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### Correlation of FMS and LESS scores in predicting lower limb injury risk among university-level male players

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**Abstract:** To explore the relationship between Functional Movement Screen (FMS) and Landing Error Scoring System (LESS) scores in predicting lower limb injury risk among university-level male athletes. This study specifically focused on five lower limb–dominant components of the FMS, excluding push-up and shoulder mobility assessments, to align with the needs of lower limb–dominant athletes. A cross-sectional observational study was conducted at the Sports Science Department, Guru Nanak Dev University, Amritsar. Forty-eight physically active male university athletes (aged 18–25 years) were selected through well-defined inclusion criteria, all of whom were regularly physically active. FMS scores from five lower limb–dominant components and LESS total scores were analyzed using Pearson correlation to understand their relationship. The analysis showed a significant moderate negative correlation ( $r = -0.363$ , 95% CI  $[-0.512, -0.168]$ ,  $p = 0.01$ ), indicating that better lower limb movement quality (higher FMS scores) correlates with safer landing mechanics (lower LESS scores). The combined use of five lower limb–dominant FMS components and LESS assessment can provide a clearer picture of lower limb injury risk in university-level male players. The study highlights how these tools can be adapted for diverse athletic populations focusing on lower limb functionality.

**Keywords:** Functional Movement Screen, Landing Error Scoring System, Lower Limb Injury, Injury Prediction, Athlete Screening.

#### 1. INTRODUCTION

In recent years, the study of human movement and its role in injury prevention has gained significant attention, particularly among athletic and physically active populations. Tools such as the Functional Movement Screen and the Landing Error Scoring System are widely used to assess movement quality and predict injury risk. The FMS evaluates core stability, flexibility, and balance, while LESS focuses on landing mechanics and alignment. These tools are important for identifying movement dysfunctions that may predispose individuals to injuries, especially during dynamic or high-impact activities. However, the potential synergy between these tools in predicting injury risk remains unclear, particularly in non-Western contexts<sup>3, 8</sup>.

Lower limb injuries are common among active individuals and often result from multifactorial causes such as poor movement mechanics, environmental influences, and individual physical characteristics. Limitations in flexibility or core stability, as assessed by FMS, can lead to compensatory movement patterns that increase the risk of lower limb injuries<sup>2, 14</sup>. For example, deficits in hip or ankle mobility may cause improper knee alignment during dynamic activities, increasing the likelihood of injuries such as ACL tears or patellofemoral pain.

Similarly, improper landing mechanics identified through LESS may reflect misalignments or high-impact forces that further elevate injury risk<sup>15,16</sup>. Together, FMS and LESS provide complementary insights into movement quality and susceptibility to lower limb injuries.

Although the predictive capacity of FMS and LESS has been widely studied in Western populations, their applicability in Asian populations remains underexplored<sup>20</sup>. Cultural and environmental factors may influence movement patterns and test outcomes. For instance, squatting as a resting posture is common in many Asian cultures and may enhance hip and ankle flexibility, thereby affecting FMS performance, particularly during squatting tasks<sup>4</sup>. Additionally, footwear preferences such as minimal or flat-soled shoes may influence movement and landing mechanics. Environmental factors including climate, terrain, and temperature may also affect joint mobility and muscle stiffness, influencing performance on both FMS and LESS tests<sup>7,13</sup>. These factors highlight the need to evaluate these tools in diverse populations.

Injury prevention is essential for maintaining performance and long-term musculoskeletal health. Both FMS and LESS have demonstrated utility in identifying injury risk; however, their combined predictive value requires further investigation. Studies have shown that lower FMS scores are associated with increased risk of lower extremity injuries, while poor landing mechanics assessed by LESS are linked to a higher incidence of knee injuries such as ACL tears and patellar tendinopathy<sup>9,21</sup>. This suggests that integrating these tools may provide a more comprehensive assessment of injury risk, incorporating multiple aspects of movement.

Furthermore, the effectiveness of these tools may be enhanced by considering culture-specific factors. Regional movement habits, such as frequent squatting, may influence joint mobility and posture, thereby affecting both FMS and LESS outcomes. Similarly, habitual patterns like barefoot walking or varied footwear use may alter kinetic chain mechanics and impact injury risk<sup>5</sup>. Understanding these interactions is important for developing accurate and culturally relevant injury assessments.

This study seeks to investigate the correlation between FMS and LESS scores in predicting lower limb injury risk within an Asian population—an area that remains underexplored<sup>11</sup>. The aim is to examine whether higher FMS scores correlate with lower LESS scores, indicating better movement quality and safer landing mechanics. It is hypothesized that individuals with higher FMS scores will demonstrate lower LESS scores, reflecting reduced injury risk. This research is expected to contribute to the understanding of injury prevention and support the development of more personalized and culturally relevant strategies<sup>12,23</sup>.

## **2. MATERIALS AND METHODS**

### **2.1. Study Design**

This cross-sectional observational study was designed to explore the relationship between Functional Movement Screen (FMS) scores and Landing Error Scoring System (LESS) scores, with a specific focus on lower limb injury risk. Standardized protocols were followed for both FMS and LESS assessments. Ethical approval was obtained from the Institutional Ethics Committee, and the study followed the principles of the Helsinki Declaration.

### **2.2. Participants**

The study included 48 physically active male university athletes aged 18–25 years (mean age: 22.16 ± 2.5 years). Participants were recruited from Guru Nanak Dev University, Amritsar. Inclusion criteria required participants to have no recent lower limb injuries within the last 6 months and to maintain an active lifestyle. Individuals were excluded if they had any current injuries or conditions that might affect their ability to perform the functional movement or landing tests accurately. All participants provided written informed consent prior to participation.

## **3. PROCEDURES**

### **3.1. Functional Movement Screen (FMS)**

The FMS was adapted to focus specifically on lower limb movements. Two tests—Shoulder Mobility and Trunk Stability Push-up—were excluded to align with the study's focus on lower limb injury risk. The following five FMS components were assessed: Deep Squat, Hurdle Step, In-line Lunge, Active Straight Leg Raise, and Rotary Stability. Each movement was scored on a scale from 0 to 3: 3 points for optimal movement without compensation; 2 points for acceptable movement with some compensation; 1 point for significant movement deficiencies; and 0 points if pain occurred during the movement. The total FMS score was calculated by summing the scores for all five movements, resulting in a maximum possible score of 15. Assessments were conducted by trained evaluators to ensure consistency and accuracy.

### 3.2.Landing Error Scoring System (LESS)

The LESS assessment was performed to evaluate landing mechanics. Participants were instructed to jump off a 30 cm platform and land with both feet on a marked area approximately 50 cm away before immediately performing a vertical jump. Video recordings were captured using a Nikon Coolpix camera (Nikon Corp, Tokyo, Japan) from the front and side views to analyze landing errors. Video data were analyzed using Kinovea software (Version 0.9.5, USA). Scoring focused on key components such as knee valgus, trunk positioning, and overall landing alignment. Higher LESS scores indicated more landing errors, signifying poorer mechanics and a higher risk of injury.

### 3.3.Data Collection

The LESS protocol was used to assess landing mechanics, focusing on identifying landing errors associated with increased lower limb injury risk. Participants performed a jump-landing task from a 30 cm platform to a marked landing area. They were instructed to jump forward off the platform, land within the marked area on both feet, and then perform a maximal vertical jump immediately upon landing. An average score from multiple trials was calculated for each participant's final LESS score.

### 3.4.Assessment

Assessment of the landing technique was conducted using a two-dimensional setup with a Nikon Coolpix camera (Nikon Corp, Tokyo, Japan). The captured movements were recorded and scored based on predefined criteria evaluating knee alignment, trunk position, and foot placement upon landing. The movements were assessed using Kinovea software (Version 0.9.5, USA) to identify specific movement errors. This setup enabled a detailed analysis of landing mechanics for each participant.

### 3.5.Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics (Version 27.0, IBM Corp, Armonk, NY, USA). Descriptive statistics were used to summarize the data. The relationship between the five-component FMS scores and LESS total scores was examined using Pearson correlation analysis. A significant negative correlation was hypothesized, suggesting that better movement quality (higher FMS scores) would align with safer landing mechanics (lower LESS scores). The level of significance for all tests was set at  $p < 0.05$ .

## 4. RESULTS

The results of present study provide a comprehensive analysis of participants demographic characteristics and relationship between Functional Movement Screen (FMS) scores and Landing Error Scoring System (LESS) scores.

**Table 1: Descriptive Statistics of Participants (N = 48)**

Demographic variables	Mean $\pm$ SD
Age (years)	22.16 $\pm$ 2.5
Height (m)	1.75 $\pm$ 0.08
Weight (kg)	68.36 $\pm$ 10.80
BMI (kg/m <sup>2</sup> )	22.03 $\pm$ 2.51

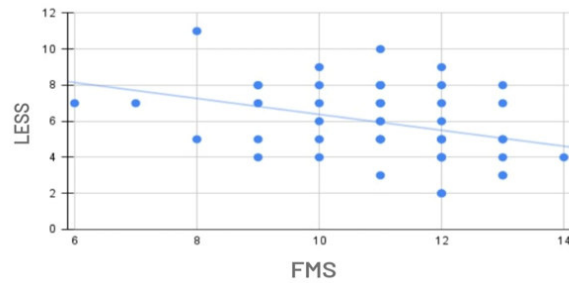
**Table 2: Mean values and standard deviation of FMS and LESS scores**

Variables	Mean $\pm$ SD
FMS	10.95 $\pm$ 1.68
LESS	5.95 $\pm$ 2.05

**Table 3: Pearson's correlation between FMS and LESS scores (N = 48)**

Variable	Correlation coefficient (r value)	P value
Scores obtained from FMS and LESS	-0.363	0.01

Table 3 shows a moderate negative correlation between Functional Movement Screen (FMS) and Landing Error Scoring System (LESS) scores (Pearson correlation coefficient  $r = -0.363$ ,  $p = 0.01$ ). This correlation suggests that higher FMS scores is an indicative of better functional movement quality and lower LESS scores reflect fewer landing errors and potentially reduced injury risks.



**Figure 1: Scatter Plot of LESS Scores versus FMS Scores**

Figure 1 shows the relationship between participants' Functional Movement Screen (FMS) scores and Landing Error Scoring System (LESS) scores. Each point on the graph represents an individual participant's scores on these assessments, with FMS scores plotted along the horizontal axis and LESS scores along the vertical axis.

A downward-sloping trend line highlights a general pattern in the data: as FMS scores increase, indicating better movement quality, LESS scores tend to decrease, suggesting fewer landing errors. This negative association aligns with the study's statistical analysis, which revealed a moderate inverse correlation between FMS and LESS scores ( $r = -0.363$ ,  $p = 0.01$ ).

The data points display a range of scores for both FMS and LESS, reflecting diverse movement abilities and landing mechanics within the participant group. This trend supports the hypothesis that individuals with stronger functional movement skills are likely to show more controlled and stable landings, an insight that could be valuable in developing injury prevention strategies focused on movement quality.

## 5. DISCUSSION

The present investigation offers insight into the moderately strong negative relationship between Functional Movement Screen (FMS) scores and Landing Error Scoring System (LESS) scores among university-level athletes, demonstrated by a Pearson correlation coefficient of  $r = -0.363$  ( $p = 0.01$ ). This finding aligns with the conclusions drawn by Everard et al. (2017), who also identified a moderate correlation between FMS and LESS, suggesting that higher performance in one does not necessarily guarantee parallel outcomes in the other<sup>5</sup>. This is likely due to the fundamentally different physical demands each test places on the athletes.

The LESS test is heavily reliant on efficient eccentric muscle control to optimize landing quality, a key aspect of injury prevention in many sports. Proper landing technique minimizes ground reaction forces and lowers injury risk, especially in dynamic and high-impact activities. A study by Chaudhary et al. (2022) found that in static as well as dynamic phase, the total pressure is more in the forefoot region in subjects with MTSS as compared to without MTSS. In contrast, the FMS test emphasizes slower, controlled movements that generate less ground reaction force, aiming to assess joint stability, mobility, and overall functional movement rather than dynamic landing capabilities. As a result, the two tests provide complementary but distinct insights into an athlete's physical capabilities and potential injury risk. In this study, the mean FMS score for male university players from an Asian population was  $10.95 \pm 1.68$ . This is noticeably lower than scores reported in prior studies<sup>5,11</sup>. A key methodological note in this study is that the FMS scoring was based on only five lower-limb-dominant components, omitting shoulder and trunk stability to focus on lower-body function. This modification reduced the maximum possible score to 15 instead of 21. If scaled to the equivalent 21-point system, our mean would be roughly 15.3, which is very similar to prior reports. The average LESS scores observed in this study were  $5.95 \pm 2.05$ , which is consistent with findings from other research where scores averaged  $7.37 \pm 3.3$  and  $4.93 \pm 1.67$ . These findings suggest a moderate injury risk level in the present cohorts. Variations in scores compared to previous research may be attributed to multiple factors, including the unique physical and cultural characteristics of an Asian demographic<sup>12</sup>. It was previously reported that genetic and environmental factors play a role in shaping athletic performance and injury susceptibility. Cultural differences in training and movement habits may thus contribute to the observed differences in FMS and LESS scores across diverse populations<sup>12</sup>.

## 6. CONCLUSION

The present study concluded a moderate negative correlation between FMS and LESS scores in university-level athletes. Higher FMS scores moderately associated with lower LESS scores signify safer landing mechanics. These observations highlight the importance of using both the tools together to gain a comprehensive understanding of movement quality and landing mechanics. These insights allow clinicians and sport

professionals to design targeted interventions that address both static movement deficiencies and dynamic landing errors, reducing the overall risk of lower limb injuries.

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