Title: Effect of Low-Dye Taping and Navicular Sling Kinesiotape on Athletic Performance in Performance Fatigue Condition: A Study on Professional Male Basketball Players with Flat Foot

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ABSTRACT

Purpose: This study examined how Low-dye tape and Navicular Sling Kinesiotape impacted athletic performance in performance fatigue condition in basketball athletes with flat feet.

Methods: The current research was conducted on 12 professional basketball players between 18_25 years old with flat feet. Staheli Index, Y balance, 20-meter speed, modified T-test, and Sargent tests were employed to assess flat foot, dynamic balance, speed, agility, and power. A basketball-specific performance fatigue protocol was used to induce performance fatigue, and treatments included low-dye taping and Navicular Sling Kinesiotape.

Results: Statistical analysis indicates that Low-Dye taping significantly improves dynamic balance in both fatigued (P = 0.01) and non-fatigued (P = 0.01) conditions (F = 18.33). Additionally, performance fatigue negatively affects dynamic balance in both Low-Dye taping and non-taping conditions (P = 0.01). It also leads to impaired performance in the 20-meter speed test in the low-dye and Kinesiotape conditions (0.49 and 0.60), a 3.75 cm reduction in the Sargent test in the non-taping condition. Additionally, Low-Dye taping condition leads to a 0.68-second decreased in agility performance record.

Conclusion: While fatigue did have an impact on performance, low-dye taping, and Navicular Sling Kinesiotape resulted in a smaller performance decline compared to non-taping conditions. In addition, low-dye taping had a greater effect on performance and flat foot than did Navicular Sling Kinesiotape. Basketball players with flat feet are recommended to use low-dye taping and Navicular Sling Kinesiotape.

Keywords: Low-dye, Navicular Sling Kinesiotape, Flat foot, Basketball, Performance fatigue

Highlights

● Performance fatigue is associated with a significant decline in athletic performance, (including dynamic stability, speed, agility, and power).

● Although performance fatigue leads to a decrease in performance, in low-dye taping and Navicular Sling Kinesiotape conditions, this decrease is less compared to non-taping conditions.

● Compared to Navicular Sling Kinesiotape, Low-dye taping had a stronger impact on athletic performance in both performance fatigue and non-fatigue conditions.

Plain Language Summary

Flat foot is the most common (22%) postural deficit among basketball players. Both Low-dye taping and Navicular Sling Kinesiotape appear to be valuable techniques and effective methods to increase the navicular and internal longitudinal foot arch height. In previous studies, the impact of these techniques was examined only in normal conditions, but this research investigated the impacts of both techniques simultaneously in basketball players with flat feet, on athletic performance (dynamic balance, speed, power, and agility) in basketball-specific performance fatigue conditions. The study's findings demonstrated that, while fatigue conditions led to decreased performance (dynamic balance, speed, power, and agility), low-dye taping and Navicular Sling Kinesiotape showed less of a reduction in performance than non-taping conditions. Moreover, the Low-dye taping had a greater effect on flat foot and performance than Navicular Sling Kinesiotape.

Introductions

According to FIBA, about 11% of the global sports community plays basketball, making it is ranked as the second most popular worldwide. [1, 2]. Success in basketball hinges on specific abilities including strength, power, speed, and agility [3]. In this regard, some unique movements in basketball include defending against opponents' movements and using skills like agility, sidestepping, acceleration, blocking, and physical confrontation to hold their position, which is directly linked to the enhancement of jumping and landing, running at different speeds, and sudden changes in direction [3]. Additionally, professional basketball players are required to perform an average of 42 to 56 jumps during a game [2]. Although playing basketball increases strength, boosts the immune system, and improves body composition, the contact nature of the sport and the complexity of its demands also increase the risk of injury, which includes running, jumping, switching, and deceleration [4].

In basketball, multiple jumps and landings increase the risk of lower extremity injuries [4, 5]. More than half of all injuries to young basketball players are lower extremity injuries [6]. An analysis of 12,000 basketball injuries found that the ankle at 22% (2,832 injuries) and The knee was the most common injury site, with 18% (2,305 injuries) [4]. Female basketball players experience a rate of 13.8 injuries per 1000 hours of exposure, whereas male counterparts experience a rate of 14.8, with females experiencing more ankle injuries at 45% and males experiencing knee injuries at 51% [7]. The most common injury in basketball is a sprain, with the ankle being the most common site, usually occurring in the contact mechanism. In addition, athletes who practice more than four times a week have an almost twofold increased risk of injury compared to those who practice fewer times [7]. Investigating potential risks and biomechanical factors is crucial in light of these injury rates.

Since basketball is a weight-bearing sport, with the high involvement of the foot in the game, it may result in changes in foot anatomy [8]. Running and jumping, which are two crucial factors in basketball, increase the amount of bodyweight pressure in the forefoot and midfoot [8]. In this regard, one of the most common postural deficits among basketball players accounting for around 22% is flat foot [9, 10]. A flat foot is a result of a depression in the medial longitudinal arch, which is being risk factor for injury in the foot [8]. The human movement chain is connected, so if one segment is weak, it can affect another segment too [11]. For example, a study showed that National Basketball Association (NBA) Players with larger legs and flat feet suffer from hallux valgus because flat foot is an important risk factor for hallux valgus [12]. It was also stated that flat foot is a risk factor for postural deficits and spinal injuries [10]. Flat foot reduces not only the Vertical Ground Reaction Force (VGRF), but also the time that takes to transfer the reaction force to the foot, which are risk factors for foot bones fractures and ankle sprain [13]. As it seems that the most common form of postural deficits in basketball players is flat feet, the present study was conducted on basketball players with flat feet.

Various methods including shoes, insoles, and taping are used to modify flat feet in athletes [1, 14]. A study found that foot orthoses, a common treatment for flat foot, had limited effects [15]. Moreover, stretching exercises and continuous use of orthosis seem to reduce pain in people with flat feet, but do not change the structure of a person's foot [16]. The shape and height of the arch can be maintained by arch taping for athletes with pain or injury as a result of overpronation [17]. In this context, anti-pronation taping strengthens the transverse angle, increases static and dynamic balance, increases the internal longitudinal arch, and improves flat foot by reducing ankle pronation [18, 19]. Low-dye taping is highlighted as an effective method to increase the height of the navicular, increase explosive power, and reduce the risk of injury [5]. Navicular Sling Kinesiotape is also recognized as a valuable technique for lifting navicular height [20]. The low-dye tape and the navicular sling kinesiotape appear to effectively alter the foot pressure and raise the internal longitudinal foot arch [17].

While previous studies have examined the impact of these techniques only in normal and fatigue conditions, until now, no research study has investigated the impact of both Low-dye taping and the Navicular Sling Kinesiotape simultaneously on performance in basketball-specific performance fatigue conditions. To this end, This study sought to explore how these techniques affect the most important performance factors (dynamic balance, speed, power, and agility), in basketball players with flat feet under conditions of performance fatigue. Understanding these effects is crucial for optimizing athletic performance and reducing the risk of injury, not only in basketball but also in other sports that require rapid movements and stability. We hypothesized that (1) both Low-dye taping and the Navicular Sling Kinesiotape would modify flat feet and (2) improve performance in performance fatigue conditions.

Method

Study design

The study used a randomized crossover design (repeated measure), according to the Declaration of Helsinki guidelines. The ethical review and approval of the research was conducted by the Research Ethics Committee of the University of Kurdistan with the code IR.UOK.REC.1403.012.

Participants

12 male professional basketball players (age: 22.91±2.39 years old; background: 6.75±1.81; weight: 93.83±18.95 kg; height: 190.83±9.35 cm and Staheli Index 0.94±0.03) were selected from 112 volunteered with flat foot (after screening). According to the sample size formula outlined in the study conducted by Charan and Biswas (2013), a total of 12 participants were considered sufficient for this study [21]. The included sample was relatively homogeneous because only players from the basketball teams were recruited.

To be included, you need to have a score of 0.89 on your feet, no ankle problems, no injuries to your lower body in the past 12 months and have been playing basketball for at least three years. The

exclusion criteria comprised declining to participate in the fatigue protocol and experiencing acute injury during the study protocol. The participants knew everything about the study, including how it was done, its benefits, goals, and possible problems. After providing personal, medical, and athletic background information, Participants did a 10-minute basketball-specific dynamic warm-up. The athletes were told to do the assessments (described in the assessment tests section) both before and after the performance fatigue program.

Assessment Tests

Staheli Index

To assess flat feet, the Staheli Index was employed, whose validity and reliability have been previously established [22]. The SI is used to measure the ratio between the midfoot's smallest length and the heel's largest length. Normal values were considered to be values between two standard deviations from the mean, namely between 0.44 and 0.89 [22]. The Staheli Index could predict flatfoot with a high accuracy of 0.80 and a sensitivity of 81.8. [23].

Y balance test

Dynamic balance was evaluated using the Y balance test, which has previously been used to assess neuromuscular deficiencies, lower extremity injury risk factors, and the time it takes to return to sport, with strong reliability (ICC=0.71-0.88) [24]. The athlete's leg length was measured to normalize the results after the test was repeated three times [24].

20-meter speed test

The speed was assessed using a 20-meter speed test, and prior research has confirmed the reliability of this method. The athlete was told to run fast and strong towards the finish line. They were positioned behind the starting line. The duration time in seconds was recorded using a chronometer, and the athlete's score was recorded as the time [25].

Sargent test

The Sargent test was used to assess lower extremity power, and the disparity of two points was recorded as an athlete's jump score. [24]. The athlete extended his arms and reached out to touch the gradient wall. Then immediately jumped as high as possible and touched the highest point of the wall, while bending his knees to a comfortable 90º angle. The test has a validity of 0.80 and a reliability of 0.93 [24].

Modified T-test

The modified T-test was employed to assess agility. This is a multi-factor analysis that takes into account several basketball-specific factors, including power, speed, and jumping. [5] The assessment is carried out using four cons for the design and a chronometer for recording the time. Behind the starting line, the athlete was urged to run quickly and change directions by backpedaling, left and right shuffling, and forward sprinting [26]. The reliability of this test is greater than 0.90 [26].

Treatments

Sling Navicular Kinesiotape

We used 2-inch elastic tape for the Navicular Sling Kinesiotape. Starting from the dorsal of the foot, then pushed laterally across the metatarsals and crossed over the fifth metatarsal. The tape continued under the foot on the plantar surface, moving towards the first metatarsal and coming out under the navicular. The tape stretched around the ankle, reaching the dorsum of the foot and crossing across the lateral malleolus. The tape wrapped around the ankle and covered the medial malleolus before returning to the dorsum of the foot [27].

Low-Dye Taping

Low-dye taping is an effective technique for changing the pronated or flat foot and raising the Navi's height. It's also used to boost jumping activities' explosive power. The jump pattern of basketball players with flat feet appears to be directly impacted by this taping technique [4]. To use the tape, put it on the skin above the side of the fifth metatarsophalangeal joint, wrap it around the heel, and finish on the side of the first metatarsophalangeal joint. The strips were initially positioned towards the lateral anchor, subsequently pushed medially over the arch, and finally to the medial dorsum. The strips were overlapping by half and continued along the plantar portion of the foot, culminating at the metatarsal head close to the metatarsophalangeal joints. To complete the plantar strips, another anchor strip was put, beginning at the lateral part of the foot. This strip was applied similarly to the first anchor strip. Two additional anchor strips were erected. These strips were overlapped by half and were placed on the foot's dorsal face. The strips started on the medial dorsum and ended at the anchor that covered the fifth metatarsal. [27].

Basketball-specific performance fatigue Protocol

performance fatigue was induced by using a basketball-specific protocol. This protocol consists of three minutes of rest at 70% of maximum heart rate, followed by four stages of four minutes each, at 90 to 95 percent of maximum heart rate. This protocol is comparable to a basketball game in terms of duration, intensity, and movement patterns, and it can be used on a basketball court. Following an

instruction from the examiner, the participant starts moving without the ball from cone one and runs towards cone two.

They then perform pivot movements toward cones three, four, five, and six respectively, followed by short forward vertical jumps from cones six to seven. The participant then takes the ball from cone seven and dribbles zigzag toward cones eight, nine, ten, eleven, and twelve before proceeding with a layup shot toward the basket. Subsequently, they release the ball, move outside the court behind cone thirteen, sprint toward cone Fourteen at maximum speed, and then run backward toward cone one [1]. A Polar heart rate monitor is used to track the participants' heart rates during the test. The level of fatigue was measured using the Borg scale, in which participants were asked to express their actual feelings about the activity they had just completed, and the results were scored using the Borg scale table [28]. If this score is less than 15, the fatigue protocol is carried out again [1].

Analyzing statistics

The Kolmogorov-Smirnov test was employed to verify the normal distribution of data, while the Levene's Test was employed to verify the homogeneity of variances. To see how Low-dye taping and Navicular Sling Kinesiotape affect balance, power, speed, and agility when people are tired or not, we used an ANOVA test. Tukey's test was employed to compare sports functions in different conditions and situations. The significance level was set at p 0.05, and the entire statistical analysis was done with SPSS software (version 25, SPSS Inc. 2000)

Results

The Kolmogorov–smirnov statistical test ($p < 0.05$) verified the normality of the data distribution. Although balance status was decreased in fatigued condition with Low-dye taping and Sling Navicular Kinesiotape, this reduction was less than in non-taping condition. The Low-Dye taping led to significant improvements in balance status in non-fatigued by 2.3 cm ($p < 0.01$) and fatigued by 1.81 cm ($p < 0.01$) conditions, while there was a slight improvement in Navicular Sling Kinesiotape in fatigued and non-fatigued conditions in comparison with non-taping condition (Fig. 1).

Tuky's analysis showed that basketball-specific performance fatigue protocol significantly increased the 20-meter speed record in different conditions compared to non-fatigued condition. In other words, in fatigue conditions there was a statistically significant increase of 0.49 seconds in speed record in the non-taping condition, 0.60 seconds in the Low-dye taping, and 0.48 seconds in the Navicular Sling Kinesiotape conditions ($p = 0.01$). Moreover, in non-fatigued condition, speed record reduced more in Low-dye taping condition by 0.13 seconds than in the Navicular Sling Kinesiotape condition by 0.02 seconds (Fig. 2).

Power declined in all three categories when fatigued, but the non-taping condition showed the largest reduction 3.75 cm ($p = 0.01$). Furthermore, a slight improvement in power record was observed with

Low-dye taping when compared to the Navicular Sling Kinesiotape condition, despite no significant improvement in power records in the non-fatigued condition (Fig. 3).

The Tuky's test conducted on agility revealed a significant increase in agility record in three types of conditions after fatigued protocol, with it being substantially more in non-taping condition 0.68 seconds (p = 0.04) in comparison to the Navicular Sling Kinesiotape and Low-dye taping. In non-fatigued condition, agility record decreased around 0.19 seconds in Low-dye taping, while it did not change in the Navicular Sling Kinesiotape (Fig. 4).

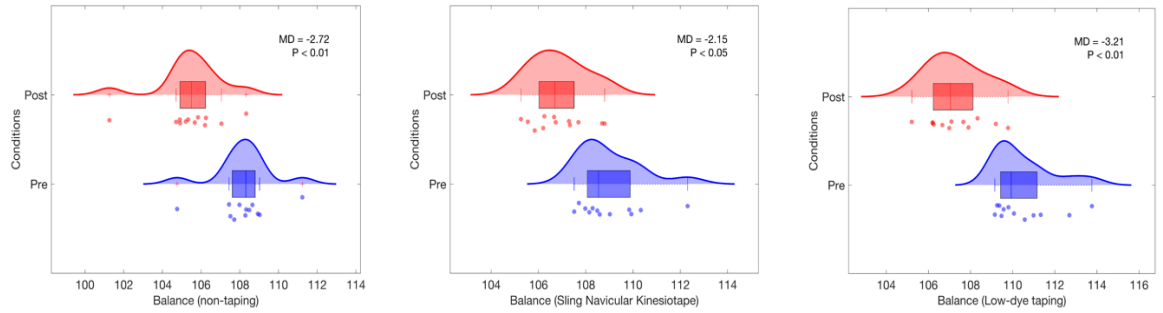

Fig. 1 Raincloud plots and differences in balance status between three conditions, including non-taping, the Navicular Sling Kinesiotape and Low-dye taping before(bottom) and after (top) basketball-specific performance fatigue protocol

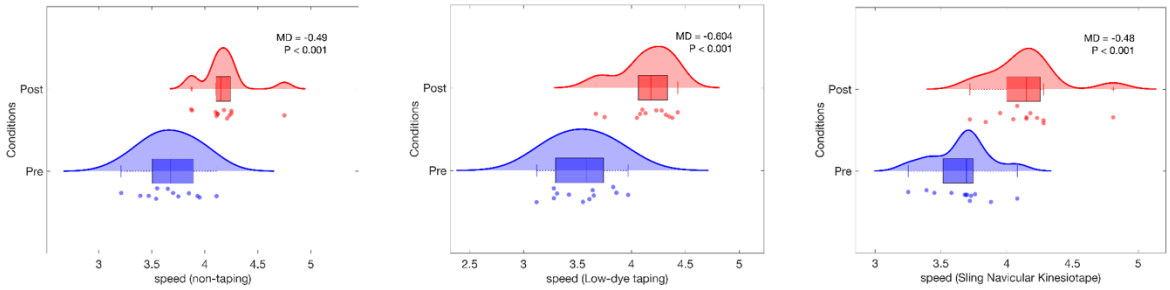

Fig. 2 Raincloud plots and differences in speed between three conditions, including non-taping, the Navicular Sling Kinesiotape and Low-dye taping before(bottom) and after (top) basketball-specific performance fatigue protocol.

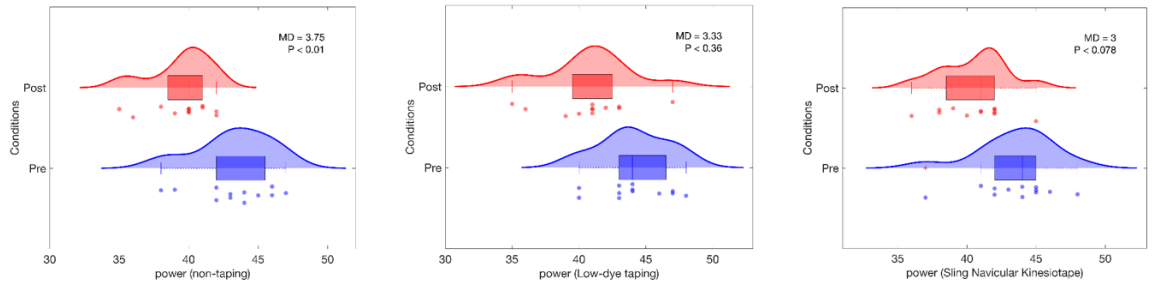

Fig. 3 Raincloud plots and differences in power between three conditions, including non-taping, the Navicular Sling Kinesiotape and Low-dye taping before(bottom) and after (top) basketball-specific performance fatigue protocol

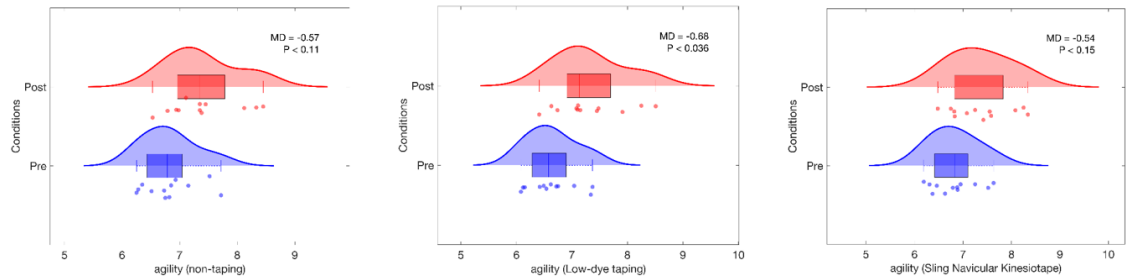

Fig. 4 Raincloud plots and differences in agility between three conditions, including non-taping, the Navicular Sling Kinesiotape and Low-dye taping before(bottom) and after (top) basketball-specific performance fatigue protocol

Table 1. Mean and standard deviation (SD) of variables and the results of statistical analysis

Analyses /Group	**Mean ± SD**						**F**	**P**
	Non-taping		**Low-dye**		**Navicula Sling Kinesiotape**			
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**		
Balance	108.19 ± 1.47	105.47 ± 1.67	110.50 ± 1.46	107.28 ± 1.33	109.01 ± 1.37	106.85 ± 1.14	18.33	0.01
Speed	3.67 ± 0.25	4.17 ± 0.22	3.54 ± 0.26	4.14 ± 0.23	3.65 ± 0.22	4.14 ± 0.27	16.85	0.01
Power	43.25 ± 2.73	39.50 ± 2.19	44.08 ± 2.57	40.75 ± 3.16	43.50 ± 2.81	40.50 ± 2.43	6.12	0.01
Agility	6.82 ± 0.46	7.39 ± 0.61	6.63 ± 0.43	7.31 ± 0.63	6.82 ± 0.46	7.36 ± 0.61	4.59	0.01

Discussion

The primary objective of this study was to investigate how low-dye tape and navicular sling kinesiotape affect athletic performance in basketball players with flat feet when they're going through a basketball-specific fatigue protocol. The study's findings demonstrated that, while fatigue conditions led to decreased performance, low-dye taping, and Navicular Sling Kinesiotape showed less of a

reduction in performance than non-taping conditions. Moreover, the Low-dye taping had a greater effect on flat foot and performance than Navicular Sling Kinesiotape.

The foot plays a vital role in activities as one of the most significant lower extremity structures. Distributing body weight and maintaining balance during activities is one of its tasks [29]. Accordingly, any deficits in the legs such as flat foot can lead to imbalance, increased risk of injury, including plantar fasciitis, tibial stress fracture, anterior cruciate ligament rupture (ACLR), and back pain, as well as decreased performance [29]. Taping is one of the common intervention methods to reduce the impact of flat foot on performance. No study has examined whether low-dye tape and Navicular Sling Kinesiotape affect performance and balance in basketball players with flat feet in fatigued and unfatigued conditions. Siu et al., 2020 showed that Navicular Sling Kinesiotape resulted in improving the function of the posterior tibial muscle and modifying flat foot during running [18]. The present findings follow the findings reported by Newell et al. (2015), indicating that Low-dye taping had a greater impact on flat feet during activities. Moreover, the Navicular Sling Kinesiotape effectively raised the height of the navicular immediately after taping. However, the efficacy of this technique rapidly diminished after the initial 5 minutes of running [27].

Previous research has shown that fatigue conditions can have a negative impact on balance and there is a strong correlation between balance status and flat foot [1, 30]. Numerous disorders of the musculoskeletal and nervous systems in the lower extremities, like flat foot, can affect balance status, necessitating ongoing modifications to joint alignment and muscular activity [31]. An increase in the angle of heel valgus results from an increase in the rear angle, which disrupts balance status. Muscle stretch angles and inactive components surrounding joints change as a result of misalignment of the heels. This causes erroneous signals to be sent from the foot to the central nervous system, which may impact balance [32]. In the present study, balance statues were lower in the non-taping condition, but they improved with low-dye taping and then with Navicular Sling Kinesiotape. This improvement may have been caused by changes in the structure of the foot following tape applications. Dynamic tape has been shown in earlier studies to help improve the reduced dynamic balance status caused by flat feet [33]. The current study's findings showed that, although balance status did decline under fatigued conditions, it did so less under low-dye taping than under Navicular Sling Kinesiotape when compared to non-taping conditions in basketball players with flat feet. These outcomes closely match those of earlier research [32, 33].

Having abnormalities in the legs such as flat feet can cause a decrease in physical abilities [34]. Furthermore, fatigue can significantly impair an athlete's performance by weakening stability and leading to deficits in dynamic activities like balance, speed, vertical jump, and agility [35]. A study showed that fatigued protocol can negatively affect the kinematic and kinetic of running, resulting in decreased speed performance [36]. Fatigue not only reduces power generation but also reduces

acceleration and speed during functional movements such as jumping [37]. A recent study by Ho et al., 2020 demonstrated that applying low-dye taping to basketball players with flat feet significantly enhances Navicular height, gluteal activity during the eccentric phase, and explosive power, thereby reducing injury risk and improving sports performance, particularly strength and power factors [38]. Our findings suggest that athlete performance decreased following the implementation of a basketball-specific performance fatigue protocol, with further enhancements observed after the application of low-dye taping and Navicular Sling Kinesiotape. These interventions mitigated the negative impact of flat feet on performance, aligning with previous research indicating the positive effects of modifying flat feet with taping techniques [39]. The enhancements of performance factors, which are important components of basketball success, were predictable, with low-dye taping and Navicular Sling Kinesiotape, even after applying basketball-specific performance fatigue protocol.

Study limitations

There were certain limitations on this study. First, because force plates are more difficult for coaches and athletes to access, we assess power using the Sargent test rather than force plates. Second, there was no comparison between the training and control groups. Finally, The sample size (12 participants) was small, making it difficult to generalize the findings to a broader population.

Conclusion

Among basketball players, the flat foot appears to be the most prevalent type of postural deficit. These can have a negative impact on performance, as well as causing an imbalance and an increased risk of injury. The findings of the study indicated that despite the impact of fatigue on performance, low-dye taping, and Navicular Sling Kinesiotape had a less detrimental effect on performance than non-taping conditions. Additionally, low-dye taping had a stronger impact on flat feet and performance compared to Navicular Sling Kinesiotape. These results emphasize the importance of using various strategies to modify flat feet and the negative effects of flat feet on performance and balance. To improve the arch of their feet, athletes are also recommended to use low-dye taping and Navicular Sling Kinesiotape. This is because the results of this study demonstrated that these tapes not only did not interfere with performance or balance but that they are also helpful preventative strategies in situations where performance fatigue may occur. Future research should look into the effects of low-dye taping and Navigating Sling kinesiotape on landing technique because fatigue causes deficits in landing technique [43]. Furthermore, it is recommended to use the force plate to gain a deeper comprehension of the force and kinematics of landings. future research should investigate the long-term effects of these taping techniques and include larger sample sizes for more robust findings.

MoralConsiderations

Following ethical guidelines.

The Kuristan University Research Ethics Committee approved the studies involving human participants (IR.UOK.REC.1403.012). In this article, all ethical principles are considered. The article followed ethical rules like giving permission to participate, keeping information private, and giving permission to stop participating.

The funding process

The first author's MSc theses were used to create this study. There were no grants from funding agencies in the public, commercial, or non-profit sectors for this research.

Data Availability

The corresponding author can provide the data used to support the findings of this study upon request.

Conflict of interests

There was no commercial or financial relationship that could be construed as a potential conflict of interest, according to the authors.

Consent to be informed

Before the study procedure, the participants had to give written consent.

The authors' contributions

The preparation of this article was shared equally by all authors.

Competing interests

There was no conflict of interest between the authors.

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