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# Comparison of Skill and Landing Technique in Basketball Players with Pes Planus during Applying Low-Dye Taping and Kinesio Taping: A Randomized Controlled Trial

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Original Article

## Abstract

**Introduction:** Seventy percent of basketball injuries are non-contact, with 75% occurring in the lower extremities. Flexible pes planus is the most common malalignment among basketball players, and the most common intervention is supportive taping. However, research on the effects of taping and kinesio taping on landing techniques and skills is limited and warrants further exploration. Therefore, the present study aimed to compare the skills and landing errors of basketball players with flexible pes planus when using two common supportive taping methods.

**Materials and Methods:** The subjects of this quasi-experimental, applied study included professional male basketball players with flexible pes planus (age: 22.91 ± 2.39 years, height: 190.83 ± 9.35 cm, weight: 93.83 ± 18.95 kg, basketball experience: 6.75 ± 1.81 years, Staheli index: 0.94 ± 0.03). Assessments included the Staheli index for flexible pes planus, skill tests (free throw, jump shot, and layup tests), and landing technique [Landing Error Scoring System (LESS) test]. The research interventions included supportive taping and kinesio taping. Data analysis was performed using a paired t-test at the 0.05 significance level.

**Results:** Data analysis revealed that supportive taping, compared to no taping, resulted in a 12.75% reduction in landing errors (P = 0.03) and a 5% increase in layup scores (P = 0.05). Additionally, supportive taping compared to kinesio taping led to a 6.5% increase in layup scores (P = 0.05), while kinesio taping compared to no taping resulted in a 6.5% decrease in free throw scores (P = 0.04).

**Conclusion:** In addition to reducing landing errors and their consequences, supportive taping also improves layup scores. Therefore, it is recommended that basketball players with flexible pes planus use low-dye taping rather than kinesio taping and no taping, as it reduces the risk of non-contact injuries from landing errors.

**Keywords:** Flexible pes planus; Basketball; Athletic skills; Landing technique; Taping; Kinesio taping

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## Introduction

A study of elite national basketball athletes competing in European leagues over six seasons (2014–2019) reported an injury prevalence of 12.59 per 1000 player-hours. Among all recorded injuries, 70.9% were non-contact, 74.8% involved the lower extremities, and 22.9% affected the knee joint. Moreover, injuries occurred approximately ten times more frequently during competition (77.83%) than during training (8.29%) (1). A comprehensive review of basketball injury epidemiology from 1990 to 2024 indicated that the knee and ankle were the most frequently injured sites among both male and female athletes. Ankle sprains and ligament strains were identified as the most prevalent injury types. The primary factors influencing the high incidence of these injuries were related to the

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biomechanics of jumping, landing, and directional changes (2). An analysis of anterior cruciate ligament (ACL) injury mechanisms among European professional basketball players (2014–2020) revealed that 3% of ACL injuries resulted from direct contact, 58% from indirect contact, and 39% were non-contact injuries. Notably, 83% of ACL injuries occurred during cutting movements in offensive and defensive plays (47% and 14%, respectively) or landing from a jump (22%). In over 75% of cases, the knee was flexed and valgus at the time of injury (3). Similarly, a study of collegiate basketball athletes (2015–2019) found an injury prevalence of 1.54 injuries per 1,000 player-hours among male athletes. The most common injury sites were the ankle (36.3%) and knee (10.4%), with sprains and strains being the predominant injury types (48%) (4). Collectively, epidemiological studies in basketball consistently report that the lower extremities (particularly the ankle and knee) represent the most common injury sites, non-contact mechanisms are the most frequent causes, and sprains and strains are the most prevalent injury types.

A review of 33 studies examining the prevalence and risk factors of musculoskeletal disorders among basketball players identified postural imbalance and dysfunctions of the human movement system as the primary causes of musculoskeletal injuries in this population (5). It appears that impairments in any component of the musculoskeletal system may serve as a risk factor for injuries in other body regions. Globally, more than 1.71 billion individuals suffer from postural misalignments and musculoskeletal imbalances. These misalignments can lead to pain, restricted range of motion, reduced muscular strength, and impaired performance, and are common not only among athletes but also within the general population (5). The prevalence of pes planus (flatfoot) among collegiate basketball players aged 18 to 25 years is approximately 80%, and this prevalence increases with longer basketball participation. Specifically, athletes who have played regularly for more than 4 years exhibit a 50% higher prevalence of pes planus than those with shorter participation histories (6). A review of 44 articles investigating pes planus assessment methods indicated that the Staheli Index (14 articles) and arch height measurement (14 articles) are the most frequently used evaluation techniques. Among these, the Staheli Index was identified as the most suitable method for use in screening and epidemiological studies (7).

Furthermore, an analysis of the validity and reliability of three common diagnostic tests for pes planus—compared with radiography as the gold standard—among competitive athletes aged 17 to 30 years demonstrated that both the Staheli and Smirak indices possess acceptable validity and reliability. Although reliable, the Clarke Index lacks sufficient validity. Overall, the Staheli Index was determined to be the most reliable assessment method, exhibiting an accuracy and sensitivity of 78% (8). Accordingly, the Staheli Index assessment method was employed in the present study.

In addition to increasing the risk of overuse injuries to bones, muscles, and ligaments, pes planus in weight-bearing sports such as basketball reduces the vertical ground reaction force, shortens the duration of force transmission to the foot during landing, and diminishes both static and dynamic balance (6). Poor landing technique and pes planus are two key risk factors for non-contact lower extremity injuries in basketball. Pes planus elevates the risk of non-contact injuries by altering movement patterns and load distribution during activities such as landing. Players with pes planus exhibit reduced ankle plantarflexion during the take-off phase of jumping, resulting in a stretched position of the gastrocnemius and soleus muscles and consequently decreased maximal force generation. To achieve performance comparable to their peers, these athletes must rely more heavily on the joints adjacent to the knee and hip, leading to accelerated lower-extremity fatigue, altered biomechanics, and an increased risk of injury (6). Overall, pes planus not only heightens injury risk in basketball players but also impairs athletic performance (6). Despite these findings, previous studies have not evaluated the specific effects of pes planus on basketball-related skills. Incorrect landing technique is a major risk factor for injury—particularly anterior cruciate ligament (ACL) rupture—and can also impair sports performance (9). Accordingly, landing-technique screening tests have been developed to identify athletes at risk of non-contact injuries. The Landing Error Scoring System (LESS) is a reliable, valid, and cost-effective two-dimensional assessment tool compared with more expensive three-dimensional motion analysis systems, demonstrating excellent intra- and inter-rater reliability (ICCs = 0.99–0.89 and 0.99–0.83, respectively). This test is commonly used to identify improper landing patterns and conditions that predispose athletes to non-contact lower extremity injuries, particularly those involving the knee, and to evaluate the effects of intervention programs (9). In the present study, the LESS test was therefore employed to assess landing technique.

Pes planus in basketball players reduces dynamic balance and negatively affects vertical jump

performance and landing forces (6). Pes planus is also directly associated with lower extremity injuries, including Achilles tendinitis, iliotibial band syndrome, knee pain, and low back pain. For example, the prevalence of patellar tendinopathy in basketball players with flexible pes planus is 20.7% higher than in their peers with normal foot posture (10). One of the most common corrective strategies for flexible pes planus is kinesio taping. Techniques such as Kinesio taping, Low-Dye taping, and modified Low-Dye taping have been shown to elevate the medial longitudinal arch, improve foot alignment, and enhance both static and dynamic balance (11, 12). Several studies have reported the beneficial effects of kinesio taping and Low-Dye taping in individuals with flexible pes planus (11, 12). Among these, Low-Dye taping and the navicular sling kinesio-taping are considered two effective interventions for mitigating the effects of flexible pes planus, as both significantly influence plantar pressure distribution, increase the medial longitudinal arch, and improve athletic performance, particularly balance (11–13). Although the Low-Dye technique appears more effective in reducing forefoot plantar pressure, athletes generally report greater comfort with the navicular sling kinesio-taping method (13). However, the influence of these two taping methods on landing technique and sport-specific skills has not yet been thoroughly investigated. Therefore, the present study aimed to compare the effects of these two common taping techniques on the landing technique and skills performance of basketball players with pes planus.

## Materials and Methods

The present study used a randomized, crossover design and adhered to the Declaration of Helsinki. Also, ethical approval of the study was obtained from the Research Ethics Committee of the University of Kurdistan with code IR.UOK.REC.1403.012.

*Research design and participants:* After collecting forms on personal information, sports history, and medical history from 112 volunteer basketball athletes with flexible pes planus, the sample size was estimated using the formula described by Althubaiti (2023). Twelve male professional basketball players (age 22.91 ± 2.39 years; playing experience 6.75 ± 1.81 years; weight 93.83 ± 18.95 kg; height 190.83 ± 9.35 cm; Staheli Index 0.94 ± 0.03) were randomly selected as the research subjects (14). Inclusion criteria included a foot score of 0.89, no ankle problems, no lower-extremity injuries in the past 12 months, and at least three years of regular basketball participation. Exclusion criteria included experiencing an acute injury during the study. Participants were informed about the procedures, potential benefits, and risks, and provided written informed consent. After consent, arrangements were made for participation in the evaluation session. At the outset, and after anthropometric measurements (height and weight) to familiarize participants with the tests, a healthy basketball player without pes planus performed the LESS and the other skill tests. After a 10-minute dynamic basketball warm-up (15), assessments were conducted in a random order across three conditions: no taping, taping, and kinesiotaping. In each condition, the LESS was performed first, followed by a 2-minute rest, after which the three skill tests were performed in random order, with a 2-minute rest between tests. The study employed a randomized, crossover design and adhered to the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the University of Kurdistan (IR.UOK.REC.1403.012).

### Assessment tests

*Staheli Index:* The Staheli Arch Index, which has been validated and shown to be reliable (16, 17), was used to determine flexible pes planus. After drawing the footprint, the narrowest part of the arch and the widest part of the heel were measured to 1 mm precision and used in the Staheli index formula (the ratio of the arch-narrow width to the heel width). This index has reported accuracy of 0.80 and a sensitivity of 81.8%, with an intra-group reliability (ICC) of 0.93 (17). The normal Staheli index range is reported as 0.7-1.35 in children and 0.44-0.89 in adults (18). Values higher than 0.89 are considered indicative of flat feet (18).

*LESS Test:* The LESS test was used to assess landing technique (Figure 1). A basketball player stands on a 30 cm-high platform, feet shoulder-width apart. At the start of the test, the player steps off the box onto a line 50 cm in front of the box and immediately performs a maximal vertical jump, similar to a rebound. LESS was recorded by two Casio zR1000 video cameras (240 frames per second) in the frontal and sagittal planes. The cameras were positioned at a distance of 3.5 m and a height of 1 m (6). A three-point scoring system (0 = excellent, 1 = moderate, 2 = poor) was used to quantify lower-limb and trunk kinematics at initial ground contact and at maximum knee flexion, using Kinova software (version 0.9.5). Intra- and inter-rater reliability were reported as ICCs of 0.89–0.99 and 0.83–0.99, respectively (6).

### Skill Tests

*Free Throw:* The participant performs free throws for one minute (Figure 2, right). The number of successful free throws is recorded as the test score (20).

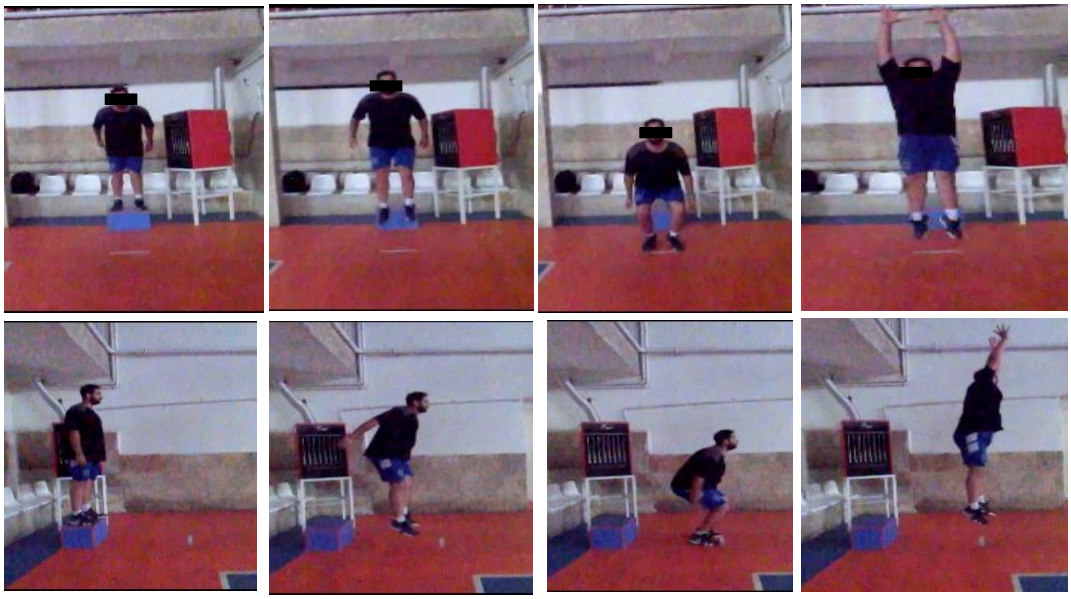

**Figure 1.** LESS test, right side

*Jump Shot:* The participant dribbles the ball into the zone from behind the three-point line for one minute without interruption, and immediately returns behind the three-point line to initiate the next attempt. The number of successful shots is recorded as the test score (Figure 2, middle) (20).

*Layup Shooting:* The participant dribbles the ball into the zone from behind the three-point line for 1 minute without interruption, then immediately returns to the three-point line to start the next attempt (Figure 2, left). The number of successful layups is recorded as the test score (20).

**Interventional measures**

*Kinesio taping of the navicular sling:* A two-inch-wide blue Kinesio tape was applied using the navicular sling taping technique (Figure 3, right). Before application, the skin was cleaned, dried, and hair-free to ensure proper adhesion. The tape was anchored on the dorsal aspect of the foot, extending laterally from the midfoot over the metatarsal region toward the fifth metatarsal. It was then directed under the plantar surface of the foot, moving medially across the first metatarsal, and continued beneath the navicular bone. From there, the tape was brought upward over the medial malleolus, then pulled obliquely across the anterior aspect of the ankle, passing over the lateral malleolus. Finally, it extended posteriorly across the heel, above the Achilles tendon, where it was secured (11, 12). This taping configuration provides dynamic support for the medial longitudinal arch and enhances stabilization of the navicular bone during weight-bearing activities.

*Low-Dye Taping:* The Low-Dye taping technique is an effective method for increasing navicular height and correcting an overpronated foot or flexible pes planus (13).

**Figure 2.** Skill tests in basketball: Layup (left), jump shot (middle), and free throw (right)

**Figure 3.** Navicular Sling Kinesio taping (right) and Low-Dye taping (left)

A rigid white zinc oxide tape was used for this procedure. During the application, the subject positioned the ankle in a neutral alignment. An anchor strip was first applied, extending from the medial aspect of the head of the first metatarsal joint, passing under the medial malleolus, and wrapping around the heel. The tape then continued beneath the lateral malleolus toward the lateral aspect of the head of the fifth metatarsal joint (Figure 3, left). Subsequently, supporting strips were applied across the plantar surface of the foot, running parallel from lateral to medial, and attaching to the anchor on each side. Depending on the size of the participant's foot, approximately five to six strips were used to fully cover the metatarsal region of the sole (12, 13).

*Data analysis:* After confirming normality of the data distribution via the Shapiro–Wilk test in SPSS version 25, a paired-samples t-test ($\alpha = 0.05$) was conducted to examine differences in sports skills and landing techniques across conditions.

## Results

The results of the paired-samples t-test (Table 1) revealed that taping significantly reduced the LESS score compared with no taping ($t = 2.57$, $P = 0.03$). In contrast, the comparison between kinesio taping and no taping did not reach statistical significance ($t = 1.17$, $P = 0.27$).

The study examining the effects of taping and Kinesio-taping on sports skills showed that Kinesio-taping, compared to Low-Dye taping, led to a significant 6.5% decrease in free-throw scores ($P = 0.04$, $t = 2.34$). Changes in regional throw scores during Low-Dye taping and Kinesio-taping, compared to no-taping, were not statistically significant. Low-Dye taping, compared to no-taping, caused a significant 5% increase in layup scores ($P = 0.05$, $t = 2.24$). Furthermore, Low-Dye taping compared to Kinesio-taping resulted in a significant 6.5% increase in layup scores ($P = 0.05$, $t = 2.28$) (Figure 4).

## Discussion

Flexible pes planus (flat feet) is one of the most common lower-extremity malalignments among athletes, particularly basketball players, and is characterized by internal rotation of the talus, eversion of the calcaneus, and the reduction or collapse of the medial longitudinal arch (21,22). This malalignment leads to altered biomechanical patterns of the lower extremity and increases shear and compressive forces at the joints of the foot, knee, and hip. Because the foot plays a key role in body weight distribution and balance, any structural or functional malalignment can affect the entire kinetic chain (23).

Studies have shown that the prevalence of flat feet among athletes ranges from 11% to 39%, and among professional basketball players up to 80% (21, 22). In professional basketball players, flat feet are associated with pain, early fatigue, movement inefficiency, and, in some cases, the development of secondary deformities such as hallux valgus (24). Moreover, individuals with flat feet exhibit poorer athletic performance than those with neutral arches in short-duration high-intensity activities, such as sprinting (25). This underscores the importance of attention to correction and control of this malalignment. In sports like basketball, which involve frequent jumping and rapid directional changes, this condition can lead to poorer landing technique and an increased risk of knee and ankle injuries (26, 27). Jumping and landing are repetitive movements in several sports, such as basketball.

**Table 1.** Results of Paired-Samples t test: Differences in Basketball Skills and LESS in Different Situations

| Variable | No taping-taping | | | No taping- Kinesiotaping | | | Taping- Kinesiotaping | | |
|---|---|---|---|---|---|---|---|---|---|
| | P | t | SEM | P | t | SEM | P | t | SEM |
| LESS | 0.03 | 2.57 | 0.50 | 0.27 | 1.17 | 0.34 | 0.44 | 0.80 | 0.17 |
| Free Throw | 0.11 | 1.73 | 0.49 | 0.04 | 2.35 | 0.67 | 0.62 | 0.52 | 0.18 |
| Jump Shot | 0.14 | 1.60 | 0.42 | 0.31 | 1.07 | 0.50 | 0.84 | 0.21 | 0.09 |
| Layup shooting | 0.05 | 2.25 | 0.58 | 0.64 | 0.49 | 0.17 | 0.05 | 2.28 | 0.75 |

LESS: Landing Error Scoring System; SEM: Standard error of the mean

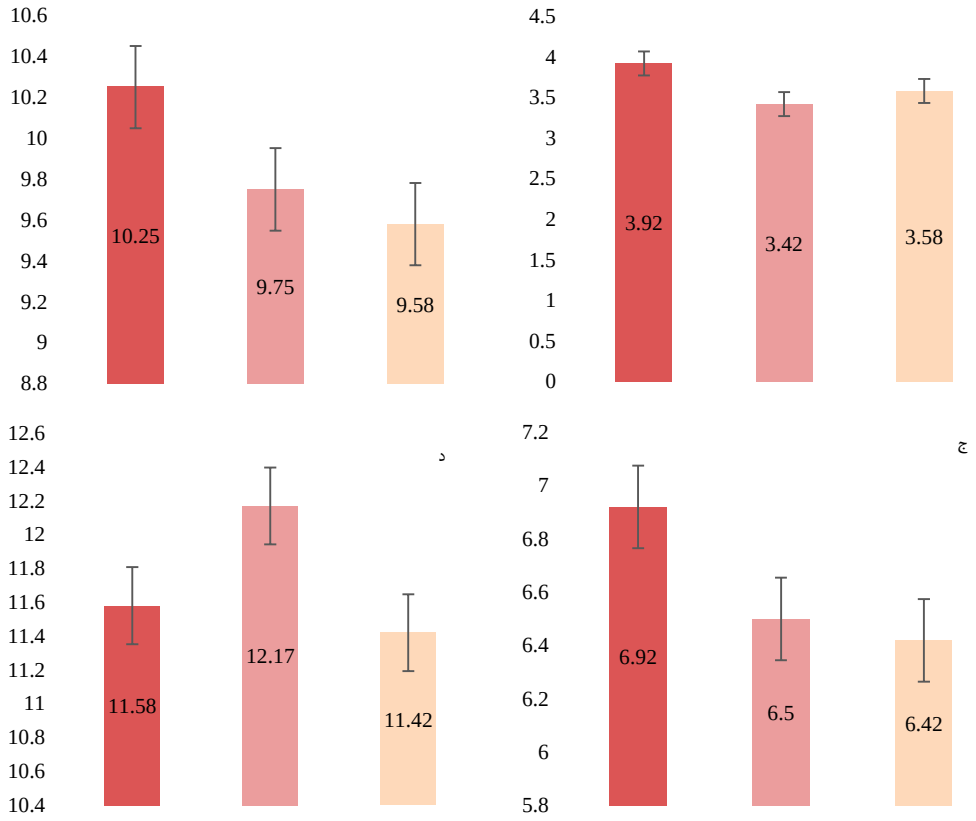


**Figure 4.** Research variables in three conditions: no-taping (blue), taping (red), and kinesio-taping (green). Variables from left to right: LESS, free throws, jump shots, and layups

On average, a basketball player performs about 70 jumps and landings per game, and each jump/landing transmits 5–7 times body weight to the lower extremities (26). Poor landing technique increases the risk of lower-extremity injuries. Indeed, 45% of basketball injuries occur during landing and adversely affect skill and performance (26, 27). Therefore, precise assessment of foot status and the use of corrective interventions are important for maintaining performance and preventing sports injuries.

The most common interventional measure among athletes and clinicians to mitigate the effects of flexible flatfoot is supportive taping, such as Low-Dye taping and navicular sling kinsio taping (28). The present study found that Low-Dye taping, compared with notaping, produced a significant reduction in the Landing Error Scoring System (LESS) score (12.75%) and a notable increase in the mean layup skill score (5%). In contrast, the navicular sling did not significantly affect landing technique or free-throw performance. This may reflect the high level of landing technique among participants in this study, as the mean LESS score was less than 4 and within the range of excellent landing technique (29). In addition, results indicated that flat feet, by increasing extraneous foot movements during tasks such as landing and jumping, reduce neuromuscular control and increase injury risk (30, 31). These findings align with previous studies showing that individuals with flat feet, compared with healthy controls, exhibit greater lower-limb joint flexion angles, reduced ground reaction forces, and poorer control of the loads imposed during landing (30–32). Consequently, it can be stated that Low-Dye taping, by increasing the stability of the longitudinal arch and improving movement control, may play a meaningful role in reducing injury risk and enhancing athletic performance.

Among basketball players with excessive pronation, Low-Dye taping, in addition to reducing navicular drop and correcting overpronation, is associated with increased Reactive Strength Index (RSI) and greater gluteal muscle activity during the eccentric (downward) phase of a bilateral squat, but does not significantly affect vertical jump performance (33). A review of 16 studies on the effects of Low-Dye taping and navicular sling on the arches of adults with

flexible flat feet up to March 2020 showed that all three techniques—Low-Dye, modified Low-Dye, and navicular sling—were effective in reducing navicular drop (34). Although the Low-Dye technique better controls arch collapse in a non-activity state, during functional activity, the modified Low-Dye technique yields better results. Navicular sling and Low-Dye did not sustain this effect during running; however, during activity, the modified Low-Dye technique better limits arch deformation (34). The recent study by Khoṛshidi and colleagues (2025) also showed that Low-Dye taping provides better short-term performance than the navicular sling in men with flexible flat feet (35). The findings of this study and the existing literature suggest that both supportive Low-Dyetaping and navicular sling reduce navicular drop and improve longitudinal arch status, but their effects on dynamic activities differ. Evidence suggests that the modified Low-Dyetechnique offers more effective control of longitudinal arch collapse during functional activities and yields more stable performance compared with the navicular sling. Accordingly, the modified Low-Dye taping is recommended for basketball players with flexible flat feet to improve landing technique, movement efficiency, and sport-specific skills (34). Additionally, given the foot's direct role in absorbing and transferring forces, implementing corrective interventions can positively affect gluteal muscle activity, the RSI, and the control of the lower-extremity kinetic chain. Finally, the results emphasize that employing effective supportive methods, such as the modified Low-Dye taping, can serve as a preventive and performance-enhancing strategy to reduce lower-limb injury risk and improve athletic performance in basketball players with flexible flat feet.

## Limitations

The present study was conducted on professional male basketball players with flexible pes planus and proficient landing technique, investigating the short-term effects of taping and Kinesio-taping under non-fatigue conditions. Therefore, the results cannot be generalized to fatigued conditions, female basketball players, semi-professional or elite athletes, or to other age groups outside the 18-25 years range. This limitation arises because landing technique and sports skills may vary across populations.

## Recommendations

Professional male basketball players with flexible pes planus, aged 18 to 25 years, and their coaches are recommended to use low-dye taping rather than other common methods, such as navicular sling Kinesio-taping, as it not only reduces landing errors but also improves performance in basketball skills. It is further recommended that future research investigate the effects of taping and Kinesio-taping on landing kinetics under functional fatigue conditions. To better understand the forces and kinetics during landing and jumping, force-plate assessments are recommended. Additionally, future studies should focus on basketball players with flexible pes planus and landing-technique deficits, particularly those with LESS scores above 6.

## Conclusion

In conclusion, flexible flatfoot is prevalent among basketball players and is associated with altered lower-limb mechanics, increased injury risk, and potential performance limitations. Corrective interventions—most notably the modified Low-Dye taping—can improve arch stability, landing technique, and certain performance indices, while the navicular sling may offer limited benefits for dynamic activities. For athletes with flexible flat feet, incorporating targeted taping approaches alongside conditioning and technique training appears to be a practical strategy to reduce injury risk and enhance movement efficiency and sport-specific skills. Further longitudinal and sport-specific studies are warranted to confirm long-term benefits, optimize application protocols, and clarify which subgroups of athletes benefit most from each technique.

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## Authors' Contribution

Project design and conceptualization: Hemn Mohammadi, Mohammad Rasoul Omid
Attracting financial resources to carry out the project: Hemn Mohammadi
Project support, scientific and executive services: Hemn Mohammadi, Mohammad Rasoul Omid
Providing equipment and statistical sample: Hemn Mohammadi, Mohammad Rasoul Omid
Data collection: Mohammad Rasoul Omid
Analysis and interpretation of the results: Hemn Mohammadi
Specialized statistics services: Hemn Mohammadi
Manuscript preparation: Hemn Mohammadi, Mohammad Rasoul Omid

Critical scientific evaluation of the manuscript: Hemn Mohammadi, Mohammad Rasoul Omid
Approving the final manuscript to be submitted to the journal: Hemn Mohammadi, Mohammad Rasoul Omid
Maintaining the integrity of the study process from the beginning to the publication and responding to the reviewers' comments: Hemn Mohammadi, Mohammad Rasoul Omid

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## Conflict of Interest

The authors did not have a conflict of interest.

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