ISSN: 2476-5279; International Journal of Musculoskeletal Pain Prevention. 2026;11(1):1356-1362.

# Comparison of the Landing Error Scoring System Between Individuals with Concurrent Flexible Flatfoot and Genu Varum and Healthy Controls

**ARTICLE INFO**

*Article Type*
**Original Article**

*Authors*

Naser Ebrahimi[1*], MSc
Hashem Piri[1*],PhD
Pouria Tangsiri[1], Msc

**How to cite this article**

Ebrahimi N, Piri H, Tangsiri P. Comparison of the Landing Error Scoring System Between Individuals with Concurrent Flexible Flatfoot and Genu Varum and Healthy Controls Int J. Musculoskelet. Pain. Prev. 2026;11(1): 1356-1362.

[1] Department of Corrective Exercise and Sport Injury, Faculty of Physical Education and Sport Sciences, Allamah Tabatabaei University, Tehran, Iran.

doi .48311/ijmpp.2026.118350.8291110

*** Correspondence**
Department of Corrective Exercise and Sport Injury, Faculty of Physical Education and Sport Sciences, Allamah Tabatabaei University, Tehran, Iran
P.O. Box: 1678815811
Tel: 00 98 903 0817449
E-mail hpiry63@gmail.com

*Article History*
Received: Dec 16, 2025
Accepted: Jan17, 2026
ePublished: Jan 28, 2026

**ABSTRACT**

**Aims:** The Landing Error Scoring System (LESS) is a valuable tool for quantifying jump-landing biomechanics and identifying injury risk. While Flexible Flat Foot (FFF) and Genu Varum (GV) are prevalent postural deformities known to influence lower-limb alignment, their combined impact on LESS performance has remained unexplored. This study aimed to compare LESS scores in athletes with concurrent FFF and GV deformities with those of healthy controls.

**Method and Materials:** This clinical trial study recruited 52 male athletes from Tehran sports clubs and allocated them to either a control group (n=26) or a concurrent FFF and GV group (n=26). The deformities were clinically diagnosed by using the navicular drop test (>9mm) and intercondylar distance measurement (>3cm). Participants performed a double-leg jump-landing from a 30-cm box, which was analyzed via video assessment in the frontal and sagittal planes, and their LESS scores were meticulously recorded. Individual LESS items and demographic data were compared using independent t-tests, Chi-square, and Mann-Whitney U tests. The statistical significance level is set at 0.05.

**Findings:** The groups were demographically similar (p>0.05). The statistical analysis of the total LESS Score (sum of all 17 items) did not reveal a significant difference between the concurrent FFF/GV and Control groups (p>0.05). However, the "joint displacement" did show a significant between-group difference, with the concurrent deformities group having a higher mean rank (U = 237, p = 0.024).

**Conclusion:** The finding that the total LESS score was preserved suggests that the overall landing strategy may be maintained through compensatory mechanisms. Nevertheless, the significantly greater joint displacement in the deformity group indicates localized biomechanical alteration and a potential compensatory strategy. This highlights that the composite LESS score may mask clinically meaningful impairments. For athletes with FFF and GV, a component-level analysis of the LESS is recommended to identify these subtle deficits and guide targeted neuromuscular and corrective training programs to mitigate injury risk.

**Keywords**: Anterior cruciate ligament; Biomechanics; Flatfeet; Injury; Jump-Landing; Knock-knee; Prevention

## Introduction

Musculoskeletal disorders and structural deformities of the lower limbs significantly impact movement patterns, balance, and functional capacity during both daily activities and sports. Identifying these alterations is of great clinical and injury-preventive importance, as abnormal movement patterns are recognized risk factors for pathologies such as Anterior Cruciate Ligament (ACL) tears (1). Among the most common lower limb postural abnormalities in the athletic population are flatfoot and Genu Varum (GV) (2). Flatfoot is characterized by a reduction in the medial longitudinal arch height (3) and is often associated with pain during gait, foot deformities, and lower back pain (4, 5). Biomechanically, flatfoot promotes excessive foot pronation, which subsequently alters knee alignment (6, 7). Similarly, GV (bowleg) involves a frontal-plane (8) knee impairment that increases medial knee loading and joint mechanics, increasing the risk of patellofemoral pain syndrome and ACL injuries (9-11). Increased medial knee loading and altered joint mechanics secondary to GV both augment the risk of knee injuries. Several studies identified GV as a potential risk factor in the development of

*Copyright© 2026, TMU Press. This open-access article is published under the terms of the Creative Commons Attribution-Noncommercial 4.0 International License which permits Share (copy and redistribute the material in any medium or format) and Adapt (remix, transform, and build upon the material) under the Attribution-Noncommercial terms*

patellofemoral pain syndrome, as well as a predictor of ACL injury [12]. Flexible Flatfoot (FFF) and GV are two highly prevalent limb deformities that can independently alter limb alignment, joint loading mechanics, and the quality of motion. The literature substantiates that lower landing quality is related to larger faults, greater knee valgus or knee varus angulations, and diminished neuromuscular control [1, 12]. Jump-landing movements are a high-risk activity in athletics due to the high forces—often up to 12 times body weight—transmitted through lower-limb joints [13]. Approximately 80% of ACL injuries occur during non-contact activities, typically during deceleration or jump-landing phases [14, 15], lateral turns, or sudden changes in direction that exert considerable stress on the knee joint [15]. Poor trunk control and force distribution can lead to exaggerated frontal plane motion and high knee valgus, resulting in excessive rotatory forces across the knee joint [16]. While FFF and GV independently alter joint loading, their combined impact on landing quality, as measured by the LESS, has not been established [17]. Optimal landing with correct knee alignment will allow for the best possible distribution of forces during load absorption [18]. Knee valgus (medial collapse), along with foot abduction, was found to be the most common position during non-contact ACL injuries [19]. According to modified biomechanical models, significant risk factors for non-contact ACL injury include decreased knee flexion angles, high posterior ground reaction forces, and high knee valgus moments [20]. Various jump-landing tests, including the Landing Error Scoring System (LESS), jump-landing video screening, and the tuck jump assessment, are widely used in clinical practice. Based on our current literature review, a variety of studies have investigated the usefulness of such tests for assessing ACL injury risk [16, 21]. The LESS is a valid and widely utilized instrument to qualitatively and semi-quantitatively evaluate landing quality, with respect to movement errors during the landing phase [22]. Several investigations have recognized LESS as a valid and reliable screening indicator of injury risk among athletes [3]. The Landing Error Scoring System (LESS) is a movement analysis tool developed by Padua (Padua et al., 2009) in 2009 to identify the risk of sustaining non-contact anterior cruciate ligament (ACL) injuries and biomechanical movement patterns involved [23,24]

Inadequate neuromuscular control of the lower limbs and trunk can increase the risk of non-contact injuries, particularly ACL tears. Such injuries often result from dynamic knee valgus, poor trunk control, and improper force distribution during landing. Given the high prevalence of non-contact ACL injuries and the critical role of neuromuscular [25] deficits in altering landing mechanics, it is essential to examine interventions that improve trunk and lower-limb control [26, 27]. This issue is significant for athletes with structural or functional lower limb abnormalities, such as FFF or GV, as these conditions may further increase the likelihood of dynamic knee valgus during landing. No research study has, to date, specifically explored the combined impact of FFF and GV on the outcomes of the LESS. Given that each deformity can independently affect lower limb alignment, joint range of motion, and loading mechanics, the combination of both deformities may cumulatively have additive or exacerbating effects on landing quality and movement patterns. This study aims to compare LESS scores and their sub-components to identify subtle deficits that could inform specific preventive measures

## Method and Materials

This clinical trial study recruited male athletes (aged 18–32). It divided them into a control group (n = 25) and a concurrent FFF/GV group (n = 27), based on a G*Power sample size calculation ($\alpha$ = 0.05, power = 0.80).

Participants were required to have at least 3 years of athletic experience and to attend three weekly practice sessions. The deformity group was explicitly defined by a navicular drop >9 mm (Brody test) and a standing intercondylar distance >3 cm. Excluded were those with a history of ankle sprains, recent lower-limb surgeries or fractures within the past year, incomplete data, or injury during the study.

Assessment tools and procedures were as follows.

FFF diagnosis: Brody procedure (navicular drop >9 mm) was used. It was evaluated using the Tip-Toe test differentiated FFF from structural flatfeet [28].

GV diagnosis: It was measured as a medial distance between the knees (intercondylar distance) greater than 3 cm while the medial malleoli were touching [29, 30].

Landing quality was evaluated using the Landing Error Scoring System (LESS), where participants performed a double-leg jump from a 30-cm platform to a distance of 50% body height (Figure 1), immediately followed by a maximal vertical jump. Following 2–3 practice attempts, trials were recorded without technique feedback, and incorrect trials were repeated. Two cameras (frontal/sagittal planes; 3m distance, 1.5m height) captured the motion for analysis via Kinovea software. The standard 17-item LESS scores faults as one and correct performance as 0, with higher cumulative scores indicating poorer technique and elevated injury risk. Previous research confirms the LESS as a valid and reliable tool with good-to-excellent agreement for identifying neuromuscular deficits and ACL injury risk [23, 31-34].

**Figure 1-** LESS test procedure

Data were analyzed using SPSS version 26 with significance set at P < 0.05. Independent t-tests and Mann-Whitney U tests were applied to continuous variables based on normality, while the Chi-square test was used for categorical data.

## Findings

The groups showed no significant differences in demographic variables, ensuring baseline homogeneity (Table 1).

**Table 1)** Summary of Group CBT Intervention Sessions

| Group | With deformities | Controls | Independent T-test |
|---|---|---|---|
| Variable | Mean ±SD | Mean ±SD | P-value |
| age | 22.51±2.94 | 23.28±2.5 | .322 |
| Height | 177.09±4.82 | 178.16±5.03 | .430 |
| weight | 74.45±8.82 | 75±7.14 | .809 |
| BMI | 23.72±2.49 | 23.62±1.96 | .871 |

Chi-square analysis of the 15 LESS items revealed no significant between-group differences for the majority of variables (P > 0.05; Table 2), although knee-flexion displacement approached significance (P = 0.064).

Mann-Whitney U analysis revealed that the concurrent deformity group had significantly higher mean ranks for joint displacement (Median = 1, Mean Rank = 30.22) compared to controls (Median = 0, Mean Rank = 22.48) (U = 237, z = −2.255, p = 0.024, r = 0.31). In contrast, no significant differences emerged for overall impression (Concurrent Median = 1, Mean Rank= 25.76, Control Median= 1, Mean Rank=27.30, p=0.618) or total LESS score(Concurrent Median = 1, Mean Rank= 29.78, Control Median= 1, Mean Rank=22.96, p=0.094) (Table 3).

**Table 2)** Chi-Square Test Results for Landing Error Scoring System (LESS) Variables

| Variable | Pearson Chi-Square | df | p-value |
|---|---|---|---|
| Knee flexion: initial contact | .428 | 1 | .513 |
| Hip flexion: initial contact | 1.926 | 1 | .165 |
| Trunk flexion: initial contact | .145 | 1 | .704 |
| Ankle plantar flexion: initial contact | 1.258 | 1 | .262 |
| Medial knee position: initial contact | .006 | 1 | .936 |
| Lateral trunk flexion: initial contact | .001 | 1 | .991 |
| Stance width: wide | .944 | 1 | .331 |
| Stance width: narrow | .424 | 1 | .515 |
| Foot position: external rotation | 2.914 | 1 | .088 |
| Foot position: internal rotation | 1.926 | 1 | .165 |
| Symmetric initial foot contact: initial contact | .349 | 1 | .554 |
| Knee-flexion displacement | 3.438 | 1 | .064 |
| Hip-flexion displacement | 1.926 | 1 | .165 |
| Trunk-flexion displacement | .146 | 1 | .703 |
| Medial-knee displacement | 2.016 | 1 | .156 |

**Table 1)** Mann-Whitney U Test Results

| Variable | Group | n | Mean Rank | Sum of Ranks | Z | P | Effect Size | Median |
|---|---|---|---|---|---|---|---|---|
| Joint displacement | Concurrent deformities | 27 | 30.22 | 816 | -2.255 | .024 | .31 | 1 |
| | Control | 25 | 22.48 | 562 | | | | 1 |
| Overall impression | Concurrent deformities | 27 | 25.76 | 695.50 | -.498 | .618 | .06 | 1 |
| | Control | 25 | 27.30 | 682.50 | | | | 1 |
| Overall score | Concurrent deformities | 27 | 29.78 | 804 | -1.673 | .094 | .23 | 1 |
| | Control | 25 | 22.96 | 574 | | | | 1 |

## Discussion

The primary finding of this study is that, although the total LESS score was statistically similar between groups, athletes with concurrent FFF and GV exhibited significantly higher error scores in the joint displacement category. This suggests that localized biomechanical alterations occur even when overall landing quality appears maintained. These results align with previous research indicating that specific biomechanical faults may be present despite a stable composite score. These findings align with the study by Hébert-Losier et al. (2023), who found that slight structural variations can influence specific biomechanical faults under external conditions. Still, the overall LESS score will not be substantially affected [35]. Similarly, Padua et al. (2011) validated that LESS is an effective indicator for evaluating biomechanical faults during landing, though its sensitivity to general or moderate alterations might be limited [36].

The observed differences in the joint displacement item of the LESS may be explained by the biomechanical alterations associated with FFF and GV. FFFpromotes excessive foot pronation and internal tibial rotation [6], whereas GV shifts the mechanical load axis medially [12]. These structural deviations can lead to reduced sagittal-plane knee motion, which is often captured as a higher joint displacement score on the LESS.

Mechanistically, joint displacement can be exacerbated by impairments in neuromuscular control and biomechanical alterations. Past studies have determined that FF results in overpronation of the foot, leading to internal tibial and femoral rotation and knee valgus angles [37, 38]. These ordinal changes, along with delayed activation and proprioceptive deficits of joint-stabilizing muscles [39], can affect knee and ankle joint displacement and reduce landing control. This study is consistent with the with the findings of Abolfathi et al. (2021) that FF athletes exhibit poorer landing quality and achieve higher LESS scores, thereby increasing the risk of ACL and other non-contact lower-limb injuries [38].

Although the overall LESS score did not vary significantly, this finding should not be overlooked. It has been demonstrated by Hébert-Losier et al. (2023, 2021) that specific dimensions of the LESS, particularly joint displacement, are more sensitive to structural or environmental variations and can identify local biomechanical deficits and increase the risk of injury. This means that while overall LESS analysis would likely fail to detect nuanced differences in joint-specific motor control, a component-level analysis, specifically of joint displacement, can prove advantageous for injury prevention and movement correction program design [40] These findings point to the fact that even if the overall LESS score is unchanged, a single focus on improving motor control and stability of key joints, such as the knee and ankle, can reduce the risk of injury from non-contact conditions [41, 42]. Moreover, studies such as Wesley et al. (2015) have found that sex differences in landing mechanics can affect the risk of ACL injury, which highlights the importance of developing preventive and corrective training programs with specifications for each sex [43].

Previous research has shown that targeted neuromuscular and plyometric training can improve landing mechanics, decrease dynamic knee valgus, and enhance athletic performance, emphasizing the potential of specific interventions to modify movement patterns [31, 32]. Previous research has shown conflicting results. For example, Padua et al. (2011) showed no difference in total LESS score between non-injured and injured athletes [36]. These results highlight that in trained populations with reasonable movement control, the overall LESS score can have low sensitivity, thus lending additional importance to the component analysis of the landing elements, such as joint displacement. The structural deviations of FFF (excessive pronation and internal tibial rotation) and GV (medial load axis shift) likely contribute to reduced sagittal-plane motion, as evidenced by higher joint displacement scores. This study corroborates the findings of Abolfathi et al. (2021) that foot postural deformities can enhance landing errors even in otherwise healthy athletes [38]. Previous reviews have highlighted sex-related differences in jump-landing mechanics and emphasized the need for establishing normative and clinically applicable LESS values across athletic populations. Therefore, the present findings provide clinically relevant joint-level displacement information that may assist practitioners in refining injury-risk screening and targeted corrective exercise programs [23].

In a field-based setting, coaches and therapists must understand that the "joint displacement" item in the LESS evaluates explicitly the amount of sagittal plane motion (flexion) at the knee, hip, and trunk from the moment of initial foot contact to the point of maximum joint flexion.

Regarding observable measures, a "fault" is recorded if the athlete demonstrates a "stiff" landing, characterized by minimal observable increases in knee or hip flexion during the loading phase

Regarding field assessment, practitioners can assess this using standard smartphone video recording from a sagittal (side) view. A lack of visible "give" or joint displacement suggests poor impact absorption, increasing the risk of non-contact injuries.

This study is cross-sectional, so we cannot confirm cause-and-effect between lower-limb deformities and landing mechanics. A significant limitation of this study is the exclusive inclusion of male athletes, which substantially restricts the generalizability of these findings. Given the well-established sex differences in jump-landing biomechanics—including the higher incidence of dynamic knee valgus and non-contact ACL injuries in females—these results may not apply to female athletic populations. We used 2D video analysis, a single jump-landing task, and simple yes/no classification of deformities, which may overlook subtle biomechanical changes. Neuromuscular and proprioceptive factors were not directly measured.

Future research must adopt longitudinal designs and include diverse, multi-sex populations. Furthermore, utilizing 3D motion capture and electromyography would provide a more granular understanding of the muscle activity and joint mechanics involved in these compensatory.

## Conclusion

Athletes with concurrent FFF and GV demonstrate significant deficits in joint displacement during jump-landing, despite having total LESS scores comparable to healthy controls. Clinicians should prioritize component-level analysis over global scores to identify these subtle biomechanical faults. Targeted neuromuscular training focusing on knee and ankle stability is essential to mitigate injury risks, particularly ACL tears, in athletes with these postural deformities.

### Acknowledgments

The authors sincerely thank all participants for their cooperation in this study.

### Authors' Contribution

All authors were involved in designing and performing the study. The manuscript was written by the first author and confirmed by all authors.

### Confilicts of Interest

There is no confilict of inteest for this study.

### Ethical Permission

Ethical approval was obtained from the Motor Sciences Research Institute (IR-KHU.KRC.1000.284), and all participants provided written informed consent.

### Funding/Support

The authors received no financial or material support for this study.

### References

1. Hewett TE, Myer GD, Ford KR, Heidt RS, Jr., Colosimo AJ, McLean SG, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med. 2005;33(4):492-501.
2. Letafatkar A, Mantashloo Z, Moradi M. Comparison of the time to stabilization and activity of the lower extremity muscles during jump-landing in subjects with and without Genu Varum. Gait & Posture. 2018;65:256-61.
3. Ueki Y, Sakuma E, Wada I. Pathology and management of flexible flat foot in children. J Orthop Sci. 2019;24(1):9-13.
4. Capodaglio P, Gobbi M, Donno L, Fumagalli A, Buratto C, Galli M, Cimolin V. Effect of obesity on knee and ankle biomechanics during walking. Sensors. 2021;21(21):7114.
5. Böhm H, Schoormann V, Alexander N, Schäfer A. Foot Kinematics and Running Dynamics in Children and Adolescents with Flexible Flatfoot. Gait & Posture. 2025.
6. Gross KD, Felson DT, Niu J, Hunter DJ, Guermazi A, Roemer FW, et al. Association of flat feet with knee pain and cartilage damage in older adults. Arthritis Care Res (Hoboken). 2011;63(7):937-44.
7. Baumgart C, Böhm H. Impact of Running on Foot Dynamics in Children and Adolescents with Flexible Flatfoot. Gait & Posture. 2025;117:S2-S3.
8. Letafatkar A, Hatefi M, Babakhani F, Ghanati HA, Wallace B. The influence of hip rotations on muscle activity during unilateral weight-bearing exercises in individuals with and without genu varum: A cross-sectional study. Physical Therapy in Sport. 2020;43:224-9.
9. Samadi M, Rajabi R. Laboratory manual motion correction. Tehran, Iran: University of Tehran. 2009:65-7.
10. Anbarian M, Esmailie H, Hosseini Nejhad SE, Rabiei M, Binabaji H. Comparison of knee joint muscles' activity in subjects with genu varum and the controls during walking and running. Journal of Research in Rehabilitation Sciences. 2012;8 (2): 298-309.
11. Witvrouw E, Danneels L, Thijs Y, Cambier D, Bellemans J. Does soccer participation lead to genu varum? Knee surgery, sports traumatology, arthroscopy. 2009;17(4):422-7.
12. Lun V, Meeuwisse WH, Stergiou P, Stefanyshyn D. Relation between running injury and static lower limb alignment in recreational runners. Br J Sports Med. 2004;38(5):576-80.
13. McNair PJ, Prapavessis H, Callender K. Decreasing landing forces: effect of instruction. Br J Sports Med. 2000;34(4):293-6.
14. Boden BP, Dean GS, Feagin JA, Garrett WE. Mechanisms of anterior cruciate ligament injury. SLACK Incorporated Thorofare, NJ; 2000. p. 573-8.
15. Ireland ML. The female ACL: why is it more prone to injury? Orthop Clin North Am. 2002;33(4):637-51.
16. Hewett TE, Johnson DL. ACL prevention programs: fact or fiction? Orthopedics. 2010;33(1):36-9.
17. Beynnon BD, Fleming BC. Anterior cruciate ligament strain in-vivo: a review of previous work. J Biomech. 1998;31(6):519-25.
18. Zhang SN, Bates BT, Dufek JS. Contributions of lower extremity joints to energy dissipation during

landings. Med Sci Sports Exerc. 2000;32(4):812-9.
19. Williams DS, McClay IS. Measurements used to characterize the foot and the medial longitudinal arch: reliability and validity. Phys Ther. 2000;80(9):864-71.
20. Griffin LY, Albohm MJ, Arendt EA, Bahr R, Beynnon BD, Demaio M, et al. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. Am J Sports Med. 2006;34(9):1512-32.
21. Hollis JM, Takai S, Adams DJ, Horibe S, Woo SL. The effects of knee motion and external loading on the length of the anterior cruciate ligament (ACL): a kinematic study. J Biomech Eng. 1991;113(2):208-14.
22. Padua DA, Marshall SW, Boling MC, Thigpen CA, Garrett Jr WE, Beutler AI. The Landing Error Scoring System (LESS) is a valid and reliable clinical assessment tool of jump-landing biomechanics: the JUMP-ACL study. The American journal of sports medicine. 2009;37(10):1996-2002.
23. Arlettaz ME, Dorsch LN, Catalfamo-Formento PAL. Landing error scoring system: A scoping review about variants, reference values and differences according to sex and sport. Physical Therapy in Sport. 2024;69:67-75.
24. Hanzlíková I, Hébert-Losier K. Landing Error Scoring System scores change with knowledge of scoring criteria and prior performance. Physical Therapy in Sport. 2020;46:155-61.
25. Hanzlíková I, Athens J, Hébert-Losier K. Factors influencing the Landing Error Scoring System: Systematic review with meta-analysis. Journal of science and medicine in sport. 2021;24(3):269-80.
26. Tafakoriollah A, Daneshmandi H, Samami N. The Effect of Selected Core Stability Exercises on the Jumping-Landing Pattern and Trunk Muscular Endurance in Adolescent Volleyball Players With Trunk Defect. Physical Treatments: Specific Physical Therapy Journal. 2020;10(2):89-98.
27. Limroongreungrat W, Mawhinney C, Kongthongsung S, Pitaksathienkul C. Landing error scoring system: data from youth volleyball players. Data in brief. 2022;41:107916.
28. Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urrialde JA, Gómez-Conesa A. Medial longitudinal arch: accuracy, reliability, and correlation between navicular drop test and footprint parameters. Journal of manipulative and physiological therapeutics. 2018;41(8):672-9.
29. Ghasemi GH AH, Haji-Rezaei P. The effect of a functional fatigue protocol on postural control and balance in individuals with different foot arch heights. . Journal Rehabil Med 2018;7(3):113-24.
30. Jamil K, Chong Y, Abd Rasid AF, Rashid AHA, Ahmed L. The Effect of Clinical Knee Measurement in Children with Genu Varus. Barw Medical Journal. 2025;3(3):2-5.
31. Mohammadi H, Fakhraei Rad N. The Effect of Sportsmetrics on the Performance and Knee Valgus During Landing of Female Soccer Players. Physical Treatments - Specific Physical Therapy Journal. 2022;12(3):175-88.
32. Babaei Jafari M, Barati A, Akoochakian M, Alizadeh MH. Investigate the Effect of a Comprehensive Warm-up Program on the Functional Movement Patterns and Landing Error of Young Male Wrestlers. Physical Treatments - Specific Physical Therapy. 2024;14(3):201-16.
33. Onate JA, Dewey T, Kollock RO, Thomas KS, Van Lunen BL, DeMaio M, Ringleb SI. Real-time intersession and interrater reliability of the functional movement screen. J Strength Cond Res. 2012;26(2):408-15.
34. Padua DA, DiStefano LJ, Beutler AI, De La Motte SJ, DiStefano MJ, Marshall SW. The landing error scoring system as a screening tool for an anterior cruciate ligament injury–prevention program in elite-youth soccer athletes. Journal of athletic training. 2015;50(6):589-95.
35. Hebert-Losier K, Boswell-Smith C, Hanzlikova I. Effect of Footwear Versus Barefoot on Double-Leg Jump-Landing and Jump Height Measures: A Randomized Cross-Over Study. Int J Sports Phys Ther. 2023;18(4):845-55.
36. Padua DA, Boling MC, Distefano LJ, Onate JA, Beutler AI, Marshall SW. Reliability of the landing error scoring system-real time, a clinical assessment tool of jump-landing biomechanics. J Sport Rehabil. 2011;20(2):145-56.
37. Khamis S, Yizhar Z. Effect of feet hyperpronation on pelvic alignment in a standing position. Gait Posture. 2007;25(1):127-34.
38. Abolfathi E, MINOONEJAD H, KARIMIZADEH AM, Mohammadkhani K. Comparison of landing kinematics of athletes male with flat and natural foot by using landing error scoring system and tuck jump. 2021.
39. Rajaeian O, Khaleghi M, Abbasi A, Eftekhari F. ACL risk factors using lower limb joint angles in single-leg drop landing between young athletes with normal and flatfeet. The Scientific Journal of Rehabilitation Medicine. 2019;8(1):79-86.
40. Hanzlikova I, Hebert-Losier K. Is the Landing Error Scoring System Reliable and Valid? A Systematic Review. Sports Health. 2020;12(2):181-8.
41. Nikkhouamiri F, Akochakian M, Shirzad Araghi E. Effect of a course of selected corrective exercises on balance and function of female adolescents with flexible flatfoot. International Journal of Musculoskeletal Pain Prevention. 2019;4(2):170-9.
42. Ghaderiyan M, Ghasemi GA, Zolaktaf V. The effect of rope jumping training on postural control, static and dynamic balance in boy students with flat foot. Journal of Practical Studies of Biosciences in Sport. 2016;4(8):89-102.
43. Wesley CA, Aronson PA, Docherty CL. Lower Extremity Landing Biomechanics in Both Sexes After a Functional Exercise Protocol. J Athl Train. 2015;50(9):914-20.