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Immediate effects of soft tissue mobilization and percussive massage on balance in young adults with pes planus: A single blind, randomized controlled pilot study

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A R T I C L E I N F O

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A B S T A R C T

Background: Presence of pes planus is known to effect balance. In this study, it was aimed to examine the immediate effects of IASTM and PMT on static and dynamic balance in young adults with pes planus.
Method: The navicular drop test was used to diagnose pes planus. 51 individuals were included in the study and divided into three groups [IASTM (n:15), percussive massage (n:18) and control (n:18) groups] by simple randomization. Flamingo and Y Balance test was assessed before and immediately after intervention. Repeated Measures ANOVA test was used for the intergroup comparison, and the One-Way ANOVA test was used for the intragroup comparison, also post-hoc test with Tukey correction was performed.
Results: There was no significant difference in static balance between the three groups ($p > 0.05$). There was a significant difference in dynamic balance between groups ($p < 0.05$). Only IASTM group had significant differences at before and after intervention of all directions except for posterolateral direction of Y Balance Test ($p < 0.05$).
Conclusion: IASTM applied to the plantar fascia of individuals with pes planus have immediate effects on dynamic balance when compared to no intervention and percussive massage even within a small sample size.

1. Introduction

The plantar fascia consists of fibrous connective tissue that separates, supports, and binds the intrinsic and extrinsic muscles of the foot (Bourne et al., 2023). While it is exposed to different loads in each phase of the gait, it provides shock absorption by distributing the loads in a balanced, soft and supportive way (Kelly et al., 2018). Thus, it protects the sole of the foot from trauma, supports and stabilizes the arches of the feet (Bourne et al., 2023). While the medial longitudinal arch (MLA) is actively supported by the intrinsic and extrinsic muscles of the foot, it is considered to be more supported by passive structures such as the plantar fascia and plantar ligament (Taş et al., 2018). The plantar fascia is the most important stabilizer of the MLA, especially in the stance phase of the gait cycle (Bordoni et al., 2023; Bourne et al., 2023).

Foot deformity that occurs with the falling or flattening of the MLA is called pes planus (Raj et al., 2023). Pes planus is a foot deformity that affects 13.6%–26.6% of the adult population, and is more common in women than men, and its incidence increases with age (Aenumulapalli et al., 2017; Hagedorn et al., 2013; Pita-Fernandez et al., 2017). This deformity associated with use of high heels, excessive protonation of the foot, excessive tension in the triceps surae, obesity, posterior tibial tendon dysfunction, ligament laxity in the plantar fascia or other supporting plantar ligaments (Hagedorn et al., 2013; Khan et al., 2020; Nozaki et al., 2020; Raj et al., 2023).

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Presence of pes planus can change the biomechanics of the lower extremity and lumbar spine (Aenumulapalli et al., 2017). The plantar pressure distribution shifts to the medial side and the MLA peak pressure increases (Buldt et al., 2018). In addition, the abductor hallucis muscle thickens, the tension of the plantar fascia, Achilles tendon and plantar ligaments increases (Bourne et al., 2023; Raj et al., 2023; Taş et al., 2018). It is known that these changes in individuals with pes planus cause sensory-motor input differences, which negatively affects both static and dynamic balance (Dikici and Demirdel, 2023; Tahmasebi et al., 2015).

Ankle strategy is the most common type of response developed by the body in response to imbalances in the anterior-posterior direction. This strategy aims to maintain normal movement patterns and balanced posture by shifting the body center of gravity against internal or external factors (perturbations) that cause balance to deteriorate. This goal is achieved by moving the body around the ankle, together with support from other areas such as the hip and knee joints. To effectively implement the ankle strategy, the ankle joint must have adequate range of motion and strength. This strategy functions as a single reverse swing, providing the necessary torque through the ankle while repositioning the body's center of gravity (Horak and Nashner 1986).

The ankle strategy activated during low-intensity imbalances is resistant to rotational movements and forces (Gatev et al., 1999). When backward perturbations cause the individual to turn forward, the center of gravity shifts backward and this primarily results in the activation of the front leg muscles (Shepherd and Shepherd-Barr, 2009). In the continuation of the ankle strategy, the dorsal hip and paraspinal muscles come into play. Contractions first begin in the dorsal muscles, then progress to the plantar flexor muscles and spread from distal to proximal. In standing and minimal movement situations, the ankle joint is used more in maintaining balance than the hip and knee joints. This shows that the ankle flexor/extensor and invertor/evertor muscles come to the fore as the main muscle groups, especially when minor perturbations occur (Winter, 1995; Aoyama et al., 2011).

Instrument Assisted Soft Tissue Mobilization (IASTM); is a myofascial technique derived from cross-friction massage, providing soft tissue mobilization and in practice, the instrument used may appear with different names depending on its material and shape (Kim et al., 2017). Using stainless steel tools designed for different parts of the body, the first step of healing is aimed by applying to fascia and soft tissue at angles of 30°–60°, aiming to induce a local inflammatory response. It has been observed that when applied to the plantar flexors and Achilles tendon, dorsiflexion increases, and ankle joint stiffness decreases (Ikeda et al., 2019). IASTM also helps to dissolve adhesions in the fascia and correct collagen alignment, thus increasing flexibility in the foot. With this feature, it is also offered as the first choice in the treatment of pronated feet (Gupta et al., 2023).

Percussive Massage Technique (PMT) is a technique that combines traditional massage with vibration technique, based on the rapid and repetitive application of pressure perpendicular to the body to evoke neurological and physiological responses (Skinner et al., 2023). Studies explaining the effects on muscle strength and range of motion (ROM) have indicated that the pressure and friction created in these techniques can alter viscosity, change muscle stiffness, and increase blood flow, among other mechanisms, leading to the observed benefits (Konrad et al., 2020). Although there are studies regarding pain reduction, increased blood flow, post-exercise muscle soreness and the effects on ROM, it has been noted in the literature that there is a need for more studies explaining the effects of PMT (Konrad et al., 2020; Macaulay et al., 2019; Trainer et al., 2022). These techniques have been proven to have positive effects on balance in both individuals with pes planus and healthy adults(Gupta et al., 2023; Kweon and Kim 2023; Menek and Menek 2024; Park et al., 2020)

In pes planus, which is characterized by a decrease in MLA height, the role of muscles supporting the MLA alongside the plantar fascia is significant, and it is necessary to investigate the effectiveness of interventions targeting these muscles in preventing lower extremity injuries (Okamura et al., 2020). However, there is no study examining the immediate effect of IASTM and PMT on balance in individuals with pes planus. In this study, it was aimed to examine the immediate effects of IASTM and PMT on static and dynamic balance in young adults with pes planus.

2. Material and methods

This study adhered to the Declaration of Helsinki principles, approved by Istanbul Gelişim University Ethics Committee dated February 25, 2022 and numbered 2022-05-36. This is a parallel randomized controlled pilot study following CONSORT Checklist Guidelines, conducted at Istanbul Gelişim University's Physical Therapy and Rehabilitation Laboratory with students from Istanbul Gelişim University Faculty of Health Sciences, from March 2022 to December 2022 (clinical trial registration number: NCT06037746). The inclusion criteria of the study were: volunteering for study participation, being between the ages of 18–25 and presence of pes planus according to the Navicular Drop Test (NDT). Presence of orthopedic conditions other than pes planus, having a history of lower extremity surgery, presence of neurological or rheumatological disorders, having a problem with vision or hearing and participating in regular physical activity (>150 min/week) were the exclusion criteria.

All participants enrolled to the study have filled an informed consent form and a general information form. Participants who met the study criteria (n:51) were allocated to the groups by simple randomization method and were first asked to choose an envelope from a bell jar containing papers numbered from 1 to 60 in closed opaque envelopes. Participants were placed in 3 groups according to the number in the envelope they drew. 1–20: IASTM Group (IAG), 21–40: Percussive Massage Group (PMG), 41–60: Control Group (CG). Total of 51 individuals (21.07 $\pm$ 2.01) with pes planus in the dominant foot were included in the study and randomly divided into groups as 15 in IAG, 18 in PMG and 18 in CG.

Participants' age, gender, height, body weight and body mass index were recorded by a general information form. Before application, primary outcome measures were assessed as dynamic and static balance. Assessment of the outcome measures were instantly repeated after the applications in the study groups. Measurements and evaluations (navicular drop, static and dynamic balance) were performed by 3 different specialist physiotherapists. The physiotherapist who administered the assessment was never changed. The assessors were blind to the groups in which the participants were placed. A physiotherapist who is an expert in manual therapy applied the interventions. Statistical analysis was undertaken by a separate researcher who was not involved in any part of the practical part of the study.

2.1. Navicular drop test

NDT was used to identify individuals eligible to participate in the study by calculating navicular height. This test involves measuring the difference in navicular height between a seated position without bearing foot weight and standing position with foot weight. Participants' navicular tubercle on both feet was marked while sitting barefoot on a chair. After aligning the navicular tubercle on a white card, participants were asked to stand up, putting full weight on the foot. The alignment of the navicular tubercle was marked again on the same card. The distance between the two marks in millimeters (mm) represented the navicular drop amount (Aenumulapalli et al., 2017). NDT was conducted three times on each extremity for each individual. Those with an NDT result of 10 mm or higher were included in the study.

2.2. Outcome measures

The static balance level of individuals was evaluated in the dominant extremities with the Flamingo Balance Test (FBT), which is a valid and reliable instrument. As stated in the literature, the number of times the individual fell or disrupted the test was recorded while trying to balance on one leg for 1 min on a 15 cm long, 4 cm wide wooden plate (see Fig. 1: a). The participant is instructed to place their bare foot on the plate, ensuring that the hip does not come into flexion, and to flex the knee of the free leg to 90° while placing their hands on the iliac crests. During this period, each time the test was stopped, the time was also stopped and the time was started again after the individual took the position again. The evaluation was repeated 3 times and the average value was recorded (Rami and Prabhakar 2018).

The dynamic balance level of individuals was evaluated in the dominant extremities with the Y Balance Test (YBT), which is a valid and reliable instrument. Participants were instructed to stand on one foot at the midpoint of the assembly and reach with the other foot in anterior, posteromedial, and posterolateral directions to touch the toe tip (see Fig. 1: b). This process was repeated three times for each direction, and the average distance in centimeters was recorded as the result (Gribble et al., 2013). The results obtained after YBT were normalized according to the leg lengths of the individuals (Reach Distance/Lower Limb Length) x 100) for statistical analysis.

2.3. Interventions

2.3.1. IASTM

The individual who were allocated to the IAG, were asked to lie in a prone position, flex the knee to 90° and release the ankle. The therapist was positioned next to the individual on the side to be treated. Vaseline was used to facilitate the sliding of IASTM instruments on the skin and not cause irritation. The application was performed on the entire plantar fascia for 10 min, employing longitudinal, vertical, and oblique directions. The instruments were positioned at a 45° angle to the skin (Kethüdaoğlu and Demirdel 2021).

2.3.2. Percussive massage

The individual who were allocated to the PMG, were asked to lie in a prone position, flex the knee to 90° and release the ankle. The therapist was positioned next to the individual on the side to be treated. Vaseline was used to help shape the tissues and to facilitate the sliding of the heads of the Percussive Massager on the skin. Application was made to the entire plantar fascia for 5 min in all directions by adjusting the 2nd level of 3 different levels of the device (Konrad et al., 2020).

The participants who were allocated to the CG, waited for 10 min, like the study groups' application time, without any additional evaluation after the first one, to prevent them from learning the evaluation methods.

2.4. Statistical analysis

SPSS 24 package program was used in the evaluation of the research. Demographic evaluation data were analyzed by frequency analysis. Since our study is a pilot study, power analysis was not conducted. The distribution of the data was evaluated with the Kolmogorov-Smirnov test and also the skewness and kurtosis values were taken into account. Considering the suitability of the data to normal distribution, the Repeated Measures ANOVA and One-Way ANOVA test were used for T1 and T2 comparison. Tukey correction was applied to test the significance of pairwise differences. A value of $p \leq 0.05$ was considered statistically significant.

3. Results

Total of 76 participants volunteered to participate in the study. All participants enrolled to the study have filled an informed consent form and a general information form. 25 participants were excluded because of not having pes planus in the initial stage of the assessments (see Fig. 2). A total of 51 individuals with pes planus in the dominant foot were included in the study.

The demographic characteristics of the individuals participating in the study are shown in Table 1. There was no difference between the groups in terms of demographic characteristics of the individuals participating in the study at baseline ($p > 0.05$) (see Table 2).

There was no statistically significant difference between the groups both before (T1) and after (T2) measurements of FBT ($p > 0.05$).

There was no significant difference between the groups in terms of YBT between T1 and T2 measurements ($p > 0.05$). However, in intragroup comparisons, a significant difference was found between groups in the measurements of all directions of YBT except for PL ($p < 0.05$).

Fig. 1. a) Flamingo Balance Test. b) Y Balance Test.

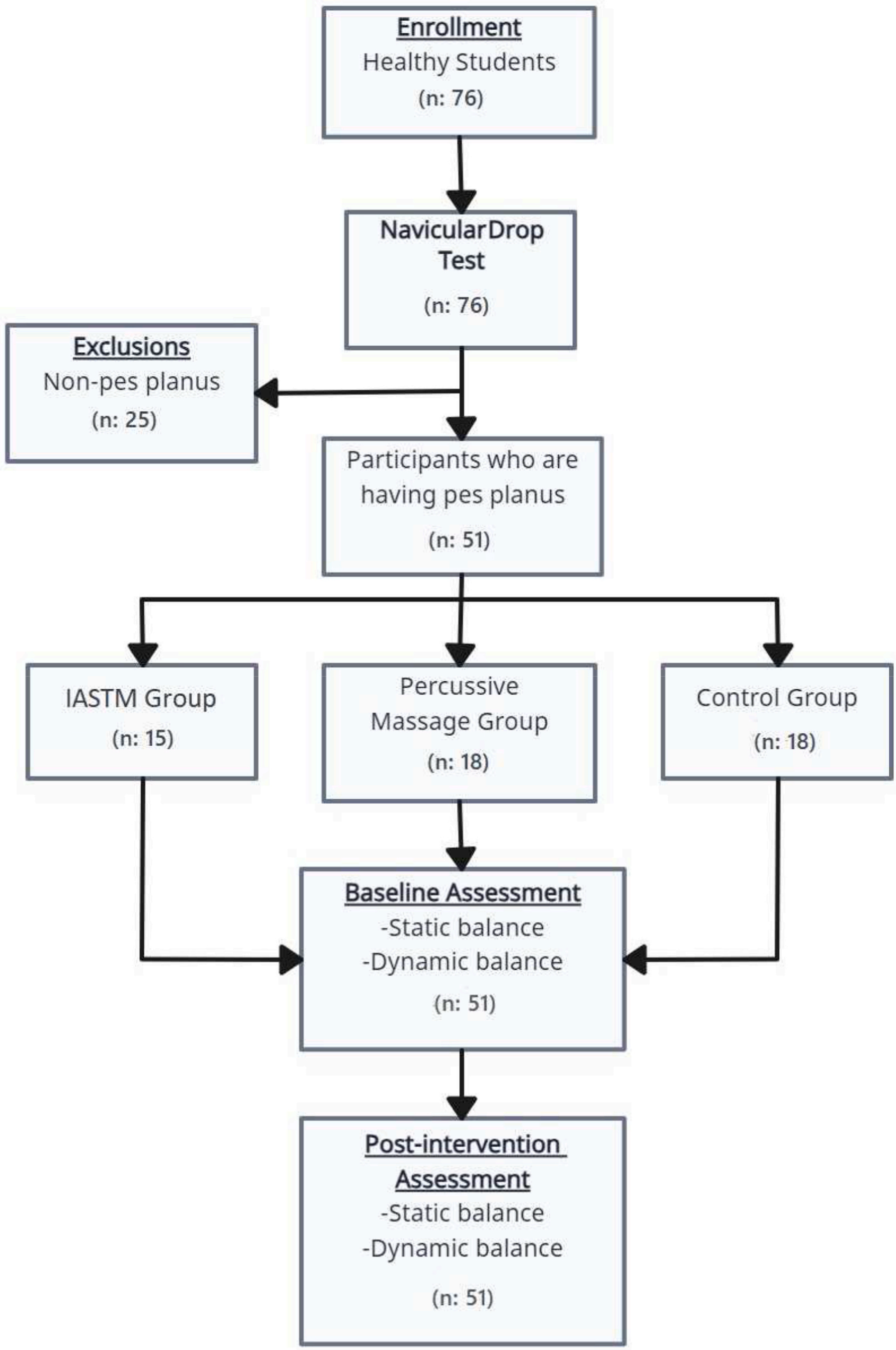

Fig. 2. Flow chart of the study.

Table 1
Demographic characteristics of participants.

	IASTM Group X ± SD (n = 15)	Percussive Massage group X ± SD (n = 18)	Control Group X ± SD (n = 18)	p
Age (year)	21.07 ± 2.01	21.50 ± 1.19	21.50 ± 1.65	0.775
Height (m)	1.66 ± 0.08	1.68 ± 0.1	1.68 ± 0.09	0.842
Weight (kg)	69.11 ± 16.85	57.57 ± 6.37	69.88 ± 18.31	0.385
BMI (kg/m^2)	23.88 ± 3.38	20.63 ± 2.50	25.38 ± 6.04	0.862

X: Mean, SD: Standard Deviation, IASTM: Instrument Assisted Soft Tissue Mobilization,p: One-Way ANOVA test.

Table 2
Static and dynamic balance test results.

	IASTM Group X ± SD (n = 15)	Percussive Massage group X ± SD (n = 18)	Control Group X ± SD (n = 18)	p^1	η^2
FBT (T1)	16.5 ± 5.17	16.3 ± 8.39	18.4 ± 5.88	0.525	
FBT (T2)	12.8 ± 5.74	12.2 ± 7.12	16.6 ± 6.52	0.122	
p^2	0.138				0.079
YBT-A (T1)	91.2 ± 17.47	82.3 ± 13.47	85.6 ± 11.18	0.549	
YBT-A (T2)	100.4 ± 22.69	91.5 ± 13.03	88.3 ± 9.99	0.170	
p^2	0.018*				0.157
YBT-PM (T1)	89.2 ± 19.84	86.1 ± 12.81	83.8 ± 12.92	0.603	
YBT-PM (T2)	99.4 ± 19.99	95.3 ± 12.42	87.2 ± 12.86	0.086	
p^2	0.039*				0.126
YBT-PL (T1)	84.5 ± 16.33	85.4 ± 12.11	81.6 ± 14.58	0.715	
YBT-PL (T2)	95.5 ± 18.22	93.7 ± 11.13	86.6 ± 14.63	0.186	
p^2	0.094				0.094

FBT: Flamingo Balance Test, YBT: Y Balance Test, T1: Pre-application evaluation, T2: Post-application evaluation, A: Anterior, PM: Postero-medial, PL: Postero-lateral, IASTM: Instrument Assisted Soft Tissue Mobilization, X: Mean, SD: Standard Deviation, **η^2: Effect Size,**p^1 One-Way ANOVA, Wallis Test, p^2 Repeated Measures ANOVA, *$p < 0.05$.

This difference was observed to originate from the IAG.

4. Discussion

In individuals with pes planus, balance issues are quite common due to both the reduced MLA and disruptions in proprioceptive inputs from the foot sole, as well as alterations in foot biomechanics (Kabak et al., 2019). In light of this information, this study investigated the immediate effects of IASTM and percussive massage on static and dynamic balance in young adults with pes planus. The application of the IASTM significantly improved dynamic balance immediately, whereas no improvement was observed with percussive massage technique (PMT) application.

IASTM stimulates the tissue healing process with microtraumas consciously created by manual or instrument assisted friction and can provide a mechanical effect. At the end of this healing process, restrictions and adhesions in the soft tissues can be removed. PMT, on the other hand, provides proprioceptive input by stimulating the Golgi tendon organ with the vibration it creates on the tissue (Kethüdaoğlu and Demirdel 2021). In our study, we attribute the fact that both static and dynamic balance were immediately improved in the IASTM Group, while this effect was not observed in the PG to this reason. We believe that the IASTM can exert a mechanical effect on the soft tissues, whereas the longer duration required for the effect in the PMG may be due to the provision of proprioceptive input. For this reason, while there was an improvement in the balance levels in the immediate measurements after the intervention in the IASTM Group, there was no immediate improvement in the PMG.

In the study of Kiran et al., including 30 plantar fasciitis patients, it is shown that 8 sessions of IASTM application significantly reduced heel pain and greatly improved foot functionality (Kiran et al., 2023). When it comes to functionality, ankle joint range of motion is known to have effects on postural control and balance (Basnett et al., 2013). Adequate ankle mobility affects balance positively. IASTM techniques are successful methods in eliminating joint movement limitations. Bush et al., have studied with 39 participants and showed that IASTM increased the dorsiflexion range of motion (Bush et al., 2020). Ankle dorsiflexion limitation is an issue that should be given priority in treatment, because it is one of the risk factors in plantar fascia injuries and also is a factor effecting balance.

When the literature is examined, although there are no studies on IASTM and percussive massage applied to the plantar soft tissues in patients with pes planus, there are studies supporting the results of this study regarding the balance outcome in other regions or different pathologies. In studies conducted on individuals with chronic ankle instabilities, 8 sessions of IASTM application did not create a significant difference compared to the control group but a positive change was observed in balance, pain and functionality parameters (Jordan 2015; Schaefer and Sandrey 2012). The authors attributed this to the fact that the participants had very little scar tissue and soft tissue adhesion at the ankle. It is known that deep friction massage can increase circulation and muscle flexibility (Bayer et al., 2023). Zhang et al. worked with 18 physically active participants, and applied 1 session of self-myofascial release with foam roller and massage ball to posterior lower extremity muscles. As a result of the study, it was shown that balance and flexibility parameters have increased (Zhang et al., 2020). Kweon and Kim applied manual myofascial release to one group and facial distortion to the other group in their study with 16 healthy individuals. They performed the applications from occiput to sacrum. Both groups showed improvement in balance control parameter (Kweon and Kim 2023). Soft tissue mobilization and massages can increase the circulation and temperature of both fascia and muscle tissue and decrease their viscosity. Because these kind of manual applications apply pressure to the tissue, they stimulate receptors such as Golgi, Pacini and Ruffini (Tozzi and Ost 2012). The pressure applied during the procedure can stimulate the mechanical receptors, which can improve the proprioceptive information after the application and thus helps to reach the balance state.

As a limitation of our study, while pes planus measurements can be made with more objective methods, it was done with the NDT as a result of the possibilities we have. It is important for the applicability of the study that all evaluation and application methods used in the study are inexpensive methods that can be easily integrated into clinical setting. On the other hand, since our work is a pilot study, a limited number of participants have been included and because of simple randomization method, the number of the participants allocated to the groups were not equal.

CRediT authorship contribution statement

Mustafa Oğuz Kethüdaoğlu: Writing – review & editing, Methodology, Conceptualization. **Ayşem Ecem Özdemir:** Investigation. **Öznur Kaya Sağlam:** Investigation. **Engin Çağlar:** Investigation. **Meltem Meran Çağlar:** Writing – original draft. **Gökhan Demir:** Resources, Formal analysis. **Tomris Duymaz:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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