint alignment abnormalities. This study systematically integrates three modules of comprehensive treatment, significantly improving the stability and sustainability of therapeutic effects.

5. Conclusion

This study holds definite clinical guidance value: specifically, in clinical practice, it is recommended to intervene 3–4 times a week, for 40–60 minutes each session, with 8 consecutive weeks as one course of treatment, while guiding patients to perform home exercise training (such as 20 short foot exercises and 50 toe curling exercises daily, holding each for 20 seconds) [10], and regularly re-measuring HVA, IMA, and functional scores. Of course, this study also has certain limitations, such as a relatively limited sample size and a follow-up period of only 8 weeks, with long-term efficacy and recurrence rates requiring longer-term tracking and observation. Future research can further explore the exercise prescription-effect relationship of 3M physical therapy and utilize objective means such as three-dimensional gait analysis and plantar pressure testing to deeply reveal its biomechanical regulatory mechanisms. In conclusion, 3M physical therapy provides a safe, effective, and sustainable innovative strategy for the conservative treatment of hallux valgus in adolescent females, worthy of promotion and application in clinical rehabilitation.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Yang J, Liang JB, Liang XJ, 2022, Advances in the Assessment and Surgical Treatment of Hallux Valgus Deformity. Chin J Orthop Trauma, 35(12): 1109–1115.

[2] Eustace S, O'Byrne J, Stack J, Stephens MM, 1993, Radiographic Features That Enable Assessment of First Metatarsal Rotation: The Role of Pronation in Hallux Valgus. Skeletal Radiol, 22(3): 153–156.

[3] Ding QS, Yan WG, Zhan LF, et al., 2024, Current Application Status of 3M Physical Therapy in Female Hypertonic Pelvic Floor Muscle Dysfunction. Med Recapitul, 30(10): 1205–1210.

[4] Wang HY, He YF, 2000, Mechanical Analysis of Transverse Arch Collapse in Hallux Valgus Feet. Chin J Orthop, (9): 94–95.

[5] Teven J, Lawrence N, Raymond D, 2004, Wright Posterior Tibial Tendon Dysfunction: Current Concepts Including Operative and Nonoperative Approaches. Curr Opin Orthop, 15(2): 62–68.

[6] Ehlivan O, Cilli F, Mahirogullari M, et al., 2012, Radiographic Correlation of Symptomatic and Asymptomatic Flexible Flatfoot in Young Male Adults. Int Orthop, 33(2): 47–50.

[7] Ikuta Y, Nakasa T, Nekomoto A, et al., 2024, Correction Effects of Peroneus Longus Contraction on Hallux Valgus Radiographic Parameters. J Orthop Sci, 29(4): 1026–1030.

[8] Hwang BH, Jeon IC, 2024, Comparison of Abductor Hallucis Muscle Activity in Subjects with Mild Hallux Valgus During Three Different Foot Exercises. J Back Musculoskelet Rehabil, 37(1): 47–54.

[9] Kim MH, Kwon OY, Kim SH, et al., 2013, Comparison of Muscle Activities of Abductor Hallucis and Adductor Hallucis Between the Short Foot and Toe-Spread-Out Exercises in Subjects with Mild Hallux Valgus. J Back Musculoskelet Rehabil, 26(2): 163–168.

[10] Yan XX, Yu Y, Jiang SY, et al., 2022, Current Research Status on the Assessment and Rehabilitation of Hallux Valgus in Children and Adolescents. J Med Postgrad, 35(1): 103–108.