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Training Exposure and Limb-Specific Postural Stability Are Associated With Running-Related Injury History in Recreational Runners: A Cross-Sectional Study

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Abstract

Objectives

To investigate the associations of training exposure and limb-specific postural stability with previous running-related injury (RRI) in recreational runners and determine whether postural stability provides additional information beyond training-related variables.

Design

Cross-sectional study.

Methods

A total of 146 recreational runners (104 with and 42 without a history of RRI) completed a questionnaire on training characteristics and injury history, underwent Functional Movement Screen (FMS) assessment, and performed single-leg postural stability testing using the Biodex Balance System. Postural stability was quantified using the Overall Stability Index (OSI), with higher values indicating poorer stability. Hierarchical logistic regression examined associations with previous RRI.

Results

Runners with previous RRI reported higher training frequency (6.4 ± 2.0 vs. 5.3 ± 1.9 sessions/week; p = 0.001) and longer running experience (4.5 ± 1.9 vs. 3.4 ± 2.1 years; p = 0.003). Training frequency (OR 2.47, 95% CI 1.35–4.51), running experience (OR 2.76, 95% CI 1.40–5.45), and their interaction (OR 0.87, 95% CI 0.77–0.98) were independently associated with injury history. After adjustment, only non-dominant limb OSI remained independently associated with injury history (OR 0.80, 95% CI 0.64–0.99; p = 0.042). Including non-dominant limb OSI improved model discrimination (AUC 0.74–0.76) and explained variance (Nagelkerke R^2 0.21–0.29). FMS score was not associated with injury history.

Conclusions

Training frequency, running experience, and non-dominant limb postural stability were independently associated with previous RRI. Limb-specific postural stability provided additional information beyond training-related variables, although prospective studies are needed to determine its relationship with future running-related injury.

INTRODUCTION

Running is one of the most popular and accessible forms of physical activity worldwide, with participation steadily increasing over recent decades [17, 25]. Despite its well-established health benefits, running-related injuries remain common among both recreational and competitive runners and represent one of the leading causes of training interruption and discontinuation of the sport [13, 19, 24].

Beyond limiting physical activity, these injuries impose a substantial socioeconomic burden through healthcare costs, reduced productivity, and time lost from work [16].

Running-related injuries are considered multifactorial, resulting from the interaction between training-related, biomechanical, anatomical, and tissue-related factors [10][17][23]. Among these, several training-related characteristics, including training frequency, running experience, and training load, have been investigated in relation to running-related injuries [10]. Nevertheless, runners with comparable training characteristics often differ considerably in their injury history, suggesting that training exposure alone does not fully explain individual susceptibility to repetitive mechanical loading.

One potential explanation is variability in neuromuscular control. Running is characterized by repetitive single-leg support phases, during which efficient neuromuscular control is required to maintain lower-limb alignment, regulate body position, and attenuate impact forces. Experimental studies have demonstrated that reduced trunk stability alters lower-extremity biomechanics during running [8]. Furthermore, changes in balance dynamics following a high-intensity run have been associated with subsequent injury occurrence in recreational runners [1]. Together, these findings suggest that postural control may represent a relevant component of neuromuscular function associated with running-related injuries.

Objective assessment of postural stability provides a practical method of quantifying balance performance under standardized testing conditions.. Instrumented systems such as the Biodex Balance System provide objective measures of postural stability, with previous studies demonstrating good-to-excellent test-retest reliability of stability indices during unilateral stance [2]. In contrast, systematic reviews have questioned the ability of the Functional Movement Screen (FMS) to discriminate between athletes according to injury status or predict subsequent injury [4][21]. Because running consists of repetitive unilateral loading, evaluating each lower limb separately may identify limb-specific functional impairments that are not detected by global assessments.

Despite growing interest in neuromuscular factors, evidence regarding postural stability and running-related injuries remains limited. Previous studies in runners have investigated trunk stability, running biomechanics, and changes in balance dynamics associated with subsequent injury occurrence [1][8]. However, whether associations between postural stability and running-related injury history differ according to limb dominance remains unclear.

Therefore, the aim of this study was to investigate the independent associations of training exposure and limb-specific postural stability with a history of running-related injuries (RRI) in recreational runners. Particular emphasis was placed on determining whether these associations differed between the dominant and non-dominant lower limbs and whether postural stability provided complementary information beyond conventional training-related variables. We hypothesized that greater training exposure would be associated with a history of RRI and that postural stability would demonstrate limb-specific associations with previous injury history. The objective was not to evaluate postural stability as

a screening tool, but rather to determine whether it contributes additional information beyond established training-related factors.

METHODS

Participants

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Bioethics Committee of the Medical University of Lublin (approval No. XXBLINDEDXX). Written informed consent was obtained from all participants prior to study participation A total of 146 recreational runners were enrolled, including 104 runners with a history of running-related injury and 42 runners without a history of running-related injury. The study population comprised 94 women and 52 men aged 18–51 years.

Participants were eligible if they were aged 18–55 years, regularly participated in running training at least three times per week, and had not undergone lower-limb surgery within the preceding 12 months. For the purposes of this study, a recreational runner was operationally defined as an individual who regularly performed running training at least three times per week, irrespective of competitive participation. No minimum weekly running distance, running experience, or competitive experience was required for inclusion.

All participants attended a single assessment session lasting approximately 30 minutes. They were instructed to refrain from running on the day of testing. During the visit, participants completed a standardized questionnaire, underwent functional assessment, and subsequently performed postural stability testing.

The questionnaire collected information regarding training characteristics, including running experience, training frequency, and weekly training volume, as well as a history of running-related injuries. Running-related injury was defined as a self-reported musculoskeletal complaint that participants attributed to running and that resulted in pain and/or functional limitation during running or usual daily activities. Medical diagnosis by a healthcare professional and time loss from running were not required for classification as a running-related injury.

Functional assessment

Functional movement quality was assessed using a modified FMS, consisting of five movement patterns: deep squat, hurdle step, in-line lunge, active straight-leg raise, and rotary stability. These tests primarily evaluate lower-extremity mobility, trunk stability, and movement control.

Each movement was scored according to the original 4-point FMS scale [9], where higher scores indicate better movement quality. Bilateral tasks were performed on both limbs, with two attempts permitted for

each movement. Individual test scores were summed to obtain the total FMS score, which was included as an exploratory functional variable in the statistical analysis.

Postural stability assessment

Postural stability was evaluated using the Biodex Balance System (Biodex Medical Systems Inc., Shirley, NY, USA), an instrumented platform previously shown to provide reliable measurements of postural stability during unilateral stance [2]. Testing was performed using the Stability Test (Athletes) mode.

Testing consisted of two 30-second single-leg stance trials performed separately for each lower limb, with a 10-second rest interval between trials.

Testing consisted of two 30-second single-leg stance trials performed separately for each lower limb, with a 10-second rest interval between trials. The mean value of the two valid trials was used to reduce the influence of within-participant trial-to-trial variability. This protocol was selected to obtain repeated measurements while limiting fatigue during bilateral single-leg testing. Previous studies using the Biodex Balance System have demonstrated good-to-excellent test–retest reliability of stability indices measured during unilateral stance [2]. Lower-limb dominance was self-reported by participants before postural stability testing. The limb identified by each participant as dominant was classified as the dominant limb, and the contralateral limb as the non-dominant limb. The order of limb testing was self-selected by participants, and no instructions regarding the testing sequence of the dominant and non-dominant limbs were provided.Platform stability was set at level 2 on the manufacturer's 12-level scale, where level 1 represents the least stable platform and level 12 the most stable. Participants who were unable to complete the required postural stability trials according to the predefined testing protocol were classified as “did not finish” (DNF), and DNF status was analyzed separately as a categorical variable.

The Biodex Balance System quantifies postural stability based on angular displacement of the multi-axial platform from the level position. Three stability indices were calculated: the Overall Stability Index (OSI), the Anterior–Posterior Stability Index (APSI), and the Medial–Lateral Stability Index (MLSI). According to the manufacturer’s Clinical Resource Manual, APSI and MLSI quantify platform displacement from the level position in the sagittal and frontal planes, respectively, whereas OSI incorporates displacement in both directions [3]. The indices are calculated as follows:

$$APSI = \sqrt{\frac{\sum(0 - Y)^2}{n}}$$

$$MLSI = \sqrt{\frac{\sum(0 - X)^2}{n}}$$

$$OSI = \sqrt{\frac{\sum(0 - Y)^2 + \sum(0 - X)^2}{n}}$$

where X represents medial–lateral platform displacement, Y represents anterior–posterior platform displacement, and n is the number of samples recorded during the test. Higher index values indicate greater platform displacement from the level position and poorer postural stability. Previous research has demonstrated good-to-excellent intrarater test–retest reliability of these indices during unilateral stance in healthy young adults under static and dynamic platform conditions [2].

STATISTIC

All analyses were performed using Statistica software (version 13.3, TIBCO Software Inc., Palo Alto, CA, USA). Statistical significance was set at $p < 0.05$ for all analyses.

Group comparison

Comparisons of participant characteristics (age, sex, height, body mass, and body mass index [BMI]) and self-reported training exposure variables obtained from the questionnaire (training frequency, running experience, and weekly running distance) between participants with and without a history of running-related injuries were performed to describe baseline group differences.. The Shapiro–Wilk test was used to assess normality of the data, while homogeneity of variances was examined using Levene's test. As the assumptions of normality was not met, group differences were analysed using the Mann–Whitney U test for numerical variables and the chi-square test for nominal variables. Differences in non-dominant leg OSI across the most common injury locations (hip, knee, and ankle/foot) were assessed using the Kruskal–Wallis test.

Logistic regression

Logistic regression analysis was used to examine factors associated with a history of running-related injuries (injury: yes/no). Odds ratios (ORs) with 95% confidence intervals (95% CI) were calculated to quantify the strength of associations.

A hierarchical modelling strategy was applied to evaluate whether postural stability provided additional information beyond training-related variables in relation to running-related injury history. First, potential predictors were screened using univariate logistic regression analyses. Variables with a p-value < 0.2 in univariate analyses [7] were considered for inclusion in multivariable models to avoid premature exclusion of potentially relevant predictors. Two multivariable logistic regression models were subsequently constructed. The baseline model (Model 1) included training-related variables retained after univariate screening and assessment of linearity, together with the interaction term between training frequency and running experience. The extended model (Model 2) included the same training-related variables and interaction term, with the addition of non-dominant limb OSI, which was the only postural stability variable meeting the predefined criterion for multivariable modelling. Comparison of the baseline and extended models was performed to evaluate whether inclusion of non-dominant limb OSI improved model discrimination and explained variance beyond training-related variables alone.

Self-reported training exposure variables obtained from the questionnaire were considered primary candidate predictors and included training frequency (number of training sessions per week), running experience (years), and weekly running distance. Based on univariate screening and assessment of linearity, training frequency and running experience were retained for multivariable modelling, whereas weekly running distance was excluded. An interaction term between training frequency and running experience was tested to account for potential effect modification.

Participant characteristics (age, sex, height, body mass, and BMI) were examined in univariate analyses but were not included in multivariable models because they were not associated with injury history. Functional assessment variables included the total Functional Movement Screen (FMS) score, did-not-finish (DNF) status from the postural stability test, and numerical postural stability indices. Overall stability index (OSI) were calculated separately for the dominant and non-dominant lower limbs, and the difference between limbs (delta stability index) was also computed. Variables that were not associated with injury history in univariate analyses were excluded from further modelling. Only the non-dominantleg OSI met the inclusion criterion and was entered into the extended multivariable model.

Multicollinearity among predictors was assessed using variance inflation factors (VIF) and tolerance values. Model discrimination was evaluated using the area under the receiver operating characteristic curve (AUC), and model fit was assessed using standard goodness-of-fit statistics. All analyses were performed using Statistica software, with a binomial distribution and logit link function.

RESULTS

Participants

Baseline characteristics are presented in Table 1. Groups did not differ in age, sex distribution, height, body mass, or BMI (all p > 0.05). However, runners with a history of injury reported higher weekly training frequency (6.4 ± 2.0 vs. 5.3 ± 1.9 sessions/week, p = 0.001) and longer running experience (4.5 ± 1.9 vs. 3.4 ± 2.1 years, p = 0.003).

Table 1
Participant characteristics by history of running-related injury

Variables	**Groups**		***p***
	No injury history (n = 42)	**Injury history (n = 104)**	
Sex, n (%)**			*0.691*
Women	26 (61.9%)	68 (65.4%)	
Men	16 (38.1%)	36 (34.6%)	
Age (years), mean ± SD*	34.6 ± 7.7	35.1 ± 8.1	*0.900*
Height (cm), mean ± SD*	173.2 ± 9.4	171.8 ± 8.7	*0.495*
Weight (kg), mean ± SD*	67.5 ± 12.1	66.5 ± 12.6	*0.681*
BMI, mean ± SD*	22.4 ± 2.5	22.4 ± 2.8	*0.670*
Training sessions per week, mean ± SD*	5.3 ± 1.9	6.4 ± 2	**0.001**
Experience (years), mean ± SD*	3.4 ± 2.1	4.5 ± 1.9	**0.003**
Weekly running distance category, median [IQR]*	3.0 [2.0–4.75]	3.5 [3.0–5.0]	0.278
Injury location, n (%)**			
Upper extremity		1 (1%)	
Back		2 (1.9%)	
Hip joint		16 (15.4%)	
Knee joint		40 (38.5%)	
Ankle and foot		45 (43.3%)	

Legend: * *–Mann-Whitney U Test;* ** *– Chi–squared test;*

Weekly running distance categories: 1 = 0–10 km/week, 2 = 11–20 km/week, 3 = 21–30 km/week, 4 = 31–40 km/week, and 5 = ≥ 41 km/week.

Training exposure

The baseline logistic regression model demonstrated that training exposure was independently associated with running-related injury history (Table 2).

Both weekly training frequency (OR = 2.47; 95% CI 1.35–4.51; p = 0.003) and running experience (OR = 2.76; 95% CI 1.40–5.45; p = 0.003) significantly influenced injury history. A significant interaction between training frequency and running experience was also observed (OR = 0.87; 95% CI 0.77–0.98; p = 0.019), indicating that the effect of training frequency differed according to running experience.

The baseline model demonstrated acceptable discrimination (AUC = 0.74) with a Nagelkerke R^2 of 0.21.

Postural stability

Among all postural stability variables examined, only the Overall Stability Index (OSI) of the non-dominant lower limb demonstrated a significant association with injury history in univariate analysis (p = 0.03). Neither dominant-limb OSI nor inter-limb differences were associated with injury history (p = 0.68 and p = 0.73, respectively).

After inclusion of non-dominant limb OSI in the multivariable logistic regression model, this parameter remained independently associated with injury history (OR = 0.80; 95% CI 0.64–0.99; p = 0.042), together with weekly training frequency (p = 0.026), running experience (p = 0.010), and their interaction (p = 0.033).

Inclusion of non-dominant limb OSI improved model discrimination from an AUC of 0.74 to 0.76, while the explained variance increased from a Nagelkerke R^2 of 0.21 to 0.29 (Table 2).

Table 2
Logistic regression models for history of running-related injury

Predictor	**Baseline model OR (95% CI)**	***p***	**Extended model OR (95% CI)**	***p***
Training frequency (sessions/week)	2.47 (1.35–4.51)	*0.003*	2.13 (1.10–4.16)	*0.026*
Running experience (years)	2.76 (1.40–5.45)	*0.003*	2.95 (1.30–6.67)	*0.010*
Training × experience	0.87 (0.77–0.98)	*0.019*	0.86 (0.75–0.99)	*0.033*
Non-dominant leg overall stability index (OSI)	—	—	0.80 (0.64–0.99)	*0.042*
AUC	0.74		0.76	
Nagelkerke R^2	0.21		0.29	

The distribution of non-dominant limb OSI according to injury history is presented in Fig. 1.

Secondary analyses

Somatic characteristics, including age, sex, height, body mass, and BMI, were not associated with injury history in univariate analyses (all $p > 0.40$).

Similarly, total FMS score ($p = 0.30$) and did-not-finish (DNF) status during postural stability testing ($p = 0.295$) were not associated with injury history and were therefore not included in multivariable analyses.

Injury location

To determine whether postural stability differed according to injury location, non-dominant limb OSI values were compared among runners reporting hip, knee, and ankle/foot injuries.

No significant between-group differences were observed (Kruskal–Wallis $H = 2.47$, $p = 0.29$) (Fig. 2).

DISCUSSION

The present study investigated the associations of training exposure and limb-specific postural stability with running-related injury history in recreational runners. Higher training frequency and longer running experience were independently associated with the presence of previous running-related injury. In addition, postural stability of the non-dominant lower limb was independently associated with injury history after adjustment for training-related variables, whereas dominant-limb postural stability and inter-limb differences were not associated with injury history. These findings indicate that the association between postural stability and previous running-related injury was limb-specific in this sample of recreational runners.

Training-related factors have been widely investigated in relation to running-related injuries, and our findings are consistent with previous literature reporting associations between training characteristics and running-related injuries [10]. From a mechanistic perspective, greater training frequency may increase cumulative mechanical loading and tissue stress when recovery is insufficient [20]. In the present study, both training frequency and running experience were independently associated with previous running-related injury, and a significant interaction between these variables was observed. This interaction indicates that the association between training frequency and injury history differed according to running experience. However, given the cross-sectional design, the temporal direction and underlying mechanisms of this association cannot be determined.

Previous epidemiological studies have reported differences in injury incidence between novice and experienced runners [24]. Repeated exposure to mechanical loading may induce structural adaptation of bone, tendon, and other musculoskeletal tissues, potentially increasing their capacity to tolerate subsequent loading [26]. Accordingly, biological adaptation has been proposed as one possible explanation for differences in injury occurrence according to running experience. However, other training-related factors, including differences in training organization, training volume and intensity, and recovery between training sessions, may also contribute to differences associated with running experience [22]. These factors were not assessed in the present study, and the observed interaction between training frequency and running experience should therefore not be attributed to any specific mechanism.

Running experience should be interpreted here only as a self-reported training characteristic associated with previous injury history. Prospective studies are needed to determine whether biological adaptation contributes to the relationship between running experience and subsequent injury occurrence and to evaluate the role of gradual training progression during the early stages of running participation [5].

The most novel finding of the present study was the limb-specific association between non-dominant limb postural stability and previous running-related injury. Non-dominant limb OSI remained independently associated with injury history after adjustment for training-related variables, whereas neither dominant-limb OSI nor inter-limb differences in OSI demonstrated significant associations. Importantly, because higher OSI values indicate poorer postural stability, the observed odds ratio below 1.0 indicates that higher non-dominant limb OSI values were associated with lower odds of previous running-related injury. Therefore, the present findings should not be interpreted as evidence that poorer postural stability of the non-dominant limb predisposes runners to injury.

Indeed, runners with a history of running-related injury tended to demonstrate lower non-dominant limb OSI values, corresponding to better postural stability, than runners without previous injury. Because injury laterality and the temporal sequence between injury occurrence and postural stability assessment were not available, it remains unclear whether this association reflects characteristics preceding injury, adaptations following injury or rehabilitation, or other unmeasured differences between the groups.

Running consists of repetitive single-leg loading cycles requiring continuous regulation of body position during the stance phase. Previous research has suggested that postural control may be related to lower-extremity kinematics, force attenuation, and mechanical loading across the kinetic chain [15]. Neuromuscular control and core stability have also been associated with lower-extremity biomechanics [11, 18], while experimental evidence indicates that reduced trunk stability can alter running mechanics [8]. hese findings provide a broader biomechanical context for investigating postural stability in runners. However, the present study did not assess running biomechanics or mechanisms of injury, and the observed association between non-dominant limb postural stability and previous injury should not be interpreted as evidence that impaired postural stability contributes to injury occurrence. Rather, our findings indicate that the association between postural stability and injury history differed according to the limb assessed, although the temporal direction and clinical significance of this association remain uncertain.

The explanation for the limb-specific association observed in the present study remains uncertain. Although running is a repetitive bilateral task and substantial symmetry between limbs is often assumed, inter-limb asymmetries in functional, kinematic, and kinetic variables have been documented in runners; however, their functional and clinical relevance remains unclear [12]. Furthermore, previous research suggests that limb dominance may influence selected biomechanical characteristics during running, although these effects may depend on factors such as fatigue and the specific biomechanical variable examined [6]. The present study did not assess side-specific loading or running biomechanics. Moreover, injury laterality was not recorded, precluding determination of whether the non-dominant limb

corresponded to the previously injured limb. Consequently, the observed association may reflect persistent changes following previous injury, unmeasured differences in limb-specific function, or other factors not assessed in the present study. Given the cross-sectional design, the temporal direction and mechanisms underlying this association cannot be determined. Future prospective studies incorporating injury laterality, repeated assessments of postural stability, and biomechanical and electromyographic analyses are required to clarify the clinical significance of this finding.

From a clinical perspective, the present findings suggest that objective, limb-specific assessment of postural stability may complement the evaluation of training exposure when characterizing recreational runners with a history of running-related injuries. The independent association of non-dominant limb OSI with injury history after adjustment for training-related variables suggests that instrumented assessment may capture limb-specific functional characteristics not reflected by training exposure alone. Although the cross-sectional design does not allow these findings to be interpreted in terms of future injury prediction or prevention, the observed association supports further investigation of limb-specific postural stability as a potentially relevant component of clinical assessment in runners. Whether postural stability measures can identify runners at increased risk of subsequent injury or whether interventions targeting balance and sensorimotor control can modify future injury occurrence requires evaluation in prospective studies.

Functional movement quality assessed using the modified FMS was not associated with injury history. This finding is consistent with previous studies and systematic reviews reporting limited predictive value of the FMS when used as a standalone screening tool [4, 14, 21]. In contrast, non-dominant limb OSI remained independently associated with injury history after adjustment for training-related variables, suggesting that instrumented, limb-specific assessment of postural stability may provide information not captured by observational assessment of global movement quality. However, because the present study was not designed to directly compare the diagnostic or predictive performance of these assessment methods, the findings should not be interpreted as evidence that postural stability assessment is clinically superior to the FMS.

The present study has several strengths. Objective assessment using the Biodex Balance System, combined with detailed characterization of training exposure and multivariable modelling, enabled evaluation of associations between limb-specific postural stability, training-related factors, and previous running-related injury. Nevertheless, several limitations should be acknowledged. The cross-sectional design precludes causal and temporal inference, and injury history was self-reported and therefore susceptible to recall bias. Importantly, injury laterality was not recorded, preventing assessment of whether the previously injured limb corresponded to the dominant or non-dominant limb and whether previous injury itself may have influenced postural stability. In addition, potentially relevant variables, including injury severity, rehabilitation history, running biomechanics, training intensity, recovery strategies, fatigue monitoring, footwear, and training surface, were not assessed. Limb dominance was self-reported, and its functional relevance to running biomechanics remains uncertain. Finally, the findings may not be generalizable to elite running populations.

Overall, the present findings indicate that training frequency, running experience, and non-dominant limb postural stability were independently associated with previous running-related injury in this sample of recreational runners. The association between postural stability and injury history was limb-specific, as neither dominant-limb postural stability nor inter-limb differences demonstrated significant associations. However, the cross-sectional design and lack of information regarding injury laterality preclude conclusions regarding the temporal direction, mechanisms, or clinical implications of the observed association. Limb-specific assessment of postural stability may provide additional information when characterizing runners with a history of running-related injuries, but prospective studies are required to determine whether these measures are associated with subsequent injury occurrence and have value for injury screening or prevention.

CONCLUSION

Training frequency, running experience, and non-dominant limb postural stability were independently associated with previous running-related injury in recreational runners. The association between postural stability and injury history was limb-specific, as neither dominant-limb postural stability nor inter-limb differences were significantly associated with injury history. Given the cross-sectional design and the lack of information regarding injury laterality, the temporal direction and clinical significance of the association between non-dominant limb postural stability and previous injury remain uncertain. Prospective studies are required to determine whether limb-specific postural stability is associated with subsequent running-related injury and has potential clinical value in the assessment of recreational runners.

DECLARATIONS

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Author Contribution

M.K, D.K, A.K, B.M, J.D Conceptualization, Methodology, Investigation, Data curation, Writing – original draft, Writing – review & editing.A.A: Formal analysis, Writing – review & editing.P.K: Supervision, Writing – review & editing.All authors interpreted the data, critically revised the manuscript for important intellectual content, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

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Figures

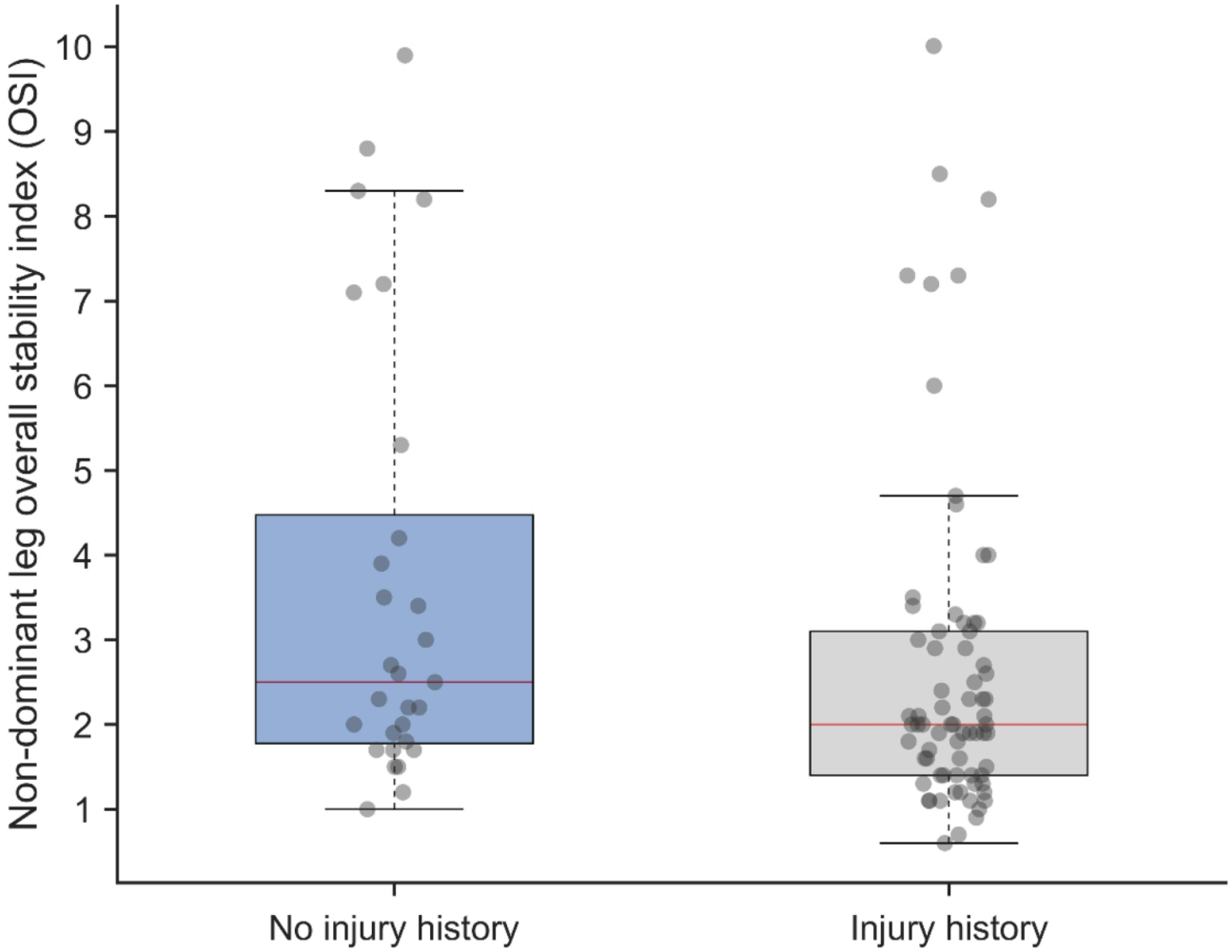


Figure 1

Distribution of non-dominant leg overall stability index (OSI) values in runners with and without a history of running-related injury. Boxes represent the interquartile range, the central line indicates the median, whiskers extend to 1.5 times the interquartile range, and dots represent individual observations.

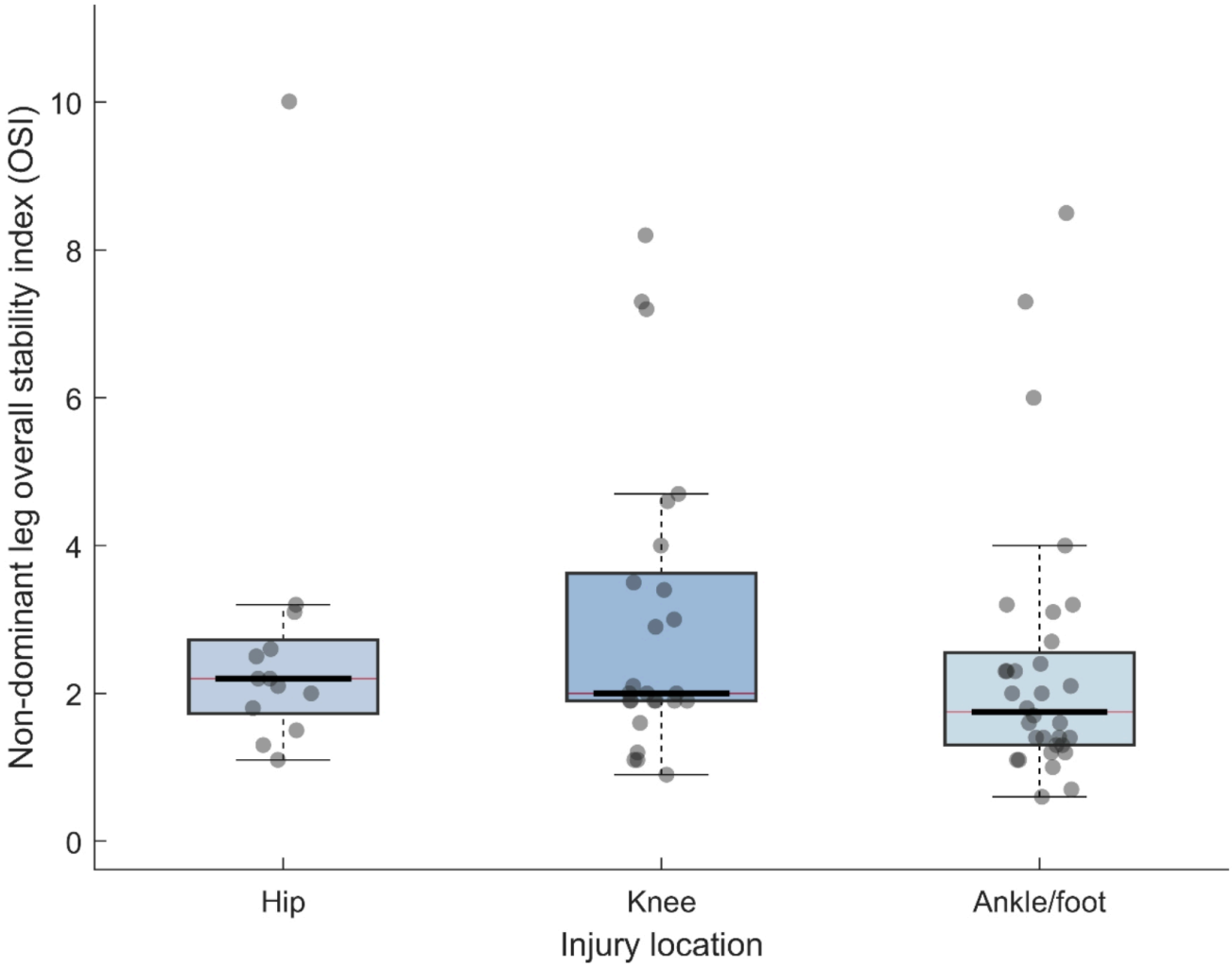


Figure 2

Distribution of non-dominant leg overall stability index (OSI) values according to injury location in runners with a history of running-related injury. Groups included hip, knee, and ankle/foot injuries. Boxes represent the interquartile range, the central line indicates the median, whiskers extend to 1.5 times the interquartile range, and dots represent individual observations.