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# Research Paper: 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

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## ABSTRACT

**Introduction:** The present study aimed to investigate the immediate effects of two types of Kinesio taping on the temporal and spatial variables of gait initiation in individuals with and without Functional Ankle Instability (FAI).

**Materials and Methods:** Thirty semi-professional athletes (15 with and 15 without FAI [control]) were recruited for this study. The gait initiation task was examined before and after the two types of Kinesio taping on a force plate. Temporal (Reaction Phase [RP], Anticipatory Postural Adjustment Phase [APAP]), and spatial variables were recorded and compared between Groups, before and after the tape application.

**Results:** The results of multiple repeated-measure analyses of variance showed no significant differences for "factor" and "Group by factor" interaction effects for any outcome measure (P>0.05). There were no significant differences for Group effects except for the APAP (F=10.27, P=0.003). The APAA was 71.95 ms longer in the FAI Group (476.95±15.87 ms) compared to the control Group (405.04±15.87 ms).

**Conclusion:** Kinesio taping application does not influence any of the gait initiation parameters on the force plate. Participants with FAI demonstrated longer APAP which might be due to recurrent injury and instability during sports or physical activity.

**Keywords:** Gait, Functional ankle instability, Kinesio tape, Soccer

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## 1. Introduction

Lateral ankle sprains are among the most common injuries that athletes suffer from a very young age through adulthood. The mechanism of injury is usually the composition of plantar flexion and inversion of the foot/ankle. Residual symptoms such as pain and instability, recurrent sprains, and reduced physical activity can last months and years after the initial injury [1]. Postural adjustments during gait are impaired in participants who develop residual symptoms following the first sprain [2]. Sensorimotor and muscle recruitment pattern alternations have been identified during a transition from a double limb stance to a single-leg stance, which may be similar to the transition occurring during gait initiation [3].

Gait Initiation (GI) is the phase between standing and rhythmic walking: a functional task that is present in many activities of daily living [4]. In humans, GI is a specific challenge for motor and postural control as it requires an anterior displacement of the entire body out of the base of support and from a stable state (double leg support) to an unstable state (one leg support) [5]. The results of a study by Hass et al. showed that chronic peripheral joint injuries, especially Functional Ankle Instability (FAI), negatively affect the supra-spinal motor control during an internally mediated postural destabilization (GI) [1]. Impairments in posture and gait can increase the risk of falling and significantly reduce the quality of life. Therefore, it is essential to investigate the factors that impact the spatial and temporal parameters of gait, including GI [4]. Although GI is a common task, it requires a complex interaction between muscle synergies in which the muscles of the lower limbs create torque around the ankle and hip joints.

In people with FAI, the Center of Pressure (COP) displacement increases during the GI preparation phase (S1, S2), modulating secondary motor areas. Similarly, the stepping phase of GI (S3), which is modulated by the primary motor cortex, is reduced in individuals with FAI. These alterations suggest that the central changes in motor control may contribute to the neuromechanism of FAI [1].

Recent studies have also demonstrated alterations in motor control at the spinal level and the excitability of the alpha motor neuron pool in individuals with FAI [6]. These changes can lead to muscle weakness, delayed muscle activity, and reduced muscle contraction time. Despite the progress made in prevention protocols for improving strength, flexibility, and neuromuscular control, ankle sprain still occurs in athletes [7]. Recently, Kinesio tape has been considered to improve joint position sense, balance, and gait, but existing studies have contradictory findings [8-10].

Kinesio tape is a modality that can activate muscle function and increase proprioception input [11-13]. A study on healthy participants has demonstrated that Kinesio tape may impact neuromuscular activity in the lower limb [14] and increase the push-off force by increasing medial gastrocnemius muscle strength [15]. Therefore, this study aims to investigate the effects of two types of Kinesio taping. These applications include type A over peroneus longus (which is a crucial muscle in the mediolateral stability of the ankle) and type B over gluteus medius (which is the muscle in hip strategy and postural control) on the temporal and spatial parameters of GI in individuals with and without FAI. We hypothesize that both types of Kinesio tape application will improve temporal and spatial parameters of GI in individuals with and without FAI.

## 2. Materials and Methods

### Study design and setting

This research was a pre-test and post-test interventional study in a laboratory setting. Before the study, all participants were informed about the study protocol and signed the written informed consent. The study protocol was approved by the Ethics Committee (Code: IR.TUMS.MEDICINE.REC.1396.4225) and Registry of Clinical Trials (Code: IRCT20171028037057N1).

### Study participants

Fifteen physically active men with FAI (n=15, Mean±SD age: 23.07±4.76 years, Mean±SD weight: 70.80±8.90 kg, mean±SD height: 179.53±4.39 cm) and 15 healthy man (n=15, Mean±SD age: 23.73±4.95 years, Mean±SD weight, 75.87±6.07 kg, Mean±SD height: 177.07±5.51 cm) participated in this study. All participants were recruited via public announcement at sports clubs in Tehran City, Iran. The participants were semi-professional soccer players regularly taking part in two hours of physical activity at least three times per week. The inclusion criteria for the FAI Group were as follows: 1) a history of at least one ankle inversion sprain on one side over the past 6-12 months, 2) a history of two episodes of giving way in ankle joint during exercise or daily activities, 3) scoring 90% on the Foot and Ankle Ability Measure (FAAM) and 80% on the FAAM-sport [16].

The exclusion criteria included other injuries, fractures, and surgery of the lower limbs, neurological disorders, and skin allergy to Kinesio tape. The participants were also excluded if they had pain in their ankle joints during the study participation.

## Study procedures

This study is part of a larger study [17], and the details of the study procedures were previously published, but the study procedures are briefly described here. The present study was performed in two separate sessions with a 1-week interval. At the start of the experiment, the participants' age, weight, height, and injury history were recorded. After performing lower limb stretching and warm-up exercises, the participants were instructed to perform the Gait Initiation (GI) task. They were asked to stand still, bare feet with their arms by their side, and look at the wall in front of them. While standing, two auditory stimuli (Duration: 100 ms, Intensity: 60 dB, Frequency: 2 kHz at intervals of two seconds) were provided by software synchronized by the force plate [18]. The participants were asked not to respond to the first auditory stimulus (warning stimulus) and took a step with the requested leg as soon as they heard the second auditory stimulus (response stimulus). Their first steps were inside the force plate, and the second steps were outside the force plate. The GI task was repeated three times for each leg before and after the Kinesio tape application in both sessions. Data were collected at the baseline of each session and 30 minutes after the Kinesio tape application.

## Taping methods

Kinesio tape (Red Kinesio Tex Tape, Tmax, South Korea) was applied by a professional physical therapist. It was performed following the Kinesio Tape International (KTAI) instructions for muscle facilitation technique [19]. All thirty participants were tested under two conditions: type A) peroneus longus facilitation Kinesio tape application, type B) gluteus medius, and peroneus longus facilitation Kinesio tape application. These two conditions were performed in two separate sessions with a 1-week interval. The sequence of Kinesio taping methods within the first session was randomized via envelopes with red (type A Kinesio tape application on the first session) and blue (type B Kinesio tape application on the first session) cards. In the next-test session, the Kinesio taping method was the opposite of the first session. For individuals with FAI, Kinesio tape was applied on the affected side, and in the control Group, the tested side was matched with the FAI Group.

For the peroneus longus Kinesio tape application, one single I-strip was used. The first one-third of the I-strip (anchor) is laid down on the fibular head with no tension. Then the therapist asked the participant to plantarflex and invert the ankle to stretch the peroneus longus. Then the therapist applied 35% tension to the base of the I-strip and directed it along the lateral aspect of the fibula to the lateral malleolus and rubbed to activate adhesive before any further movement. The foot was then put into the neutral position, and the therapist applied the end with no tension to the plantar surface of the first metatarsal bone and again rubbed the Kinesio tape [19].

For the gluteus medius Kinesio tape application, two I-strips were used. The anchor (first third) of the first I-strip was applied over the posterior iliac crest with no tension. Then the therapist asked the participant to flex the hip and apply the base with 35% tension. Then, with the leg in its original position, the end of the tape was attached with no tension at the greater trochanter. Consequently, the second I-strip was applied similarly but beginning at the iliac crest [19].

## Instrumentation and data reduction

Temporal and spatial parameters of GI were collected by Bertec triaxial force plate (Bertec Corp, Columbus, OH, 90 * 90 series) with a sampling frequency of 500 Hz and sensitivity of 10. Butterworth filter with a cut-off frequency of 10 Hz was applied to filter all COP data. These parameters were assessed on both limbs before and 30 minutes after the Kinesio tape application at each session.

To measure temporal parameters of GI (Reaction Time Phase [RP], Anticipatory Postural Adjustment Phase [APAP]), we used a unique program designed in Excel software 2013. The swing leg was determined as the first leg, which takes the first step and the opposite leg was the stance leg. Temporal events were calculated using the Center of Pressure (COP) trajectory. The onset of GI was defined as the first mediolateral deviation of the COP toward the swing leg. The COP amplitude should be more than 3 * standard deviation of the COP amplitude in the steady-state (average amplitude during the 500 ms before the onset of the warning stimulus). Foot-off was considered the end of the mediolateral shift of COP towards the stance leg (the absolute slope of COP <100 mm/s). The RP was considered from the start of the response stimulus to the start of stepping, and the APAP was defined from the start of stepping to the foot-off [20](Figure 1).

The velocity of COP displacement at three phases of GI (S1, S2, and S3) was recorded and analyzed by a spe-

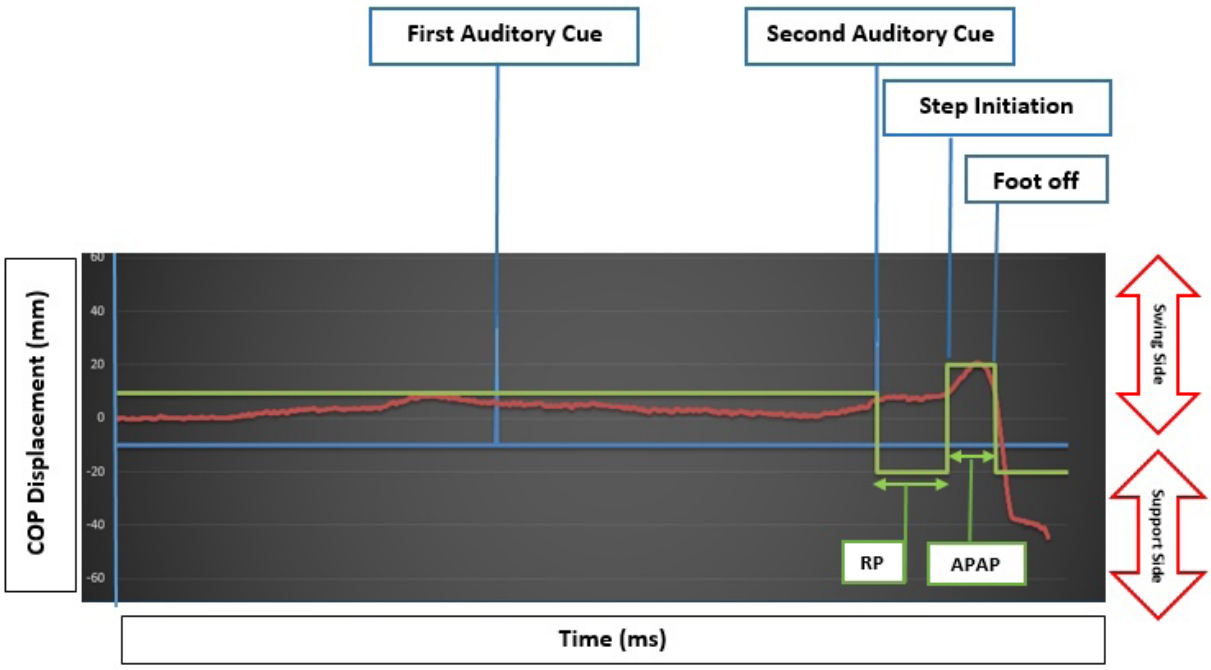


**Figure 1.** Gait initiation task starting with left leg (mediolateral trajectory of COP (vertical axis), time (horizontal axis), Reaction Phase (RP), and Anticipatory Postural Adjustment Phase (APAP))

cial designed program in Excel 2013. The S1 (anticipatory phase) began when the participant responded to the first auditory stimulus and began gait and ended with the transition of the COP to the most posterior and lateral position. The S2 (weight transfer phase) was defined by the COP shift towards the stance leg and ended when the COP transmitted to the most medial position. The S3 (locomotive phase) was defined by the movement of COP toward the anterior direction until toe-off happened, identified by reaching the 100 N threshold [3] (Figure 2).

### Statistical analysis

To analyze the data, SPSS 19 was used. The Kolmogorov-Smirnov test was used to investigate the normal distribution of data in each outcome measure. To determine the difference between demographic characteristics in the two Groups, we used the independent t-test. Descriptive statistics were used to compare the mean and standard deviations for temporal and spatial parameters of GI before and 30 minutes after type A and type B Kinesio tape application in each Group. Multiple repeated-measures Analysis of Variance (ANOVA) was used to detect significant interaction effects between the three within-subjects (tested leg, type of Kinesio taping, and time of evaluation) and between-subject (Group) factors. In the case of significant main effects, the Bonferroni post hoc test was used to detect any differences between the means of the different conditions.

## 3. Results

Based on the result of the independent t-test, there was no significant difference between the demographics of individuals with and without FAI (Table 1). The results of the Kolmogorov- Smirnov test demonstrated that all the outcome measures had a normal distribution.

The multifactorial repeated-measure ANOVA (Figures 3 & 4) yielded no significant differences for factor effect and factor by Group interaction effect for all parameters. In addition, there were no significant differences for Group effects except for the APAP (F=10.27, P=0.003) between the participants with FAI and the control Group. In other words, the individuals with FAI had longer APAP compared to the control Group (476.95±15.87 ms vs 405.04±15.87 ms) (Table 2).

## 4. Discussion

The present study investigated the effect of Kinesio taping on the temporal and spatial parameters of GI tasks in individuals with FAI and healthy controls. The study's findings demonstrated that none of the Kinesio tape application techniques (type A, type B) had changed the GI variables.

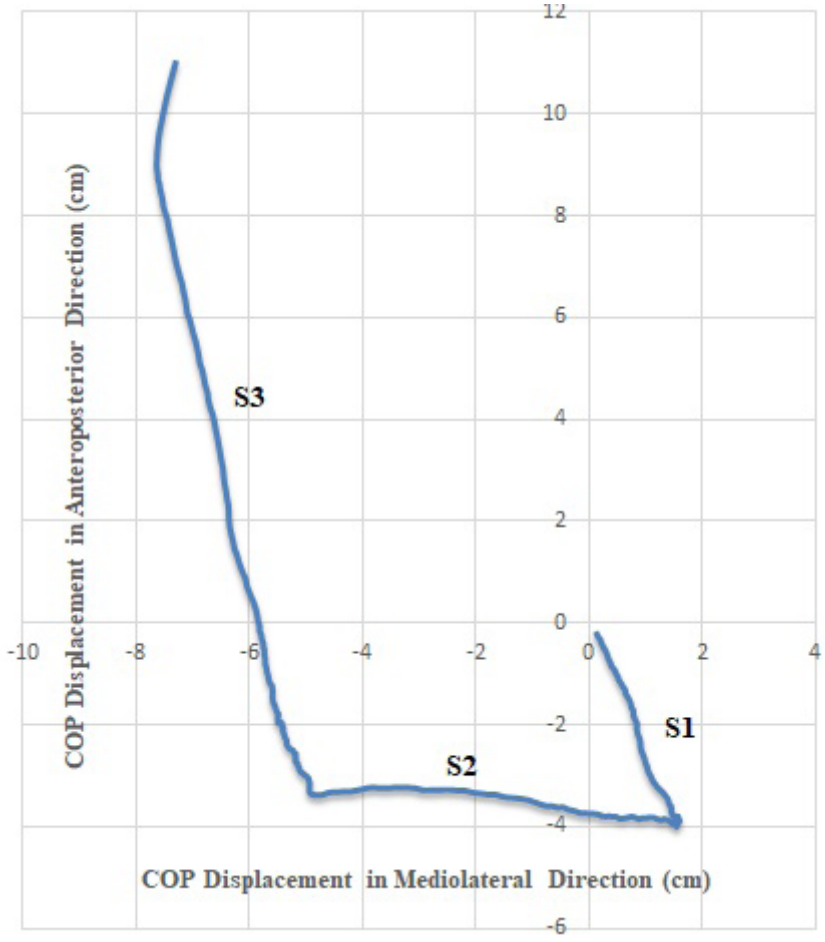


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**Figure 2.** Center of Pressure (COP) displacement in individual with Functional Ankle Instability (FAI) (S1: Anticipatory phase, S2: Weight transfer phase, and S3: Locomotive phase)

However, we found that the APAP was longer in the FAI Group compared to the control Group.

Our study was partially consistent with the study by Briem et al. [11]. They investigated the effect of Kinesio tape on muscle activity of the peroneus longus during a sudden inversion perturbation in athletes and did not find any significant results. Although the Kinesio taping method was the same as our study, they assessed the mean and maximum activity of the peroneus longus with surface Electromyography (EMG) during a sudden inversion perturbation. While we did not investigate muscle activation using surface EMA, our results support their findings.

**Table 1.** The comparison of demographic characteristics between individuals with FAI and control Group (n=15 in each Group)

| Variables | Mean±SD | | Range | | Sig. (2-tailed) |
|---|---|---|---|---|---|
| | FAI Group | Control Group | FAI Group | Control Group | |
| Age (y) | 23.07±4.76 | 23.73±4.95 | 18-32 | 18-32 | 0.71 |
| Weight (Kg) | 70.80±8.90 | 75.87±6.07 | 55-91 | 64-86 | 0.08 |
| Height (cm) | 179.53±4.39 | 177.07±5.51 | 171-187 | 169-188 | 0.19 |
| Body mass index (kg/m$^2$) | 21.9±2.43 | 24.25±2.27 | 17.36-26.88 | 20.09-28.38 | 0.06 |

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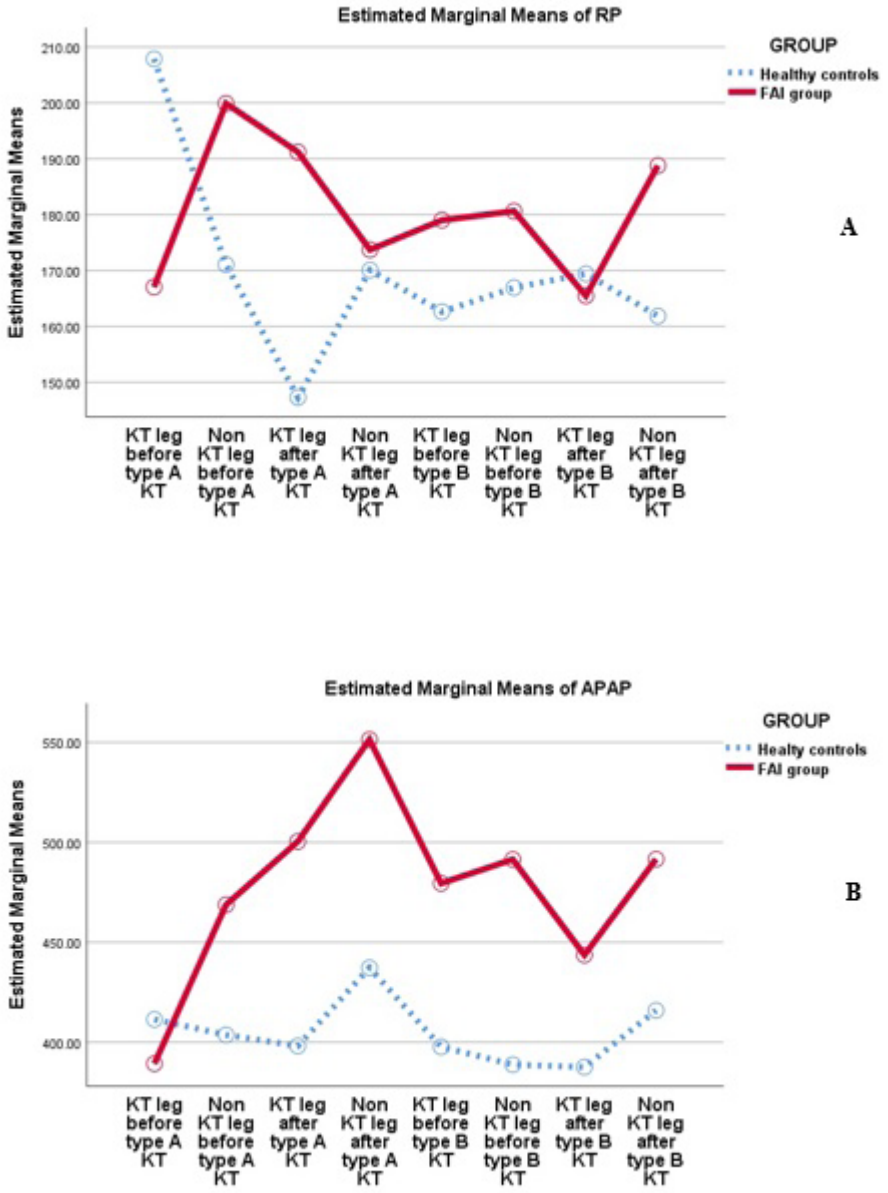




**Figure 3.** Estimated marginal means of A) Reaction Phase (RP) and B) Anticipatory Postural Adjustment Phase (APAP) before and after type A and type B Kinesio tape application in the Functional Ankle Instability (FAI) Group and healthy controls

Hijazi and Choukou demonstrated improvements in temporal-spatial parameters of walking after lateral application of taping in people with FAI. The unilateral taping application helped redistribute the pressure on the opposite foot, leading to even weight distribution on both sides. Taping also improved the functional stability of the contralateral ankle joint without injuries. Therefore, the authors suggested this technique can improve postural instability and, consequently, improve ankle movement during activities of daily living [21]. The findings of this study are in contrast with our results. This discrepancy may be due to the differences in study intervention, such as the type or method of taping and the target population. In the present study, all participants were semi-professional athletes, and perhaps, the gait and GI were not challenging tasks for them.

The walking condition can be self-initiated, cued, or be a compensatory stepping. The walking condition in our study was voluntary in response to an auditory stimulus. Different walking conditions have clear and significant effects on the preparatory phase of GI. The Anticipatory Postural Adjustment (APA) for stepping involves shifting the COP to the posterior and lateral side of the swing leg, and by the series of muscle activations

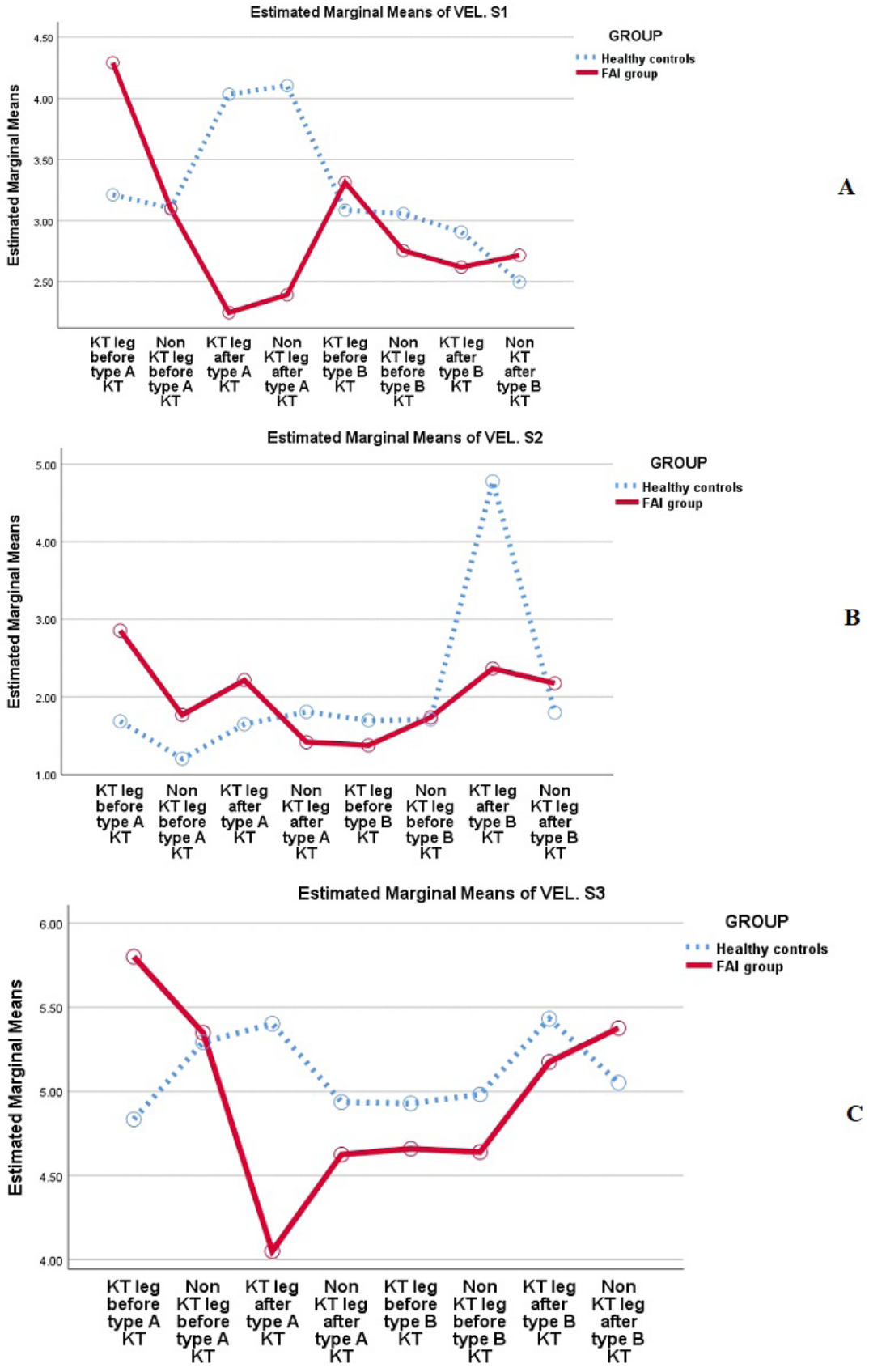


**Figure 4.** Estimated marginal means of velocity of center of pressure in S1 (A), S2 (B), and S3 (C) phases before and after type A and type B Kinesio tape application in the Functional Ankle Instability (FAI) and healthy controls

making the Center of Mass (COM) move faster and accelerate to the forward and lateral direction towards the stance foot [14]. The APAs are usually reported during the onset of voluntary stepping. However, the start of the first step without any APA is possible. Maki and Mcilroy [22] showed that during compensatory stepping, healthy adults often do not show APA, as the APA may delay the stepping time.

During the onset of walking, the anterior-posterior magnitude of the APA is related to walking speed, meaning that the larger posterior displacement of the COP will produce greater torque and more COM acceleration. In addition, the maximum distance between the COP and the vertical component of the COM relative to the ground is correlated with the improvement of dynamic postural control. Therefore, during the onset of walking by the individual, the larger APA is associated with better motor performance; it increases the walking speed and is associated with improved postural control [23].

In humans, studies have investigated the role of different brain areas in starting the walking process [23]. Using repetitive transcranial magnetic stimulation on the supplementary motor area, it has been observed that the duration of the APA in the first step is shortened after the stimulation with no impact on the APA amplitude. But when the person is expected to take a step, the brain stem releases APAs depending on the cognitive field (walking or not). Recently, the transcranial direct current stimulation, which was applied to the cerebellum, influenced the spatial characteristics of gait along with the locomotor adaptation [23]. Contrary to postural reaction in response to starting postural disturbances, the APA begins before the disturbance and thus reduces the effects of disturbances feed forwardly. Amplitude and duration of preparatory postural phase in patients with abnormal cerebrovascular injury with low amplitude and long duration, and the relationship between the postural phase and movement phase is eliminated [24]. These findings are similar to our results; APAP was longer in individuals with FAI than in the control Group. The longer APAP

**Table 2.** GI parameters in individuals with FAI and control Group before- after Kinesio taping application (n=15 in each Group)

| | Variables | Mean±SD | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Type A Kinesio Taping | | | | Type B Kinesio Taping | | | |
| | | Kinesio Taped Leg | | Non-Kinesio Taped Leg | | Kinesio Taped Leg | | Non-Kinesio Taped Leg | |
| | | Before | After | Before | After | Before | After | Before | After |
| FAI Group | RP | 167.04± 52.39 | 191.00± 58.25 | 199.91± 84.93 | 173.73± 45.07 | 179.02± 37.03 | 165.47± 46.36 | 180.64± 47.44 | 188.78± 30.25 |
| | APAP* | 389.27± 107.48 | 500.36± 165.05 | 468.76± 137.81 | 551.44± 158.13 | 479.47± 107.17 | 443.64 ± 69.40 | 491.44 ± 125.27 | 491.58± 101.59 |
| | VELS1 | 4.29±5.80 | 2.25±1.04 | 3.10±1.23 | 2.39±0.58 | 3.31±1.29 | 2.62±1.22 | 2.75±1.28 | 2.72±1.00 |
| | VELS2 | 2.85±4.27 | 2.21±2.64 | 1.76±0.70 | 1.41±0.50 | 1.37±0.74 | 2.36±1.44 | 1.73±1.19 | 2.17±2.17 |
| | VELS3 | 5.80±4.20 | 4.05±1.87 | 5.35±1.96 | 4.62±1.75 | 4.66±1.68 | 5.17±3.31 | 4.64±1.92 | 5.37±2.08 |
| Control Group | RP | 207.89± 153.16 | 147.29± 47.45 | 171.07± 41.56 | 170.09± 56.82 | 162.62± 39.81 | 169.42± 75.55 | 166.93± 63.86 | 161.84± 40.90 |
| | APAP* | 411.40± 124.86 | 398.09± 117.40 | 403.67± 110.13 | 437.24± 123.09 | 397.69± 120.62 | 387.55± 99.95 | 388.80± 117.19 | 415.91± 127.08 |
| | VELS1 | 3.21±1.90 | 4.03±3.90 | 3.10±1.23 | 4.10±3.99 | 3.08±1.12 | 2.91±0.69 | 3.06±0.82 | 2.50±1.00 |
| | VELS2 | 1.68±1.13 | 1.64±0.61 | 1.20±0.78 | 1.80±0.60 | 1.69±1.00 | 4.78±11.30 | 1.70±0.70 | 1.79±1.01 |
| | VELS3 | 4.83±1.93 | 5.40±1.70 | 5.29±1.61 | 4.94±1.46 | 4.83±1.70 | 5.43±1.90 | 4.98±1.48 | 5.05±1.57 |

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RP: Reaction Phase; APAP: Anticipatory Postural Adjustment Phase; VEL: Velocity; S1: Anticipatory Phase; S2: Weight Transfer Phase; S3: Locomotive Phase. The units of RP and APAP were ms, and for velocity measurements was cm/s.

*Indicates significant result for Group effect (P<0.05).

may alter the neuromuscular activity of lower limb muscle Groups or even recurrent injuries.

The rate of neuromuscular commands that control the quiet stance posture is proportional to the speed of the body [25]. Increasing the speed of walking increases the body acceleration, which may ultimately be more challenging in the mediolateral dynamics of the GI. These findings suggested that when faced with postural constraints, the central nervous system can modulate the mediolateral APA and the stride width to maintain dynamic stability [26]. The COP trajectory or gait line can also provide helpful information in assessing or recognizing foot/ankle function. In addition, COP speed is one of the most valuable indicators for describing walking performance. The COP velocity has a three-peak pattern. The first peak is between 0% and 20% of the stance phase. The second and third peaks occur in about 35% and 92% of the standing phase. Gender and dominance (right or left leg) have no significant effect on the COP pathway, and with increasing walking speed, COP velocity increases significantly [27]. Grundy et al. examined the COP velocity in different situations in people with normal and injured legs. They reported that velocity increases with the increasing use of the metatarsal bar or heavy rigid shoes. Another study done by Mann et al. included 10 patients who were under a severe finger amputation. They found that COP velocity was significantly reduced in the metatarsal head of the surgical side. Lehmann et al. examined the progression of COP during walking in a Group of six healthy participants with tibial paresis, which was temporarily developed for them. Although Lehmann et al. did not really measure the COP velocity, they reported delayed advancement of COP in these participants [28]. In the present study, we asked the participants to walk at their maximum speed. Based on the provided evidence, the inter-individuals differences in walking speed could influence the GI parameters. In fact, by setting the maximum walking speed, we have limited the inter-individuals' differences.

## 5. Conclusion

Both types of Kinesio taping had no effect on the temporal and spatial parameters of GI, and their immediate effects are less conclusive and would benefit from further research. It should not be overlooked that participants with FAI demonstrated longer APAP which might contribute to recurrent injury and instability during sports or physical activity. Therefore, researchers and clinicians should have a more comprehensive view of the design of research and treatment programs for athletes with FAI.

This study has several limitations. First, the immediate effects of the Kinesio taping were examined after 30 minutes. It would be better to assess its short-term (24-72 hours) effects to improve muscle tone through the facilitation of sensory-motor pathways. Second, the walking speed and step length were not normalized based on the inter-individuals' differences (e.g. speed or step length). The authors suggest establishing further studies with 2 or 3 force plates to evaluate the longer walking distance instead of one step.

## Ethical Considerations

### Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed about the research purpose and its implementation stages. They were also assured about the confidentiality of their information. Also, they were free to leave the study whenever they wished, and if desired, the research results would be available to them. The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences, (Code: IR.TUMS.MEDICINE.REC.1396.4225) and Registry of Clinical Trials (Code: IRCT20171028037057N1).

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### Authors contributions

Conceptualization and supervision: Sara Fereydounnia and Azadeh Shadmehr; Methodology: Saeed Talebian Moghadam; Investigation, writing – original draft, and writing – review & editing: All authors; Data collection: Sara Fereydounnia, and Parsa Salemi; Data analysis: Sara Fereydounnia and Saeed Talebian Moghadam; Funding acquisition and Resources: Sara Fereydounnia and Azadeh Shadmehr.

### Conflict of interest

The authors declared no conflict of interest.

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