



Comparison between the effects of tibialis posterior versus fibularis longus Kinesio taping on foot posture, physical performance, and dynamic balance in young women with flexible flatfoot

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Received: 8 September 2022 / Accepted: 30 September 2022 / Published online: 6 December 2022
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Abstract

Purpose The purpose of the study is to compare the effectiveness of the tibialis posterior Kinesio taping and fibularis longus Kinesio taping on the foot posture, physical performance, and dynamic balance in young women with flexible flatfoot.

Methods Twenty-four subjects were recruited for the study. They were randomly divided into groups (A = 12, B = 12). In group A, Kinesio taping was applied on the tibialis posterior, and in group B, Kinesio taping was applied on the fibularis longus and remained for 30 min. Outcome measures were the navicular drop test (NDT), foot posture index (FPI), timed up and go (TUG) test, and Y-balance test. The pre- and post-treatment results were compared for each group; between-group differences were determined as well.

Results For group A, NDT, FPI, and TUG test changed significantly ($P=0.01$, $P=0.001$, $P=0.006$, respectively). For group B, the FPI score decreased ($P=0.03$), and the Y-balance test in the anterior direction improved significantly ($P=0.01$). Any variables have not shown a significant difference between groups ($P>0.05$).

Conclusion Kinesio taping of the tibialis posterior and fibularis longus can improve foot posture in young women with flexible flatfoot. Also, physical performance and dynamic balance improved by Kinesio taping of the tibialis posterior and the fibularis longus, respectively. In addition to the tibialis posterior, we found that the fibularis longus muscle can be considered a therapeutic target for managing flexible flatfoot in healthy young women.

Keywords Flatfoot · Kinesio tape · Posture · Physical performance

Introduction

Flatfoot, also referred to as “pes planus” or “pronated foot,” is a common orthopedic condition that consists of reduced height of the medial longitudinal arch (MLA), which absorbs shocks and provides stability during dynamic activities [1]. Approximately it is reported that 5–20% of different

populations, including healthy subjects and athletes, have this condition [2–4]. Two types of flatfoot are mentioned in scientific literature based on the consistency of the MLA: (1) flexible and (2) rigid. The MLA exists without weight-bearing in the flexible type, but it disappears under loading conditions, like standing. In the rigid type, there is no MLA with and without weight-bearing [5].

MLA is supported by both passive structures, like plantar fascia and plantar ligament, and active structures, like extrinsic and intrinsic foot muscles [6]. Several factors are considered causes of flexible flatfoot, such as ligamentous laxity, muscle weakness, obesity, bone deformity, and family history [7]. However, there is no consensus on the exact cause of this condition.

Flexible flatfoot predisposes to other conditions, such as low back pain, patellofemoral pain syndrome, Achilles tendinopathy, plantar fasciitis, medial tibial stress syndrome, and knee osteoarthritis [8, 9]; so, it would be essential to be considered in the assessment and causative management

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of these musculoskeletal conditions as well. Furthermore, healthy people and athletes should notice foot and ankle deformations like the flexible flatfoot to prevent daily and sports injuries.

Kinesio taping, an approach that has gained popularity in recent years among practitioners, is a noninvasive therapy that uses elastic bands with specific textures to treat, modify, and prevent numerous musculoskeletal conditions. Several mechanisms have been proposed to explain its effectiveness. From a neurophysiological perspective, it can increase the activation of mechanical skin receptors, leading to a reflexive contraction of muscle spindles and an increase in the sensitivity of motor units [10]. Moreover, it can increase the blood circulation of muscles by stimulating the autonomic system and inducing peripheral vasodilation [11].

According to previous studies, Kinesio tape can affect foot posture and muscle activity [12]; moreover, it can alter foot pressure, range of motion, and pain perception in people with flexible flatfoot [5, 13]. Previous studies have shown the positive effects of tibialis posterior (TP) facilitation on the foot posture and the dynamic balance in people with the flexible flatfoot [12, 14]. Moreover, in 2020, Sumal et al. stated that the fibularis longus (FL) tendon contributes to the MLA height, and physical therapy interventions targeting this muscle can lead to positive effects on the foot posture [6]; so, we hypothesized that using a facilitatory technique by means of Kinesio tape could result in the improved activity of these muscles. Also, it should be noted that some physiological characteristics, such as soft tissue flexibility, differ among genders, so it should be considered an influential factor in the results of therapeutic interventions on musculoskeletal deformities. Therefore, this study aims to compare the results of Kinesio taping of two important muscles of the foot, the tibialis posterior and fibularis longus, and their effects on foot posture, physical performance, and dynamic balance in young women with flexible flatfoot.

Materials and methods

Study design

This study is a single-blind, parallel-design, randomized clinical trial. It is approved by the ethics committee of Tehran University of Medical Sciences with the approval identification of IR.TUMS.MEDICINE.REC.1400.771 and is registered in the Iranian Registry of Clinical Trials with the registration code IRCT20211018052805N.

Participants

In this study, 24 women were included. The sample size was calculated using G*Power software. Power

was considered 85%, the alpha value was 0.05, and the effect size was estimated using foot posture index (FPI) measurements in previous studies [15]. Inclusion criteria were: (1) 18–40-year-old people; (2) navicular drop test (NDT) ≥ 10 mm; (3) foot posture index (FPI) $\geq +6$; (4) positive Jack's test; and (5) body mass index (BMI) ≤ 25 kg/m². Exclusion criteria were: (1) ankle injury in the last six months; (2) history of foot surgery; (3) foot injury due to systemic, inflammatory, and infectious diseases; (4) foot deformities including hallux valgus, hammer toe, and claw toe; (5) pregnancy; (6) ankle pain during the study; (7) static standing and walking problems; (8) Kinesio tape sensitivity; and (9) refuse to participate in the study or not adhering to treatment anymore. All subjects were informed about the study procedures and signed the consent form prior to the study (Fig. 1).

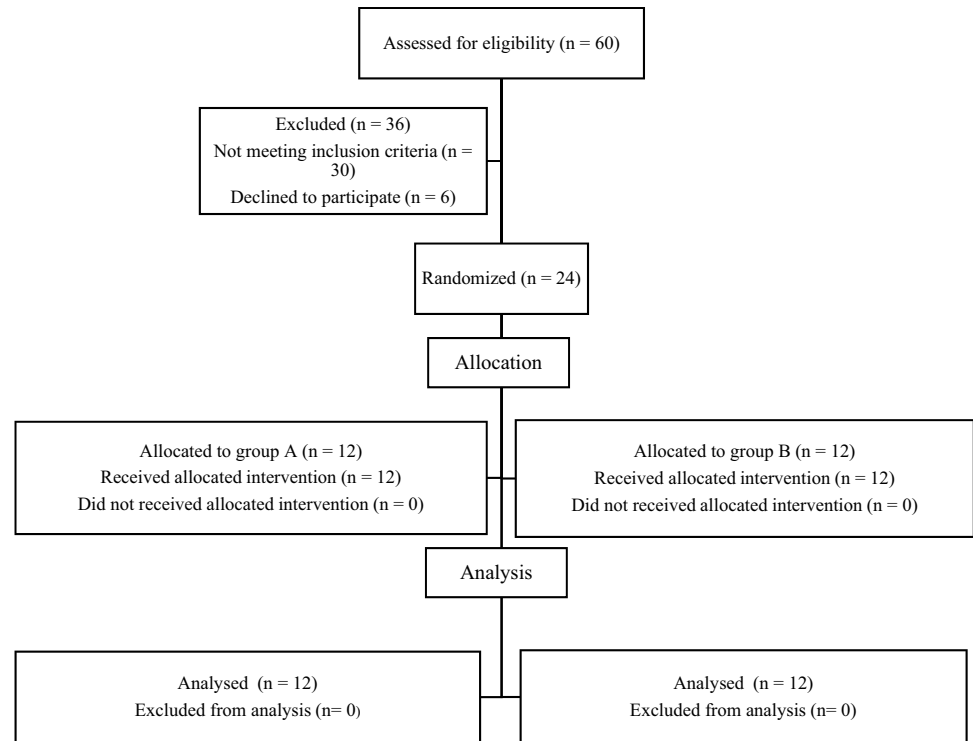
Assessment

Procedure

All of the subjects were asked to fill out a demographic questionnaire. Jack's test was used to determine the flexibility of the MLA [5]. Indeed, the type of the flatfoot was examined, while the assessor passively dorsiflexed the 1st metatarsophalangeal joint of the subject in a standing position. MLA was considered flexible if the curve appeared, so the test was positive. If the curve did not appear, it showed a rigid flatfoot, and the test was considered negative. Afterward, NDT and FPI were assessed, and the eligible subjects were included in the study. Next, they were asked to do a timed up and go (TUG) test for their physical performance assessment. Finally, subjects performed a Y-balance test to be assessed for their dynamic balance. Three trials were conducted with 2 min rest intervals between each trial. All of these assessments were reassessed 30 min after intervention. The left leg was selected for the assessments and intervention in all subjects to avoid selection bias [16].

Navicular drop test

For this test, the subject sat on a suitable chair with her hips and knees at 90°, both feet on the ground, and subtalar joint in a neutral position. Navicular tuberosity was found and marked with a removable marker. The assessor marked the height of navicular tuberosity from the ground on an index card. Then, they were asked to stand and put equal weight on both feet. Again, similar measurements were done [17]. The difference in navicular heights in both situations was measured using a ruler. This test was repeated three times, and the average value was calculated. NDT has shown good reliability and validity in previous studies [18].

Fig. 1 CONSORT flowchart of the participants

Foot posture index

A 6-item version of the foot posture index was used to assess foot posture while standing [19]. Foot postures are classified based on a scoring system for each portion of the foot from -2 to $+2$. Summation of the scores determines the type of the foot as pronated ($FPI \geq +6$), neutral ($0 \leq FPI \leq +5$), and supinated ($FPI < 0$). To determine, the subject was asked to stand with the arms at the side while looking straight-forward. The assessor scored each item using a specific checklist.

Timed up and go test

In this test, the subject stood from a suitable chair and began to walk three meters at a usual speed and then returned and walked through the chair and sat on it [20]. This time was recorded by a stopwatch.

Y-balance test

Dynamic balance is assessed with the Y-balance test [21]. First, the assessor showed the correct form of performing the tasks. Then, the subjects were asked to complete three maneuvers in each direction (anterior, posteromedial, and posterolateral direction) to avoid the learning effect. Next, three trials were conducted with 2-min rest intervals between them. If any of these errors have occurred, the test was repeated: (1) Subject was not able to stand on one leg; (2)

stance leg was moved; (3) reaching foot touched the ground due to loss of balance; and (4) subject could not return to the starting position. The average reaching distance was calculated in each direction, divided by limb length, and multiplied by one hundred (%). To measure the limb length, the subject lay supine. After correcting the pelvic position, a tape measure was placed from the anterior superior iliac spine (ASIS) to the most inferior part of the medial malleolus [14].

Randomization

Two concealed envelopes containing blue and red pieces of cardboard were placed in front of the subjects, and they were asked to choose one of them. If they chose the blue or red one, they were assigned to the tibialis posterior Kinesio taping group or the fibularis longus Kinesio taping group, respectively. Subjects were blinded to the group in which they would be allocated.

Intervention

Tibialis posterior Kinesio taping (group a)

For this purpose, the subject lay supine and actively dorsiflexed and everted her ankle. Kinesio tape was applied from half of the tibia bone, passing behind the medial malleolus, and finished at the head of the fifth metatarsal bone [12] (Fig. 2).



Fig. 2 Tibialis posterior Kinesio taping



Fig. 3 Fibularis longus Kinesio taping

Fibularis longus Kinesio taping (group b)

The subject was asked to lie supine and actively plantarflex and invert her ankle. Kinesio tape was applied from the head of the fibula, passing behind the lateral malleolus, and finished at the base of the first metatarsal bone [22] (Fig. 3).

Using a facilitatory technique, an I-shaped red piece of Kinesio tape (TEMTEX, South Korea) with 35 percent tension was used for both groups [23]. While the

subject had returned the muscle to the rest position, the anchor was applied without tension. Subjects rested in a comfortable position for 30 min [23, 24]. Afterward, they were reassessed. All assessments and interventions were performed by a single physiotherapist who was certified in the Kinesio tape method.

Statistical analysis

SPSS statistics version 24 was used for statistical analysis. The Kolmogorov–Smirnov test was used to assess the normal distribution of data. For intra-group comparison, paired samples T test and Wilcoxon test were used for parametric and nonparametric statistics, respectively. For intergroup comparison, independent T test and Mann–Whitney test were used for parametric and nonparametric statistics. The significance level (*P* value) was considered less than 0.05.

Results

Sixty participants were screened, and of them, 36 participants did not meet the inclusion criteria or were excluded. Finally, 24 participants were eligible and enrolled in the study. The subjects did not report any adverse effects during and after the study. The demographic characteristics of the subjects are shown in Table 1. The Kolmogorov–Smirnov (K-S) test showed that the distribution of the weight and BMI was not normal in group A ($P=0.03$, and $P=0.04$, respectively). Also, K-S test showed that the distribution of the NDT values was not normal in both groups ($P=0.01$ and $P=0.03$ for groups A and B, respectively), so we used the related nonparametric tests. There was no significant difference between the groups regarding the demographic characteristics ($P>0.05$). According to the results, NDT, FPI, and TUG test changed significantly in group A ($P=0.01$, $P=0.001$, $P=0.006$, respectively) (Table 2). For group B, the FPI score decreased ($P=0.03$), and the Y-balance test in the anterior direction improved significantly ($P=0.01$) (Table 2). Navicular drop decreased after the intervention in group B, but it was not statistically significant ($P=0.09$). Any variables have not shown a significant difference between groups (Table 3);

Table 1 Demographic characteristics in two groups

Variables	Group A ($n=12$)	Group B ($n=12$)	<i>P</i> value	<i>t</i> (<i>z</i>)	Power
Age (years)	22.25 ± 2.52	24.58 ± 6.02	0.23	− 1.23	0.23
Height (m)	1.63 ± 0.05	1.62 ± 0.04	0.68	0.41	0.08
Weight (kg) ^a	60 ± 6.98	59 ± 7.36	0.81	− 0.23	0.05
BMI (kg/m ²) ^a	22.42 ± 2.00	22.29 ± 2.46	0.86	− 0.17	0.03

Values are shown as mean ± standard deviation

^aFor weight and BMI, the Mann–Whitney test was used due to a lack of normal distribution

Table 2 Before–after comparison of variables in group A and group B

Variable	Group A					Group B						
	Before mean ±SD	After mean ±SD	t (z)	P value	Effect size	Power	Before mean ±SD	After mean ±SD	t (z)	P value	Effect size	Power
	NDT (mm)	10.96 ± 1.34	8.85 ± 2.03	- 2.39	0.01*	1.22	-	11.82 ± 2.39	10.35 ± 2.78	- 1.69	0.09	-
FPI	8.33 ± 1.30	6.50 ± 1.97	- 4.33	0.001*	1.09	-	8.33 ± 1.49	7.58 ± 1.62	- 2.46	0.03*	0.48	-
TUG (s)	10.32 ± 1.10	9.56 ± 1.02	- 3.43	0.006*	0.71	-	10.37 ± 1.34	9.85 ± 1.42	1.82	0.09	-	0.15
YBT (A) (%)	72.54 ± 7.16	72.90 ± 6.79	0.295	0.77	-	0.03	76.46 ± 6.62	79.52 ± 6.92	3.03	0.01*	0.45	-
YBT (PM) (%)	101.50 ± 15.21	100.90 ± 16.24	- 0.48	0.63	-	0.03	100.80 ± 7.13	103.85 ± 7.71	1.91	0.08	-	0.17
YBT (PL) (%)	88.91 ± 14.90	91.13 ± 16.55	1.65	0.12	-	0.05	87.79 ± 7.43	90.35 ± 8.92	1.52	0.15	-	0.12

SD standard deviation, NDT navicular drop test, FPI foot posture index, TUG timed up and go, YBT (A, PM, PL) Y-balance test (anterior, posteromedial, and posterolateral)

*For NDT, the Wilcoxon test was used due to a lack of normal distribution

* P < 0.05 is significant

however, FPI improved better in group A (P = 0.05, mean difference = - 1.08).

Discussion

The study investigated the immediate effects of Kinesio taping on two important muscles of the leg, the tibialis posterior and the fibularis longus. The results showed that the foot posture was improved in both groups, though the navicular drop decreased significantly just with the tibialis posterior Kinesio taping. This finding is consistent with the study of Siu et al. in 2019 on runners with flexible flatfoot [12]. They showed that the Kinesio taping of the TP and the transverse arch could immediately reduce the NDT. Since the TP activity provides dynamic stability for the MLA due to its line of action [25], it is possible that the increased activity of this muscle, and the following force generation capacity, is achievable as an immediate effect of Kinesio taping, and hence, we can expect the improved arch height. Moreover, since the TP Kinesio taping procedure passes over the medial side of the foot and covers the navicular bone, it is possible that it can provide mechanical support to the navicular bone and the MLA. However, in 2012, Roman et al. did not find any significant effect of TP Kinesio taping on rear foot pronation 24 h after the application, which questions the prolonged effect of TP Kinesio taping on foot posture [26]. In 2020, Sumal et al. stated that the fibularis longus tendon contributes to the MLA height, and physical therapy interventions targeting this muscle can lead to positive effects on foot posture [6]. Our results showed that the overall foot posture improved with FL Kinesio taping. Although there was no significant difference in FPI values between the two groups, the results were so close to being meaningful in favor of group A. Aguilar et al. in 2015 suggested that Kinesio taping using low-dye technique can lead to better result of FPI compared to the sham Kinesio taping in the pronated foot of amateur runners after 45 min of running [16]. It should be noticed that the mechanical correction of the low-dye technique was more than our method since it used 75% tension of Kinesio tape.

Y-balance test in the anterior direction increased significantly in group B. As an ankle evtor, the fibularis longus provides stability in the ankle joint [27], and it is a primary muscle for balance maintenance. Our findings were consistent with the results of Fereydounnia et al. in 2019 in which they investigated the effects of fibularis longus Kinesio taping on dynamic balance in soccer players with and without ankle instability [23]. They showed that Kinesio tape could immediately affect the dynamic balance of subjects. In 2016, Correia et al. found that the Kinesio taping of the FL has no immediate effect on the static balance in young healthy subjects, though the applied tension was

Table 3 Intergroup comparison of variables between groups A and B

Variable	Mean difference \pm SD (mean rank difference)	P value	t (z)	Confidence interval ^a (sum of ranks)		Power
				Lower	Upper	
NDT ^b (mm)	– 2.08	0.47	– 0.72	137.50	162.50	0.11
FPI	– 1.08 \pm 0.52	0.05	– 2.07	– 2.16	– 0.002	0.54
TUG (s)	– 0.23 \pm 0.35	0.52	– 0.65	– 0.97	0.51	0.10
YBT (A) (%)	– 2.69 \pm 1.59	0.10	– 1.68	– 6.00	0.61	0.39
YBT (PM) (%)	– 3.64 \pm 2.01	0.08	– 1.81	– 7.82	0.53	0.44
YBT (PL) (%)	– 0.33 \pm 2.15	0.87	– 0.15	– 4.80	4.12	0.04

SD standard deviation, NDT navicular drop test, FPI foot posture index, TUG timed up and go, YBT (A, PM, PL)Y-balance test (anterior, posteromedial, and posterolateral),

^a95% confidence interval of the difference

^bFor NDT, the Mann–Whitney test was used due to a lack of normal distribution

only 10%. Our study showed that the FL Kinesio taping with 30% tension can lead to better results in the dynamic balance [22]; however, it is unclear if there is a significant relationship between the static balance and dynamic balance with the same applied tension of the Kinesio tape.

The timed up and go test decreased significantly in group A; it might happen due to the improved support of MLA during the load transfer in the gait mechanism as a result of TP facilitation. Moreover, Siu et al. found that Kinesio taping of TP and transverse arch can increase the muscle activity of the tibialis anterior during running, which is an important muscle in the propulsion phase of locomotion [12, 28]. For group B, the result was not significant, which is consistent with the study of Fereydounnia et al. in 2021 on soccer players with and without ankle instability. In that study, Kinesio taping was applied in order to facilitate FL, and gait initiation parameters were measured with the force plate [29]. To our knowledge, it is the first study that has investigated the TUG test as a functional assessment for the physical performance of people with the flexible flatfoot.

EMG studies have shown the altered electromyographic activity of TP and FL in the gait mechanism of flatfoot people [30]. As mentioned before, several theories have been explained for the mechanisms of Kinesio tape effectiveness. It can increase blood flow through the autonomic system [11], facilitate muscle activity by increasing the sensory inputs of skin and joint receptors [10], and adjust the length–tension relationship and, subsequently, the force generation capacity of muscles [31]. All of these changes could lead to better function of the target muscles in this study.

To the authors' knowledge, it is the first study that investigated the effects of Kinesio taping on the fibularis longus muscle in flexible flatfoot, so this effect on the mentioned outcome measures can be further investigated in future studies. For example, it is suggested that the prolonged effects of FL Kinesio taping plus the comparison to the control group be addressed in future studies.

One limitation of our study is that the subjects were young females, and the results are limited to this population. Moreover, just immediate effects of the intervention were studied, and the long-term effects remained unclear. Also, the lack of the control group disabled us from deducing consistently from the present findings. Another limitation is the small sample size of the study. Due to the COVID-19 pandemic, it was not possible to enlarge the sample size.

Conclusion

Kinesio taping of the tibialis posterior can improve the foot posture and physical performance of young women with flexible flatfoot. Additionally, Kinesio taping of fibularis longus leads to promising results in the foot posture and dynamic balance in this population. No significant differences were shown between the two groups. In addition to the tibialis posterior, it is suggested that the fibularis longus muscle be considered a therapeutic target for the management of flexible flatfoot in healthy young women.

Acknowledgements The authors are grateful to the Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, for their support and the laboratory space and equipment. Also, the authors appreciate the participants' contribution to the study.

Author contributions Alireza Tahmasbi, Sara fereydounnia, Azadeh Shadmehr, and Behrouz Attarbashi Moghadam conceptualized the research. Azadeh Shadmehr and Sara Fereydounnia supervised the process. Alireza Tahmasbi gathered the data and wrote the main manuscript. Alireza Tahmasbi and Sara Fereydounnia analyzed the data. All authors reviewed and edited the manuscript. Azadeh Shadmehr managed the provided fund.

Funding This article is extracted from the MSc Dissertation of the first author in the Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, Iran (Grant: #1400-3-103-55363)

Data availability This study is original research, and data were collected from subjects via related procedures by the first author in the biomechanical laboratory of the Physical Therapy Department, School of Rehabilitation, Tehran University of Medical Sciences.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical approval This study was approved by the ethics committee of Tehran University of Medical Sciences with the approval identification of IR.TUMS.MEDICINE.REC.1400.771. It is also registered in the Iranian Registry of Clinical Trials with the registration code IRCT20211018052805N. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All subjects were informed about the study purpose and procedure and signed a consent form before the study.

References

- Birinci T, Demirbas SB (2017) Relationship between the mobility of medial longitudinal arch and postural control. *Acta Orthop Traumatol Turc* 51(3):233–237
- Bhoir T, Anap DB, Diwate A (2014) Prevalence of flat foot among 18–25 years old physiotherapy students: cross sectional study. *I J Basic Appl Med Res* 3(4):7
- Ganapathy A, Sadeesh T, Rao S (2015) Morphometric analysis of foot in young adult individuals. *W J Pharm Pharmaceutical Sci* 4(8):980–993
- Bhosale N, Nandala P (2021) Prevalence of flexible flat foot in athletes. *Kesari Mahratta Trust* 1(1):1–13
- Karthikeyan J, Singh K, Govind S, Mahalingam K, Vamsi S, Annamalai P et al (2020) To compare the effectiveness of taping and arch support on the flexible flat foot on a random population. *I J Forensic Med Toxicol* 14(4):7825
- Sumal AS, Jarvis GE, Norrish AR, Brassett C, Whitaker RH (2021) The role of the angle of the fibularis longus tendon in foot arch support. *Clin Anat* 34(4):651–658
- Atik A, Ozyurek S (2014) Flexible flatfootness. *North Clin Istanbul* 1(1):57
- Neal BS, Griffiths IB, Dowling GJ, Murley GS, Munteanu SE, Franettovich Smith MM et al (2014) Foot posture as a risk factor for lower limb overuse injury: a systematic review and meta-analysis. *Journal of foot and ankle research* 7(1):1–13
- Gross KD, Felson DT, Niu J, Hunter DJ, Guermazi A, Roemer FW et al (2011) Association of flat feet with knee pain and cartilage damage in older adults. *Arthritis Care Res* 63(7):937–944
- Oliveira AK, Borges DT, Lins CA, Cavalcanti RL, Macedo LB, Brasileiro JS (2016) Immediate effects of Kinesio Taping® on neuromuscular performance of quadriceps and balance in individuals submitted to anterior cruciate ligament reconstruction: a randomized clinical trial. *J Sci Med Sport* 19(1):2–6
- Gómez-Soriano J, Abián-Vicén J, Aparicio-García C, Ruiz-Lázaro P, Simón-Martínez C, Bravo-Esteban E et al (2014) The effects of Kinesio taping on muscle tone in healthy subjects: a double-blind, placebo-controlled crossover trial. *Man Ther* 19(2):131–136
- Siu W-S, Shih Y-F, Lin H-C (2020) Effects of kinesio tape on supporting medial foot arch in runners with functional flatfoot: a preliminary study. *Res Sports Med* 28(2):168–180
- Wang J-S, Um G-M, Choi J-H (2016) Immediate effects of kinematic taping on lower extremity muscle tone and stiffness in flexible flat feet. *J Phys Ther Sci* 28(4):1339–1342
- Alam F, Raza S, Moiz JA, Bhati P, Anwer S, Alghadir A (2019) Effects of selective strengthening of tibialis posterior and stretching of iliopsoas on navicular drop, dynamic balance, and lower limb muscle activity in pronated feet: a randomized clinical trial. *Phys Sportsmed* 47(3):301–311
- Unver B, Erdem EU, Akbas E (2019) Effects of short-foot exercises on foot posture, pain, disability, and plantar pressure in pes planus. *J Sport Rehabil* 29(4):436–440
- Aguilar MB, Abián-Vicén J, Halstead J, Gijón-Nogueron G (2016) Effectiveness of neuromuscular taping on pronated foot posture and walking plantar pressures in amateur runners. *J Sci Med Sport* 19(4):348–353
- Elataar FF, Abdelmajeed SF, Abdellatif NM, Mohammed MM (2020) Core muscles' endurance in flexible flatfeet: a cross-sectional study. *J Musculoskelet Neuronal Interact* 20(3):404
- Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urriale JA, Gómez-Conesa A (2018) Medial longitudinal arch: accuracy, reliability, and correlation between navicular drop test and footprint parameters. *J Manipulative Physiol Ther* 41(8):672–679
- Redmond AC, Crosbie J, Ouvrier RA (2006) Development and validation of a novel rating system for scoring standing foot posture: the foot posture index. *Clin Biomech* 21(1):89–98
- Larsson BA, Johansson L, Johansson H, Axelsson KF, Harvey N, Vandenput L et al (2021) The timed up and go test predicts fracture risk in older women independently of clinical risk factors and bone mineral density. *Osteoporos Int* 32(1):75–84
- Kim J-a, Lim O-b, Yi C-h (2015) Difference in static and dynamic stability between flexible flatfeet and neutral feet. *Gait Posture* 41(2):546–550
- Correia C, Lopes S, Gonçalves R, Torres R, Pinho F, Gonçalves P et al (2016) Kinesiology taping does not change fibularis longus latency time and postural sway. *J Bodyw Mov Ther* 20(1):132–138
- Fereydounnia S, Shadmeh A, Moghadam BA, Moghadam ST, Mir SM, Salemi S et al (2019) Improvements in strength and functional performance after kinesio taping in semi-professional male soccer players with and without functional ankle instability. *Foot* 41:12–18
- Lemos TV, Pereira KC, Protássio CC, Lucas LB, Matheus JPC (2015) The effect of Kinesio Taping on handgrip strength. *J Phys Ther Sci* 27(3):567–570
- Willeger M, Seyidova N, Schuh R, Windhager R, Hirtler L (2020) The tibialis posterior tendon footprint: an anatomical dissection study. *J Foot Ankle Res* 13(1):1–7
- Román MF, Méndez AC, Cabello MA (2012) Effects of treatment with Kinesio Tape for flat feet. *Fisioterapia* 34(1):11–15
- Sarvestan J, Ataabadi PA, Svoboda Z, Kovačikova Z, Needle AR (2020) The effect of ankle Kinesio™ taping on ankle joint biomechanics during unilateral balance status among collegiate athletes with chronic ankle sprain. *Phys Ther Sport* 45:161–167
- Lee H-S, Lee J-H, Kim H-S (2019) Activities of ankle muscles during gait analyzed by simulation using the human musculoskeletal model. *J Exerc Rehabil* 15(2):229
- Fereydounnia S, Shadmeh A, Moghadam BA, Moghadam ST, Mir SM, Salemi P et al (2021) The effects of lower extremity kinesio taping on temporal and spatial parameters of gait initiation in semi-professional soccer players with and without functional ankle instability. *J Mod Rehabil* 15(4):253–264
- Murley GS, Menz HB, Landorf KB (2009) Foot posture influences the electromyographic activity of selected lower limb muscles during gait. *J Foot Ankle Res* 2(1):1–9
- Csapo R, Alegre LM (2015) Effects of kinesio® taping on skeletal muscle strength—a meta-analysis of current evidence. *J Sci Med Sport* 18(4):450–456

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