Research Paper

# Immediate Effects of Kinesio and Dynamic Tapes on Postural Stability and Time to Stabilization in Women With Patellofemoral Pain Syndrome

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## ABSTRACT

**Purpose:** Patellofemoral pain syndrome (PFPS) is a common condition characterized by pain in the front of the knee. Patellar taping can be an effective intervention for reducing painful symptoms.

**Methods:** A total of 39 women with PFPS (aged 20-30 years) participated in this randomized crossover trial. The CoP oscillations during the single-leg stance test and TTS after descending the step were evaluated and recorded on three separate days under the following conditions: without tape (WT or control), with DT and with KT. This was done using a foot pressure measurement system. The data were analyzed using repeated measures analysis of variance with a significance level of $P \leq 0.05$.

**Results:** Comparing three different conditions demonstrated that the CoP sway, including the mediolateral and anteroposterior oscillations, sway area, path length, and average velocity of oscillations significantly decreased in the eyes-open and eyes-closed states during the DT condition as compared to the WT ($P<0.05$). Furthermore, the TTS significantly decreased in the DT condition compared to the WT ($P<0.001$) and KT ($P=0.007$) conditions. KT reduced CoP variables only in the EsC condition ($P<0.05$).

**Conclusion:** DT was more effective than KT and this intervention enhances postural control in women with PFPS. Given its positive effects, it is recommended that future research investigate the long-term impact of utilizing this intervention.

**Keywords:**
Anterior knee pain syndrome, Posture balance, Tape, Knee joint

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## Highlights

● Dynamic tape (DT) had a better immediate effect than kinesio tape (KT) on postural sway and time to stabilization (TTS) in women with patellofemoral pain syndrome (PFPS).

● KT was effective on postural fluctuations in women with PFPS.

● KT failed to shorten the TTS in women with PFPS.

## Plain Language Summary

As the patellofemoral joint is the least stable joint in the lower limbs, it experiences significant force (up to several times the body weight) during a wide range of movements involved in activities of daily living. PFPS is the most common knee disorder among young adults. It is often referred to as a black hole due to its unexplained nature, with no known surgical or therapeutic interventions to solve this dysfunction. Women have more knee joint laxity compared to men. This is also associated with lower proprioception in their joints, which can result in less stability, a higher risk of ligament and soft tissue damage, and loss of balance in women compared to men. One of the commonly used conservative treatments for PFPS is taping, which is considered to be more effective due to its various benefits. Kinesio tape is commonly used now; however, dynamic tape is relatively new and still less known. In this study, we compared the immediate effect of these two tapes, and the results showed that the dynamic tape was more useful for women with PFPS. Therefore, we suggest the immediate use of this type for women with PFPS and also recommend checking the long-term effects of using dynamic tape.

## Introduction

Patellofemoral pain syndrome (PFPS) refers to the pain in the patella (kneecap) or its surroundings induced by physical and biomechanical changes in the patellofemoral joint (PFJ), with an incidence rate of 15% to 25% [1]. Multiple causes have been documented for this condition to date, including patellar malalignment, joint stiffness, muscle imbalance around the knee extensors and joint overuse [2]. Of note, PFPS may lead to various complications, including impaired balance [3], which can result in an increased risk of slips and falls during activities of daily living, such as walking [4]. Maintaining balance is crucial for performing everyday tasks and sports activities independently, effectively, and without relying on others [5, 6]. On the other hand, controlling posture and maintaining static and dynamic balance are influenced by visual, vestibular, and proprioceptive systems [7]. Given that proprioception and balance are related to each other in adults [8], the former has been identified as the primary source in the sensory system for maintaining balance. Proprioception is also the leading afferent component of the motor system and an essential one in the motion control system. It significantly contributes to joint dynamics and prevents chronic injuries and degenerative joint diseases [9, 10].

As evidenced, impaired proprioception is typically seen in individuals with PFPS compared to healthy cases [11]. There is also a disorder in the proprioception of the knee joint on the affected side and a decrease in this regard on the unaffected side [12]. In addition, some changes in the movement patterns, such as walking velocity and reduced knee flexion angle in the static phase of the gait, have been reported so far [13]. Considering this, proprioception plays a crucial role in the movement of the lower limb joints, affecting both kinetic and kinematic parameters. Since neuromuscular control and coordination heavily rely on proprioceptive information from the body [14], enhancing these aspects in individuals with PFPS can improve their performance and speed up the rehabilitation process.

In this context, time to stabilization (TTS) refers to the person's ability to regain balance when transitioning from dynamic to static positions based on support [15]. It is an element of lower limb motor control, influenced by feedback from proprioceptive receptors, preprogrammed muscle activation patterns, and reflex muscle responses [16]. This index further contains the complex and coordinated efforts between the sensory and motor systems of the body, as well as the strong contraction chain of the muscles and auxiliary stabilizers in the lower limbs [17]. Therefore, examining the TTS provides much more information about the ability to reach postural control in the event of sudden changes from dynamic to static positions.

Various effective measures have been suggested to improve PFPS, including exercise therapy, muscular strengthening exercises, muscle stretching, electrotherapy, knee braces, and patellar taping [18]. Among them, taping comes in different types and is commonly used in various sports as well as clinical conditions to prevent and treat injuries, as well as to provide support to joints during movement [19, 20]. One of the most distinguished types of such tapes is the Kinesio tape (KT), produced by Kenzo Kase in 1973. This tape can be longitudinally extended up to 140% of its original length. It also creates fewer mechanical and motion restrictions than conventional ones, corrects joint dysfunction and supports muscles [21]. On the other hand, dynamic tape (DT) is being utilized to help patients recover. Compared to other tapes, the DT is a newly developed one with higher elasticity and multidirectional stretch to facilitate sensory input information and enhance proprioception, which, in previous research, was mentioned as its advantage [22]. Due to its elastic nature (tensile load capacity above 200%) and multidirectional stretch (lengthening in all directions) [18], DT as a biomechanical tape has been identified with some properties, such as speed reduction, load absorption, and effectiveness in movements in the original state [22]. It can also prevent many injuries by creating stable positions against high loads and impacts on the PFJ during activities of daily living.

In the research literature review, Kurt et al.'s study found that short-term use of KT was associated with improvements in joint position sense, pain, Kinesio-phobia, and daily limitations [1]. Additionally, Mastamand et al.'s study on the effect of KT on pain and balance in PFPS patients demonstrated that KT is an effective intervention for reducing pain and increasing balance in PFPS patients [23]. On the other hand, the results of Alahmari et al. showed that in people with chronic low back pain, the use of DT controls the processes that lead to back muscle fatigue [21]. Ha et al. (2020) found that applying DT reduced the load and impact on the PFJ during sports activities for participants with PFPS [24]. As DT is a relatively new form of intervention, it has been the subject of fewer research studies. This type of taping shows potential for helping patients with patellofemoral issues due to its associated benefits. Accordingly, this study compares the immediate effects of this taping method with Kinesio tape. If the results show positive effects, researchers can then assess its long-term impact in future studies. Therefore, this study investigates the immediate effects of KT and DT on post-landing task oscillations of the center of pressure (CoP) and time to stabilization (TTS). Our research hypothesis focuses on determining which tape would be more effective for individuals with PFPS based on these variables. The study's results could help choose the most effective taping method for individuals with PFPS.

## Materials and Methods

In this randomized crossover trial, 39 women with PFPS, aged 20-30 years were recruited voluntarily after meeting the inclusion criteria. Concerning the G*Power software, version 3.1 outputs, the sample size was then estimated to be 38 individuals, considering the effect size of 0.25, the test power of 0.80 and the significance level of 0.05 [25].

The study's inclusion criteria were as follows: Female gender, age between 20 and 30 years, experiencing knee pain while walking up and down stairs, kneeling and sitting for extended periods with bent knees, and having PFPS in the dominant leg. Additionally, the participants should have had no history of lower limb surgeries, traumas, or neurological, muscular and skeletal diseases, and they should have tested positive for the patellar apprehension test and Clarke test [1, 2, 26]. Moreover, if a participant did not attend the evaluation sessions, they were excluded from the study.

Before the evaluations, the participants received complete explanations about the research procedure and signed an informed consent form for voluntary participation in the study. All stages were conducted according to Helsinki's ethical considerations, The participants entered the study voluntarily, and data was strictly kept secret. Moreover, the participants were informed that they could withdraw from the research at any time without needing to explain.

### Study procedure and randomization

The session began by measuring the subjects' height, weight, and body mass index using a BSM370 stadiometer (InBody USA). The participants were evaluated over three separate days. At the beginning of each session, the subjects were randomly assigned to one of three conditions: Without tape (WT or control), KT (ARES Kinesio Tape, South Korea) and DT (United States). Randomization was done through a lottery at the start of each session by an individual not involved in the study, and the participants were unaware of this process. The evaluations included a single-leg stance test on the affected limb and walking down 30-cm stairs using a foot pressure measurement system (FDM-S, Zebris Medical GmbH, Germany). Each participant was evaluated three times under each condition. The maximum and minimum intervals between different test days were two and four, respectively [27].

## Taping

In the present study, two tapes of 10 and 15 cm were applied for taping purposes. At first, a 10-cm tape was affixed to the medial condyle of the femur, and the other end was attached to the lateral one from the apex of the patella. This tape was utilized to correct the patellar malalignment. Then, a 15-cm tape was connected to the midpoint of the medial and lateral condyle of the tibia. One end was pulled up upon passing the end of the medial broad muscle, and the second end was pulled up after passing the outer edge of the patella and the outer broad muscle. It was also stretched to cover the knee circumference (Figure 1). During this taping process, the knee had a 30-to-45-degree flexion angle [28, 29].

## Center of pressure oscillation recording

To assess the oscillations of the CoP in a static state, the participants stood barefoot on one leg (the taped leg) on the foot pressure measurement system plane. They were then instructed to place their hands on the iliac crest, bend the other leg at the knee and keep it raised, and maintain their single-leg stance for 20 s while looking forward at a visual target located 2 m away [30]. The data related to the oscillations of the CoP in the anteroposterior (AP) and mediolateral (ML) directions, path length (PL), average velocity (AV) and CoP sway area (SA) during the test were also collected. Each participant underwent three tests with a 10-s rest between each repetition. The average value of the results from the three tests was then recorded for each individual. The test was performed under two conditions: With eyes open (EsO) and with eyes closed (EsC).

## Time to stabilization calculation

To compute the TTS, the participants were asked to walk down a 30-cm stair with their affected limb bare feet without jumping on the foot pressure measurement system and then maintain their position for 10 s. Each participant was tested three times with a 30-s rest between the repeats [31]. The mean value of the three tests was ultimately recorded for each person.

The information about the TTS and CoP was obtained using the foot pressure measurement system (FDM-S, Zebris Medical GmbH, Germany), which has dimensions of 54.34 cm and 2560 sensors with high sensitivity and a sampling rate of 120 Hz. The Win FDM-S software, version 01.02.09, recorded this information in each test.

## Data pre-processing

The TTS data was processed using MATLAB software, version R2018b, with a fourth-order Butterworth low-pass filter [32]. From the 10 s of information obtained by the foot pressure measurement system; the mean value of the last two seconds was used as the horizontal line. A degree-three polynomial graph was plotted using the ground reaction force information. The point of intersection between the horizontal line and the cubic polynomial graph was considered the TTS. Figure 2 demonstrates the method for calculating the TTS in the single-leg landing movement.

A B

**Figure 1.** A) An example of patella kinesio taping, B) An example of patella dynamic taping

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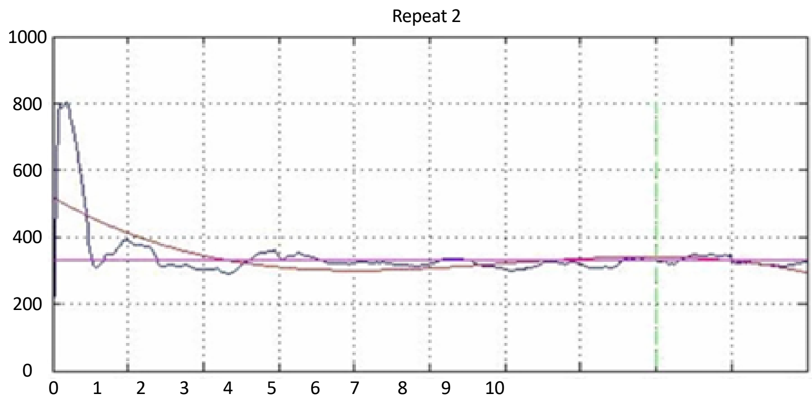


**Figure 2.** Example of calculating time to stabilization

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## Statistical analysis

Considering the normally distributed data, we used the Shapiro-Wilk test (P>0.05) to examine the data. Then, we employed repeated measures analysis of variance to compare the differences between the test conditions (WT, KT and DT). The data was evaluated using the Mauchly sphericity test to check for sphericity, and the Greenhouse-Geisser correction was applied to assess the significance of the original time effects. The Mauchly sphericity test showed no homogeneity of variance (P<0.05). Additionally, the Bonferroni post hoc test was used to make pairwise comparisons for significant main effects. A significance level of 0.05 was used for all analyses.

## Results

Table 1 shows the Mean±SD characteristics of the participants. According to Table 2, the results of the repeated measures analysis of variance for comparing various conditions with each other regarding balance with EsO, ML (F=4.544, P=0.014) and AP oscillations (F=4.021, P=0.022), SA (F=5.716, P=0.005), PL (F=3.780, P=0.025), and AV (F=3.882, P=0.025) of oscillations showed a significant difference (Table 2). In addition, the Bonferroni post hoc test outputs for the pairwise comparison between the conditions in the EsO state suggested a significant difference between the WT condition and the DT in the ML sway (P=0.045), AP sway (P=0.032), SA (P=0.014), PL (P=0.045) and AV of oscillations (P=0.037) (Table 3).

In addition, a significant difference was observed in the results for ML oscillations (F=5.317, P=0.007), AP oscillations (F=5.540, P=0.010), SA (F=7.229, P=0.002), PL (F=6.131, P=0.005) and AV (F=7.573, P=0.001) in the EsC test (Table 2). The Bonferroni post hoc test also revealed a significant difference between the WT condition and the DT (P=0.015) and between the WT condition and KT application (P=0.028) in the ML oscillations. Similarly, there was a significant difference between the WT condition and the DT (P=0.037) and between the WT condition and KT application (P=0.037) in AP oscillations. Additionally, there was a significant difference between the WT condition and the DT (P=0.007) and between the WT condition and the KT application (P=0.045) in SA, between the WT condition and the DT (P=0.022) and between the WT condition and KT application (P=0.010) in PL and between the WT condition and the DT (P=0.006) and the WT condition and the KT application (P=0.016) in AV of oscillations (Table 3).

Moreover, the TTS results (F=9.560, P<0.001) showed a significant difference in the pairwise comparison. There was a notable distinction between the WT condition and the DT (P<0.001) and between the DT and the KT (P=0.007). There was no difference between Kt and WT (P=0.963) (Table 3).

## Discussion

This study examined the immediate effects of DT and KT on the oscillations of the CoP and TTS in women with PFPS. The results demonstrated that the open-eye DT intervention significantly enhanced the CoP variables compared to the WT condition. No significant difference between the KT and WT interventions was observed when the eyes were open. However, a significant difference was found between the KT and DT interventions with WT when the eyes were closed. In terms of the TTS, the study showed that DT resulted in a decrease in TTS compared to the WT and KT conditions. No significant difference in TTS was observed between the KT and WT conditions.

**Table 1**. The participants' characteristics

| No. of Participants | Mean±SD | | | |
|---|---|---|---|---|
| | Age (y) | Weight (Kg) | Height (cm) | BMI (Kg/m²) |
| 39 | 27.92±0.82 | 63.39±1.55 | 161.99±0.59 | 25.05±0.70 |

SD: Standard deviation; BMI: Body mass index.

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Meanwhile, DT reduced postural oscillations with and without visual information, while KT reduced postural oscillations only when the eyes were closed. We used a specific taping technique to correct the patella's natural tracking, focusing on applying tape to the vastus medialis oblique and vastus lateralis muscles to take advantage of its beneficial properties. The first tape was applied to the lower part of the patella and between the two femoral condyles to maintain its normal alignment.

Research has shown that patellar gliding, tilting, and rotating are important components of movement related to taping. Patellar gliding refers to the linear distance between the midpoint of the patella and the medial/lateral epicondyle of the femur, while patellar tilting represents the movement of the anterior surface of the patella relative to the femoral condyles. Additionally, the rotation of the patella occurs around an AP axis as the movement of the distal tip of the patella [21, 23, 33, 34]. The second tape was applied to prevent patellar gliding while surrounding the space of the patella. DT's effect on reducing postural fluctuations in open and closed eye conditions is due to its mechanical support for placing the patella in its correct position. DT, a relatively new adjunct method for treating musculoskeletal issues, was developed by American physical therapist Ryan Kendrick in 2009. It is made of viscoelastic nylon and lycra and can be stretched in four directions. This tape also has strong tensile strength and recoil without a rigid endpoint, which has increased the effectiveness of elastic tapes and their popularity [21].

The study revealed that using KT with open eyes did not impact postural fluctuation, but with closed eyes, the fluctuations decreased. The primary function of KT is its neurophysiological effects. Probably, in the absence of visual information, KT has been able to improve CoP fluctuations and compensate for the lack of vision by increasing the sent afferent information such as joint positional sensory information, stimulat-

**Table 2.** The results of the repeated measures analysis of variance

| Variables | | Mean±SD | | | F | P | η² |
|---|---|---|---|---|---|---|---|
| | | WT | DT | KT | | | |
| EsO | ML (mm) | 10.03±2.88 | 8.74±1.83 | 9.67±2.24 | 4.544 | 0.014* | 0.107 |
| | AP (mm) | 21.78±7.39 | 18.26±4.87 | 19.90±6.60 | 4.021 | 0.022* | 0.096 |
| | SA (mm×mm) | 186.48±71.90 | 145.18±46.93 | 157.94±52.84 | 5.716 | 0.005* | 0.131 |
| | PL (mm) | 232.26±89.78 | 195.59±52.26 | 214.88±68.92 | 3.780 | 0.025* | 0.090 |
| | AV (mm×s) | 23.89±9.76 | 19.92±5.32 | 21.88±7.02 | 3.882 | 0.025* | 0.093 |
| EsC | ML (mm) | 18.92±4.03 | 16.70±4.48 | 16.93±4.84 | 5.317 | 0.007* | 0.123 |
| | AP (mm) | 30.56±9.02 | 25.42±7.87 | 26.64±5.98 | 5.540 | 0.010* | 0.127 |
| | SA (mm×mm) | 442.21±161.56 | 325.03±155.77 | 370.33±157.12 | 7.229 | 0.002* | 0.160 |
| | PL (mm) | 502.95±166.79 | 416.11±157.86 | 430.99±153.99 | 6.131 | 0.005* | 0.139 |
| | AV (mm×s) | 51.17±16.97 | 41.05±13.55 | 44.13±16.13 | 7.573 | 0.001* | 0.166 |
| TTS (s) | | 0.51±0.23 | 0.32±0.15 | 0.46±0.21 | 9.560 | <0.001* | 0.201 |

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Abbreviations: EsO: Eyes open; EsC: Eyes closed; AP: Anteroposterior; ML: Mediolateral; SA: Sway area; PL: Path length; AV: Average velocity; TTS: Time to stability; SD: Standard deviation.

*Significant difference (P<0.05).

**Table 3.** Bonferroni post hoc test results

| Variables | Eye | Condition (i) | Condition (j) | P | Eye | Condition (i) | Condition (j) | P |
|---|---|---|---|---|---|---|---|---|
| ML (mm) | Open | DT | KT | 0.114 | Close | DT | KT | 1 |
| | | | WT | 0.045* | | | WT | 0.015* |
| | | KT | WT | 1 | | KT | WT | 0.028* |
| AP (mm) | Open | DT | KT | 0.589 | Close | DT | KT | 1 |
| | | | WT | 0.032* | | | WT | 0.037* |
| | | KT | WT | 0.342 | | KT | WT | 0.037* |
| SA ($mm^2$) | Open | DT | KT | 0.904 | Close | DT | KT | 0.336 |
| | | | WT | 0.014* | | | WT | 0.007* |
| | | KT | WT | 0.054 | | KT | WT | 0.045* |
| PL (mm) | Open | DT | KT | 0.292 | Close | DT | KT | 1 |
| | | | WT | 0.045* | | | WT | 0.01* |
| | | KT | WT | 0.672 | | KT | WT | 0.022* |
| AV (mm/sec) | Open | DT | KT | 0.294 | Close | DT | KT | 10.674 |
| | | | WT | 0.037* | | | WT | 0.016* |
| | | KT | WT | 0.625 | | KT | WT | 0.006* |
| TTS (s) | | DT | KT | 0.007* | | | | |
| | | | WT | <0.001* | | | | |
| | | KT | WT | 0.963 | | | | |

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Abbreviations: EsO: Eyes open; EsC: Eyes closed; AP: Anteroposterior; ML: Mediolateral; SA: Sway area; PL: Path length; AV: Average velocity; TTS: Time to stability.

*Significant difference (P<0.05).

ing the muscle spindle or the Golgi tendon organ, and strengthening the proprioception of soft tissue to the central nervous system [1, 18, 23]. The KT, designed with a thickness similar to human skin, offers advantages such as creating a local stimulus, aligning fascial tissues, and providing sensory stimulation to assist or limit movements [35]. Additionally, the tape, with its waterproof, breathable fabrics, is popular due to its adhesiveness, ease of use, and lack of allergic reactions. It may also increase local blood flow or lymphatic circulation [18]. Dynamic tape had a mechanical effect in keeping the patella in its groove, while KT had more of a neurophysiological effect.

An important factor investigated in this study was the TTS after the tasks of walking down the stairs and maintaining balance for another 10 s. This index refers to the time (in seconds) the ground reaction force needs to stabilize in a quiet static state after changing from the dynamic to the static position. The ability to stabilize as quickly as possible is generally a positive characteristic because damage reduction is influenced by the effective maintenance of the perceived stability of the body following the change of position [31].

Our study results indicated a significant decrease in TTS after DT compared to the WT and KT conditions. The reduction in the DT was significantly more than the KT, and the DT led to faster TTS. One of the main reasons for these results probably was the better control of the movement of walking down the stairs due to lowering the pain felt by the participants in DT condition. Pain may thus reflexively inhibit the muscles around the knee. Since these muscles are responsible for timely and effective movement responses in controlling the body posture, the effect of DT on improving the ability to maintain balance and reach the TTS faster in people with PFPS could be thus compared to its impacts on balance and pain reduction [23]. Aminaka and Gribbel (2005) found that taping reduced nerve inhibition in the quadriceps by moderating the activity of large sensory nerve fibers, resulting in decreased knee pain [34]. The patella plays a crucial role in enhancing the functions and mechanical benefits of the quadriceps at the front of the femur. Increasing the contact area between the patella and the femur significantly helps distribute compressive forces within the joint. Additionally, the patella provides support for maintaining both static and dynamic stability [9]. Therefore, reducing the pain in this joint by decreasing the contact surface between the patella and the femur and enhancing its proprioception is a key aspect of the knee joint's dynamic stability and motion control system. This could explain the impact of DT on dynamic postural control and reducing the TTS in participants with PFPS in this study [23]. The greater impact of the DT could be further attributed to the materials and their strength, as well as some psychological factors. Of note, the primary mode of action of the DT was mechanical, specifically the deceleration of eccentric work, load absorption, and assistance in movements, while its second mode was neurophysiological [21]. The DT had a more significant effect on reducing the TTS while walking down the stairs. This task required the concentric contraction of the quadriceps and load absorption on the PFJ. The study participants showed better performance in DT conditions. In previous studies, pain perception and lower limb function have been associated with psychological factors and Kinesio-phobia (fear of movement) in patients with PFPS. Thus, Kinesio-phobia in such cases was more closely related to faulty movement patterns and self-reported pain and disability than to PFJ strength and loading [36]. In this regard, Jaffri and Baellow (2023) recommended the use of braces and tapes as a supplementary treatment to alleviate Kinesio-phobia in individuals with PFPS [36]. Therefore, using patellar taping could psychologically help the participants in performing the tasks in the current study. The study results align with Ha et al. (2020) findings, which compared the differences in muscle activity ratio, ground reaction force, and knee valgus angle during single-leg squat and landing due to the use of DT. Ha concluded that the application of DT reduced the load and impact on the PFJ during sports activities for participants with PFPS [24].

## Conclusion

The study found that DT reduced CoP variables in EsO and EsC, but KT reduced them only with EsC. Moreover, DT led to a faster TTS than WT and KT conditions. The results indicate that DT application may be more effective in improving balance and postural control in PFPS patients. It is recommended that future research investigate the long-term impact of utilizing this intervention, considering its positive effects.

### Study limitations

This randomized crossover trial had some limitations. While previous research had used the landing task to calculate the TTS, this study used the task of walking down the stairs to accommodate the participants' conditions and the need to control the joint load. The study also looked into the immediate effects of the interventions, as DT use had been less examined in previous research, but its positive effects were observed in this study. We suggest investigating the long-term effects of this intervention on patients with PFPS in future studies. It is also recommended that the impact of the DT on other tasks be explored.

## Ethical Considerations

### Compliance with ethical guidelines

This study was further approved by the Research Ethics Committee of Bu-Ali Sina University, Hamedan, Iran (Code: IR.BASU.REC.1402.013) and archived in the Iranian Registry of Clinical Trials, Tehran, Iran (Code: IRCT20200204046368N10).

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### Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

### Conflict of interest

The authors declared no conflict of interest.

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