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EFFECTS OF FOOT ORTHOSES AND KINESIO TAPE ON SPATIOTEMPORAL AND KINETIC GAIT PARAMETERS DURING RUNNING IN INDIVIDUALS WITH FLATFOOT

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ABSTRACT

Flatfoot is a common condition that influences gait and can cause discomfort for patients under higher loaded condition, such as running. Identifying the most effective treatment necessitates a comprehensive analysis of each therapy's impact on gait. Our research delved into the effects of Foot Orthosis and Kinesio Tape on the spatiotemporal and kinetic aspects of gait in individuals with flatfoot during running. Twenty female rearfoot strike runners with flatfoot participated in the running tasks at 3.3±5% m/s on the Zebris Medical GmbH treadmill. Gait data were collected under three conditions: shoe (A), shoe with Foot Orthoses (B), and shoe with Kinesio Tape (C). A one-way repeated measures ANOVA was employed to analyzed the gait parameters during the stance phase. Under conditions B and C, the foot rotation angle significantly decreased compared to condition A. Additionally, in condition B, it was significantly lower than in condition C. Under conditions B and C, the maximum force and pressure of forefoot significantly increased, whereas it in the midfoot significantly decreased, relative to condition A. Foot Orthosis and Kinesio Tape both effectively diminished peak midfoot pressure during running. Additionally, Foot Orthosis surpassed Kinesio Tape in enhancing foot stability and function throughout the running. These findings offered valuable insights for the selection of intervention measures for patients with flat feet during running.

Keywords: flatfoot, insole, tape, gait, running, biomechanics

1. INTRODUCTION

Flatfoot, also known as pes planus, is characterized by the collapse of the medial longitudinal arch, resulting in a flat appearance of the sole when standing. This condition can affect one or both feet and leads to various biomechanical changes, including eversion of the rearfoot and abduction of the forefoot when loaded. These alterations can significantly impact an individual's posture and motor mechanics[1]. Flatfoot often causes structural changes in the foot, leading to painful symptoms. One common issue is plantar fascia pain, which occurs due to increased stress on the thick band of tissue spanning the bottom of the foot caused by the collapsed arch. Additionally, the altered foot mechanics can place extra stress on the Achilles tendon, potentially leading to achilles tendonitis. The ligaments in the foot may also become overstretched or unstable, particularly during weight-bearing activities, contributing to overall joint laxity and instability[2]. This instability and associated pain often lead to rapid fatigue, limiting physical activity and endurance[3]. Medial instability can result in an uneven weight distribution, exacerbating foot discomfort and causing pain in the knees, hips, and lower back. These musculoskeletal pains arise as the body compensates for the uneven weight distribution and altered biomechanics caused by flatfoot[4].
There are several clinical interventions available for flatfoot, such as muscle strengthening, stretching, orthoses, manual therapy, and taping. Foot orthoses are widely recommended as they help to support the arch, realign foot structure, reduce pain, and improve stability[5]. Athletic taping is another effective method, as it helps to control excessive pronation by providing support to the medial arch and shifting foot pressure laterally[6]. However, the long-term effects of these interventions, particularly under high-load conditions like running, have not been thoroughly researched. Runners with flatfoot typically exhibit reduced forefoot

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pressure and increased midfoot pressure compared to those with a normal arch, indicating a greater risk of midfoot overuse and stress fracture[7,8].
To alleviate pain and enhance performance, adopting interventional strategies is pivotal. Identifying the most effective treatment necessitates a comprehensive analysis of each therapy's impact on gait. Therefore, our research focused on examining the effects of Foot Orthosis (FOs) and Kinesio Tape (KT) on the spatiotemporal and kinetic aspects of gait in individuals with flatfoot during running.

2. MATERIALS AND METHODS

2.1. Participants

For this study, we recruited 20 female amateur runners with flexible flatfoot. The participants had an average mass of 52.43±4.14 kg, a height of 165.14±3.55 cm, and an age of 24.29±3.46 years. The sample size was determined using G*Power 3.1 software, with an effect size of 0.25, a significance level of 0.05, and a power of 0.80. The arch height index (AHI) was calculated by dividing the dorsal height at 50% of the total foot length by the truncated foot length (heel to first metatarsal joint length). Measurements were taken while participants stood with equal weight distribution on two force plates. Participants were included if they had a navicular drop greater than 10 mm and an AHI of less than 0.31[9]. All participants were right-foot dominant. To control for gender differences, only female runners were included, and those with any significant injuries affecting walking were excluded. The study was approved by the Institutional Review Board of Ningbo University, and all participants were informed about the study's aims and procedures prior to data collection.

2.2. Trial condition

To capture spatiotemporal and kinetic gait parameters, we used an instrumented treadmill (HP Cosmos, Germany) equipped with a capacitance-based pressure platform (FDM-THQ, Zebris Medical GmbH, Germany). The treadmill was consistently set to a 0° incline for all tests. The Zebris FDM-THQ system has a capture surface of 1.70 × 0.65 meters, with an active sensing area of 1.36 × 0.64 meters, containing 10,240 sensors each measuring 0.85 × 0.85 cm. The sensor threshold was set at 1 N/cm^2, with a measuring range from 1 to 120 N/cm^2. Participants performed 30-step running tasks at a speed of 3.3 ± 5% m/s on the treadmill to collect spatiotemporal and kinetic gait data under three conditions: wearing shoes only (Condition A), shoes with foot orthoses (Condition B), and shoes with kinesio tape (Condition C) (Fig. 1)[10].

2.3. Data processing

Raw data from the Zebris FDM-THQ system were exported in XML format using the system's proprietary software. During the analysis phase, the initial 10 recorded steps were excluded to avoid any initial irregularities. The analysis focused on the next 20 steps, considering 10 steps per foot, to ensure accurate and consistent data evaluation[10].

2.4. Statistical analysis

The average data from 10 right-foot steps were used for statistical analysis. These analyses were conducted using SPSS 25[11]. A one-way repeated measures ANOVA was performed, with the significance level set at $p<0.05$. Post-hoc pairwise comparisons were carried out using a Bonferroni correction, with the adjusted significance level set at ($p/3 \leqslant 0.017$).

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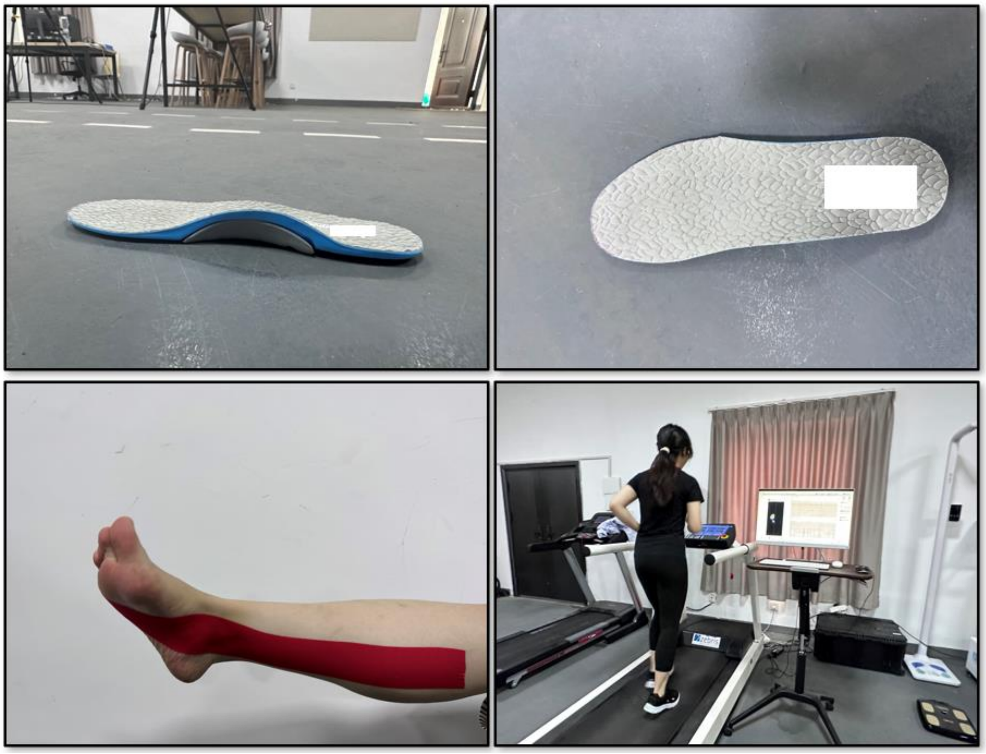

Figure 1. Trial condition

3. RESULTS AND DISCUSSION

Under condition B and C, the foot rotation angle significantly decreased compared to condition A. Additionally, in condition B, the foot rotation angle was significantly lower than in condition C. Furthermore, under conditions B and C, the maximum force and pressure in the forefoot significantly increased, whereas the peak pressure in the midfoot significantly decreased, relative to condition A (Tab. 1).

Table 1. Spatiotemporal and kinetic gait parameters under three conditions

Parameters	A(Shoe)	B(KT)	C(Fos)	F	P
Foot rotation angle (°)	**2.47±1.65**$^{a, b}$	**2.19±1.47**$^{a, c}$	**2.01±1.22**$^{b, c}$	**8.823**	**0.011**
Step length (cm)	97.85±5.62	97.55±4.96	97.14±5.08	0.843	0.373
Stride length (cm)	194.96±10.41	194.11±9.98	195.03±10.84	3.257	0.128
Step time (s)	0.32±0.04	0.31±0.05	0.30±0.03	0.684	0.421
Stride time (s)	0.64±0.08	0.65±0.18	0.64±0.07	2.651	0.077
Stance (%)	39.78±3.04	39.88±3.28	39.81±3.01	0.355	0.702
Swing (%)	60.95±6.23	60.98±6.44	60.88±6.09	0.572	0.562
Max Forefoot force (N)	**887.14±39.13**$^{a, b}$	**899.42±41.68**^{a}	**902.07±40.66**^{b}	**7.755**	**0.001**
Max midfoot (N)	**379.71±26.57**$^{a, b}$	**367.51±24.78**^{a}	**364.88±25.14**^{b}	**3.279**	**0.012**

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Max heel (N)	479.21±29.97	480.74±31.08	481.01±29.55	0.258	0.471
Max Forefoot pressure(N/cm^2)	**17.91±1.41$^{a, b}$**	**21.03±1.62^a**	**22.18±1.56^b**	**7.755**	**0.001**
Max midfoot pressure(N/cm^2)	**15.41±1.08$^{a, b}$**	**12.64±1.35^a**	**11.98±1.18^b**	**4.164**	**0.005**
Max heel pressure(N/cm^2)	17.90±1.12	17.94±1.02	18.00±1.11	0.462	0.241

Note: ^{a} represents the statistical difference between Control and KT; ^{b} represents the statistical difference between Control and Fos; ^{c} represents the statistical difference between KT and Fos.

Our findings indicated that the foot rotation angle significantly decreased under conditions B and C compared to condition A. Moreover, condition B exhibited a significantly lower foot rotation angle than condition C. This decrease in foot rotation angle might suggest an improvement in foot alignment and stability, which could be beneficial for reducing stress on the lower extremity joints. Similar results had been reported by Dahle, who found that reduced foot rotation angles were associated with lower incidences of overuse injuries in athletes[12].

Under conditions B and C, the maximum force and pressure in the forefoot significantly increased, while the peak pressure in the midfoot significantly decreased relative to condition A. This shift in pressure distribution might indicated a more effective load transfer mechanism, which could potentially enhanced propulsion during gait. According to Huang, an increased forefoot pressure was often associated with improved athletic performance due to better force application during push-off phases in running activities[13].

The significant decrease in midfoot peak pressure under conditions B and C might be indicative of improved arch support or foot orthotics effectiveness, which had been documented to reduce midfoot strain and distribute load more evenly across the foot[14]. The elastic recoil properties of Kinesio tape can support the foot arch while maintaining a certain range of mobility. Additionally, applying Kinesio tape along the muscle orientation may theoretically enhance muscle function for arch stabilization. This could be particularly beneficial for individuals with flat feet or those prone to plantar fasciitis, as it helped alleviate undue stress on the midfoot region.

The observed changes suggested that Fos and KT may enhance foot stability and efficiency, potentially lowering the risk of injury and improving overall foot function. Foot Orthosis surpassed KT in enhancing foot stability throughout the running. Future research should explore the long-term effects of these conditions on foot health and performance, including randomized controlled trials to confirm these findings and elucidate the underlying mechanisms. Additionally, studies could investigate the impact of these conditions on different populations, such as older adults or professional athletes, to determine their broader applicability.

4. CONCLUSIONS

FOs and KT both facilitated a more uniform redistribution of plantar pressure, effectively diminishing maximum force and pressure of midfoot during running. However, FOs surpassed KT in enhancing foot stability and function throughout the running. These findings offered valuable insights for the selection of intervention measures for patients with flat feet during running.

REFERENCES

[1] Chinpeerasathian C, Sin Oo P, Siriphorn A, Effect of foot orthoses on balance among individuals with flatfoot: A systematic review and meta-analysis, Plos one, 19 (3) (2024), pp. e0299446. https://doi.org/10.1371/journal.pone.0299446

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[2] Bertani A, Cappello A, Benedetti M, Simoncini L, Flat foot functional evaluation using pattern recognition of ground reaction data, Clinical Biomechanics, 14 (7) (1999), pp. 484-93. https://doi.org/10.1016/S0268-0033(98)90099-7
[3] Franco A, Pes cavus and pes planus: analyses and treatment, Physical therapy, 67 (5) (1987), pp. 688-94. https://doi.org/10.1093/ptj/67.5.688
[4] Herchenröder M, Wilfling D, Steinhäuser, Evidence for foot orthoses for adults with flatfoot: a systematic review, Journal of foot and ankle research, 14 (1) (2021), pp. 1-11. https://doi.org/10.1186/s13047-021-00499-z
[5] Banwell HA, Mackintosh S, Foot orthoses for adults with flexible pes planus: a systematic review, Journal of foot and ankle research, 7 (1) (2014), pp. 1-18. https://doi.org/10.1186/1757-1146-7-23
[6] Franettovich MM, Murley GS, David BS, A comparison of augmented low-Dye taping and ankle bracing on lower limb muscle activity during walking in adults with flat-arched foot posture, Journal of Science and Medicine in Sport, 15 (1) (2012), pp. 8-13. https://doi.org/10.1016/j.jsams.2011.05.009
[7] Siu W-S, Shih Y-F, Lin H, Effects of Kinesio tape on supporting medial foot arch in runners with functional flatfoot: a preliminary study, Research in Sports Medicine, 28 (2) (2020), pp. 68-80. https://doi.org/10.1080/15438627.2019.1638258
[8] Queen RM, Mall NA, Nunley JA, Differences in plantar loading between flat and normal feet during different athletic tasks, Gait & posture, 29 (4) (2009), pp. 10-18. https://doi.org/10.1016/j.gaitpost.2008.12.010
[9] Han K, Bae K, Levine N, Yang J, Biomechanical effect of foot orthoses on rearfoot motions and joint moment parameters in patients with flexible flatfoot, International medical journal of experimental and clinical research, 25 (1) (2019), pp. 15-20. https://doi.org/10.12659/MSM.918782
[10] Van Alsenoy K, Thomson A, Reliability and validity of the Zebris FDM-THQ instrumented treadmill during running trials, Sports biomechanics, 1 (1) (2018), pp. 1-9. https://doi.org/10.1080/14763141.2018.1452966
[11] Chen H, Shao E, Sun D, Xuan R, Effects of footwear with different longitudinal bending stiffness on biomechanical characteristics and muscular mechanics of lower limbs in adolescent runners, Frontiers in physiology, 1 (13) (2022), pp. e907016. https://doi.org/10.3389/fphys.2022.907016
[12] Dahle LK, Mueller M, Delitto A, Diamond J, Visual assessment of foot type and relationship of foot type to lower extremity injury, Journal of Orthopaedic & Sports Physical Therapy, 14 (2) (1991), pp. 10-17. https://www.jospt.org/doi/10.2519/jospt.1991.14.2.70
[13] Anbarian M, Esmaeili H, Effects of running-induced fatigue on plantar pressure distribution in novice runners with different foot types, Gait & posture, 48 (2) (2016), pp. 2-10. https://doi.org/10.1016/j.gaitpost.2016.04.029
[14] Aminian G, Safaeepour Z, Farhoodi M, Pezeshk AF, The effect of prefabricated and proprioceptive foot orthoses on plantar pressure distribution in patients with flexible flatfoot during walking, Prosthetics and orthotics international, 37 (3) (2013), pp. 27-32. https://doi.org/10.1177/0309364612461167

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