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Evaluating Movement Quality among Sports Science Students

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Abstract Background/Objective: Musculoskeletal (MSK) injuries pose a significant concern for physically active populations, affecting their mobility, balance, and quality of life. Sports science students engaged in rigorous physical training are vulnerable and particularly susceptible to injuries due to the demands of their active curriculum. This study evaluates their functional movement quality to inform preventive strategies tailored to this active demographic. Using the Functional Movement Screen (FMS), we aim to assess baseline movement patterns, discern potential gender-based differences in injury risks, and guide specific interventions. Method: Employing a cross-sectional, descriptive, and comparative study utilizing FMS was conducted on 139 sports science students (66 males, 73 females). Sample size was calculated using Cochran formula to ensure a 95% confidence interval at a 0.05 significance level. Data was collected under experts supervision and analyzed with SPSS version 23, emphasizing balance, mobility, and stability, with a significance threshold of $p < 0.05$. Results: The study found average scores in balance (7.88 ±0.98), and mobility (4.81 ±0.97), among participants, yet stability (3.54 ±1.04) emerged as a concern with significant limb asymmetries observed in HS and RS tests (p = 0.022* and p = 0.023*). No significant gender differences were found (p=0.824), suggesting uniform movement quality across the cohort. Nonetheless, a higher injury risk was identified in 20.9% of participants, predominantly females. Conclusion: The study reveals good balance and mobility among sports science students but highlights stability issues among sports science students, with female students exhibiting an injury risk. This underscores the need for curriculum enhancements and preventive measures to bolster MSK health in sports science education.

Keywords Functional Movement Screen, Musculoskeletal Health, Sports Science Students, Injury Risk, Movement Quality

1. Introduction

Musculoskeletal (MSK) injuries are a major global health issue, affecting approximately 1.71 billion individuals worldwide and leading to significant disability and reduced quality of life [1]. These injuries impact mobility, balance, and stability and hinder social participation and overall well-being. With the World Health Organization predicting an increase in MSK-related disabilities, this is an area of growing concern [2]. MSK injuries are widespread across all age groups and activities, from daily routines to sports [3-5]. With their physically demanding curriculum, sports science students face a particular vulnerability to these injuries, which can severely impact their training, skill development, and professional readiness. This prevalence highlights the critical need for effective prevention strategies and precise diagnostic tools tailored to this demographic [6].

Sports science students are particularly vulnerable due to their physically demanding curriculum. Recurrent MSK injuries in this group can impede practical training participation, affecting skill development and professional preparation [7]. Recent studies highlight a high incidence of MSK injuries among sports science students, with a 53.9% injury rate, with males exhibiting a higher prevalence [8]. The prevalent free sports leading to injuries differ between genders, with artistic gymnastics being the primary cause among males (35.4%), followed by combat sports (13.2%) and football (12.1%). For females, artistic gymnastics accounts for the majority of injuries (60.7%), followed by alpine skiing (21.4%), and outdoor activities (7.1%) [9]. The severity of these injuries often leads to academic interruptions or even career shifts. This trend underscores the need for robust injury prevention and management programs within sports science curricula to mitigate the negative effects on students' academic progression and professional aspirations. In response, academic institutions have a dual responsibility: to educate and protect their students by fostering a safe learning environment and reducing injury rates [10-12].

Despite routine health assessment in sports science programs focusing on cardiovascular fitness, strength, muscular endurance, and flexibility, a notable gap exists in evaluating functional movement pattern [13-15]. This oversight can obscure underlying MSK issues, potentially affecting students' performance and learning outcomes. Understanding MSK injury risk has traditionally relied on biomechanical motion analysis, primarily conducted in laboratory settings [16-18]. While these studies offer valuable insights, their resource-intensive nature limits their broader application. The Functional Movement Screen (FMS) system emerges as a practical and cost-effective tool to bridge this gap. It is poised to fill this gap, gaining traction in both athletic and military contexts for its practicality and cost-effectiveness. The FMS has gained traction in both athletic and military contexts by offering a feasible alternative for evaluating basic movement patterns and predicting MSK injury risk [19-21]. Despite ongoing debate around its scoring and predictive accuracy [22], the FMS’s global adoption underscores its effectiveness in identifying basic movement dysfunctions and forecasting MSK injury risk, demonstrating its potential effectiveness [23-25]. Studies [26-27] illustrate the FMS's utility in various settings, including military recruits, while several studies, systematic reviews and meta-analyses [21, 28-30] highlight its reliability and validity concerns.

Furthermore the FMS's integration into elite sports, as evidenced in the National Hockey League Combine [31], and subsequent research [32-34] reinforces the association of FMS scores with injury risk in active individuals, and extends our understanding of FMS predictive value in different demographics.

In conclusion, while there is ongoing debate over the FMS's scoring and predictive value, its widespread use among elite athletes and military personnel signifies its potential as a cost-effective and user-friendly tool for MSK injury risk assessment.

Our study contributes to the existing literature by focusing on sports science students, aiming to provide normative data on functional movement quality and explore MSK health risks among sports science students. By assessing functional movement patterns, we seek to identify areas requiring intervention, intending to enhance functional movement and reduce MSK injury risks. The goal is to establish a baseline for fundamental movement patterns and assess potential MSK injury risks in this population. This endeavor aims to create a safer educational environment and ensure that students are prepared for their professional futures, both academically and physically.

This research underlines the critical need for targeted prevention strategies and accurate diagnostic tools for MSK injuries, particularly among populations engaged in significant physical activity, our research strives to establish a baseline for fundamental movement patterns and assess potential MSK injury risks. By doing so, we aim to offer a unique contribution to the field, underscoring our commitment to improving the health and safety of sports science students.

2. Materials and Methods

2.1. Study Design

This cross-sectional, descriptive, and comparative study assesses functional movement quality in sports science students, focusing on balance (upright posture maintenance and equilibrium during movement or when stationary), stability (control and counter disturbances in body positioning during movement), and mobility (free movement, joint flexibility, and movement coordination).

2.2. Research Aims and Questions

This study aims to analyze the movement quality of sports science students focusing on balance, mobility, stability, and asymmetry and to explore gender-specific differences in these aspects. It also seeks to identify potential links between movement quality and injury risk within this group. The research questions are:

1. What are sports science students' balance, mobility, stability, and asymmetry levels?
2. Are there differences in movement quality between male and female students?
3. What is the injury risk predicted value among these students?

Table 1. Characteristics of the participants

Variable	Male (N=66) Mean ± SD	Females (N =73) Mean ± SD	Whole Group Mean ± SD	Skewness
Age (year)	21.06 ± 2.11	20.58 ± 1.27	20.81 ± 1.74	1.40
Height (m)	1.78 ± 0.06	1.63 ± 0.04	1.70 ± 0.09	0.46
Mass (kg)	73.55 ± 10.87	57.60 ± 7.38	65.17 ± 12.16	0.94
Body-mass index (kg/m^2)	23.15 ± 3.53	21.52 ± 2.22	22.29 ± 3.02	0.98

2.3. Participants

The participant sample size was determined by applying the Cochran formula, considering a confidence level of 95%, a power of 80%, and an alpha of 0.05. Out of 250 students (118 male, 132 female) enrolled in the Faculty of Sports Science at the Arab American University of Palestine (AAUP) across years one to four, a total of 139 students (66 male, 73 female) were randomly selected to participate in the study. Participant characteristics are outlined in Table 1.

2.3.1. Inclusion Criteria

Sports sciences and physical education students of varied ages and genders were eligible. Healthy sports science students, irrespective of gender, were included without current MSK injury, past joint surgeries, or ailments affecting participation.

2.3.2. Exclusion Criteria

Participants with recent MSK injuries potentially affecting their performance on the FMS were excluded.

2.4. Ethical Approval

In line with the Helsinki Declaration's ethical guidelines, this research received approval from the Institutional Review Board of the Arab American University of Palestine (Reference No. 2022/C/19/N).

2.4.1. Informed Consent

All participants were adequately briefed about the study's intent, procedures, and possible risks. After this, written informed consent was acquired. Participation was voluntary, and participants retained the right to rescind participation without repercussions.

2.4.2. Data Privacy and Confidentiality

Stringent confidentiality protocols were applied to all participant information. Personal identifiers were omitted from the datasets, ensuring participant anonymity. Data was safely stored, with access restricted to the research team.

2.5. Procedures

Functional Movement Screens (FMS) for each participant were individually administered at an appropriate location within the university premises.

2.5.1. Data Collection

Our data collection team underwent extensive FMS training, ensuring their expertise in conducting assessments accurately. To ensure consistency among evaluators, we organized a calibration session for all raters to assess participants using the FMS protocol, establishing a common evaluation standard. The Intraclass Correlation Coefficient (ICC) was used to measure inter-rater reliability, indicating a high level of agreement among our raters and affirming the reliability of our data collection process (See Appendix 1). The FMS is composed of seven functional movement patterns:

1. Balance Patterns: Overhead deep squat (DS), hurdle step (HS), inline lunge (ILL).
2. Mobility Patterns: Shoulder mobility (SM), active straight leg raises (ASLR).
3. Stability Patterns: Trunk stability pushup (TS), rotary stability (RS).
4. Asymmetry levels: Five of the seven patterns (HS, ILL, SM, ASLR, and RS) compare bilateral body performance, aiding in the quantification of MSK asymmetry.

Any discovered asymmetry was duly recorded on the FMS score sheet. Certain patterns (SM, TS, RS) also encompass a clearing test procedure.

FMS Scoring Each of the seven FMS patterns was scored on a 0 to 3 scale, cumulating in a maximum potential score of 21. Cumulative scores were computed for balance (0-9), stability (0-6), mobility (0-6), and the total FMS score (0-21). Greater scores denoted superior functional movement quality, whereas diminished scores highlighted potential concerns or amplified injury susceptibility.

To assess asymmetry, discrepancies were determined between the left and right sides for tests (HS, ILL, SM, ASLR, and RS). Asymmetry was recognized if score disparities existed between bilateral body sides across these tests.

2.6. Limitations

The cross-sectional nature of our study captures a specific moment in time, detailing the quality of functional movement but not capturing changes over time or the effects of interventions. Additionally, while we have endeavored to control potential confounders like individual fitness levels and previous injury history, their influence on our findings cannot be eliminated. The limitation of our study also extends to the sample size. With 137 participants from a pool of 250 students in the faculty, representing over half of the target group, our findings offer significant insights within our academic context. Still, they may not be directly applicable to broader populations. Acknowledging this, our research provides a foundational understanding of MSK injury rates and risk factors among sports science students at the Arab American University of Palestine, highlighting the necessity for expanded research to establish wider normative data. This acknowledgement of our study's limitations emphasizes the careful interpretation of our results and the importance of further investigations across more diverse and larger cohorts. The participants in our study spanned all years of the undergraduate program, from Year 1 through Year 4. However, it is important to note that injury risks and types may vary by academic year due to changes in physical training intensity, academic stress, and adaptation to sports practices over time.

2.7. Statistical Analysis

Data from the study were subjected to descriptive statistical analyses, encompassing measures of central tendency and variability, to aptly represent the attributes of the study cohort.

The data derived from the Functional Movement Screen (FMS) assessments underwent rigorous statistical analysis utilizing the Statistical Package for Social Sciences (SPSS) version 23 (IBM Inc., Chicago, IL, USA). All inferential tests were two-tailed, with a predetermined alpha level set at $p < 0.05$, denoting statistical significance.

Through this comprehensive statistical evaluation, the study aimed to discern any existent disparities in FMS scores and components of functional movement quality, namely balance, mobility, and stability, between male and female participants. Such an analytical approach facilitated a nuanced understanding of potential variances in functional movement attributes between genders.

3. Findings

To identify the movement quality of sports science students, the results of this study can be analyzed and classified as follows:

3.1. Evaluation of Movement Quality

This study assesses the movement quality of sports science students using the Functional Movement Screen (FMS). The evaluation focuses on balance, mobility, and stability. FMS scores for each component are analyzed, with Table 2 displaying mean scores, standard deviations, and percentages. The scoring criteria for balance (DS, HS, ILL tests) have a maximum of 9 points (100%), mobility (SM, ASLR tests) 6 points (100%), and stability (TS, RS tests) 6 points (100%). This analysis aims to understand the students' movement quality across these dimensions.

Table 2. The means, standard deviations, and relative weight of students' scores on The Functional Movement Screen FMS (N = 139)

Test	Mean	Std. Deviation	relative weight
Balance	7.88	0.98	0.88
DS	2.52	0.54	0.84
HS	2.74	0.44	0.91
ILL	2.63	0.53	0.88
Mobility	4.81	0.97	0.80
SM	2.49	0.62	0.83
ASLR	2.32	0.66	0.77
Stability	3.54	1.04	0.59
TS	1.87	0.67	0.62
RS	1.67	0.78	0.56
Quality of Movement	16.24	2.03	0.77

This study's findings include:

Balance: Students averaged 7.88 (±0.98 SD), equating to 88% efficiency.

Mobility: The average score was 4.81 (±0.97 SD), representing 80% efficiency.

Stability: Achieved an average of 3.54 (±1.04 SD), or 59% efficiency.

Additionally, asymmetries in movement were examined. This involved comparing the left and right sides in HS, ILL, SM, ASLR, and RS tests for both genders. The mean and standard deviation for these asymmetries is detailed in Table 3. An Independent T-test was conducted to assess the significance of these asymmetrical differences, with results presented in Table 4. This analysis aimed to identify any notable disparities in movement quality between the left and right sides across different tests.

Noteworthy findings from the test elucidated that no significant differences were detected in the ILL, SM, and ASLR tests. However, discernible disparities in the HS and RS tests between the left and right sides warranted attention.

3.2. Gender-based Discrepancies in Movement Quality

The study addressed whether movement quality varies between male and female sports science students. An Independent Samples Test assessed gender-based differences in movement quality scores, with the findings in Tables 5 and 6. This analysis aimed to identify significant disparities in movement quality across genders.

Despite slight score differences between genders in various components, the Independent t-Test (Table 6) revealed these variations as not statistically significant (p=0.824), indicating similar movement quality in both male and female students, with FMS total scores closely aligned (males: 16.19±1.95, females: 16.27±2.10).

Table 3. The (Mean ± SD) for the left and right sides of the HS, ILL, SM, ASLR, and RS tests for males and females

Variable	Right side.		Left side.	
	Male (N=66) (Mean ± SD)	Female (N=73) (Mean ± SD)	Male (N=66) (Mean ± SD)	Female(N=73) (Mean ± SD)
HS	2.95 ± 0.209	2.97 ± 0.164	2.66 ± 0.475	2.83 ± 0.373
ILL	2.78 ± 0.411	2.82 ± 0.419	2.63 ± 0.544	2.67 ± 0.473
SM	2.46 ± 0.613	2.56 ± 0.623	2.78 ± 0.411	2.75 ± 0.464
ASLR	2.77 ± 0.457	2.68 ± 0.684	2.34 ± 0.511	2.41 ± 0.663
RS	2.00 ± 0.784	2.15 ± 0.700	1.59 ± 0.722	1.89 ± 0.809

Table 4. The statistical differences between the left and right sides of the HS, ILL, SM, ASLR and RS using the Independent t- Test

Variable	F		T		P-value		Mean Difference		Std. Error Difference	
	R	L	R	L	R	L	R	L	R	L
HURDLE STEP (HS)	1.297	22.251	0.567	2.343	0.571	0.022*	0.018	0.168	0.031	0.072
INLINE LUNGE (ILL)	0.645	1.591	-0.482	-0.404	0.631	0.687	0.034	0.034	0.070	0.086
Shoulder Mobility (SM)	0.051	1.051	0.875-	0.460	0.383	0.646	0.091	0.034	0.105	0.074
Active SLR (ASLR)	4.015	9.240	0.897	0.625-	0.372	0.533	0.087	0.062	0.097	0.099
Rotatory Stability (RS)	0.024	0.358	1.196-	2.292-	0.234	0.023*	0.150	0.299	0.125	0.130

Table 5. The differences in the quality of movement scale according to the gender variable

Variable	Male (N=66) Mean ± SD	Females (N = 73) Mean ± SD	Whole Group Mean ± SD
DS	2.58 ± 0.49	2.47 ± 0.57	2.52 ± 0.54
HS	2.65 ± 0.48	2.82 ± 0.38	2.74 ± 0.44
ILL	2.61 ± 0.55	2.64 ± 0.51	2.63 ± 0.52
SM	2.47 ± 0.61	2.51 ± 0.62	2.49 ± 0.61
ASLR	2.30 ± 0.52	2.34 ± 0.76	2.32 ±0 .66
TS	2.08 ± 0.73	1.68 ± 0.55	1.87 ± 0.66
RS	1.52 ± 0.74	1.81 ± 0.79	± 0.78
FMS total score	16.19 ± 1.95	16.27 ± 2.10	16.23 ± 2.02

Table 6. Independent t- Test

Variable	N	F	T	P-value	Mean Difference	Std. Error Difference
FMS	139	1.085	0.223	0.824	0.077	0.3455

3.3. Injury Susceptibility among Students

The study's culminating inquiry delved into whether parameters assessing the quality of movement could serve as indicators for injury susceptibility among students specializing in sports science. It highlighted using a Functional Movement Screen (FMS) score, with a benchmark (cut-off) score of 14 or less signifying a heightened potential for injury. This criterion evaluated students' predisposition to injuries by analysing their movement patterns. Injury risk data is methodically presented in Table 7, categorized by gender, to explore the feasibility of predicting injuries within this group of students.

Table 7. Injury Risk Prediction Frequency and Percentage among sports science students (N = 139)

	Frequency	Percent
Students score ≤14	29	20.9
Males (N = 66)	11	7.9
Females (N = 73)	18	12.9

The data in Table 7 indicates that, from the student cohort of 139, 29 students, accounting for 20.9%, were identified as predisposed to injuries based on their FMS scores ≤14. Further gender-based analysis revealed that 7.9% of male students (11 individuals) and 12.9% of female students (18 individuals) were assessed as at an elevated risk of injury.

4. Discussion

This research focused on sports science students' functional movement quality, employing the Functional Movement Screen (FMS) to gauge balance, mobility, stability, and the potential to predict injury risk across genders. While the FMS outcomes—indicating high proficiency in balance and mobility among participants—underscore the importance of a curriculum rich in balance exercises, flexibility training, and joint health focus, our analysis extends beyond these component scores to address the broader implications for injury risk prediction and gender-specific vulnerabilities.

The study found an impressive 88% proficiency in balance and an 80% mobility score, aligning with previous literature suggesting that balance and mobility are crucial for athletic performance and injury prevention. Zemková and Zapletalová [35] highlighted the importance of neuromuscular control in stability, linking balance and core exercises to enhanced performance and injury prevention. Similarly, Huang et al. [36] found a strong correlation between balance abilities in physical education students and their sports performance, suggesting that specialized balance training plays a crucial role in performance and injury risk management. These insights align with our findings, emphasizing the value of balance proficiency in sports science education for improving athletic performance and minimizing injuries.

Also, Behm David's [37] findings highlight how specific stretching and flexibility exercises improve active range of motion (ROM) and mobility in sports activities. This evidence suggests that flexibility training is crucial in sports science education for optimal mobility.

Supporting this, the Sports Performance Bulletin [38] emphasizes the link between flexibility and injury prevention. It notes that limited ROM or stiffness can heighten muscle-strain risks, particularly in sports requiring larger ROMs. Therefore, the high mobility score in this study may indicate a lower injury risk for these students. However, the study's third aim, predicting injury/risk profiles, necessitates a deeper examination. While our data suggest a slightly higher injury risk among female participants, the absence of supporting inferential statistical analysis precludes definitive conclusions about gender predisposition to injury. This highlights a critical gap in our study that future research should aim to fill.

The observed 59% stability score among sports science students signals a potential area for curriculum improvement. As stability is paramount for effective joint movement and control, incorporating more dynamic and sport-specific exercises could better prepare students for athletic challenges and reduce injury risks. This approach aligns with recent recommendations for a more nuanced inclusion of stability training in sports science education. Willardson's [39] review emphasizes tailoring these exercises to the athlete's training phase and health status, advocating for a personalized approach in sports education.

Additionally, studies indicate that traditional low-load core exercises might be inadequate for athletes. Dynamic, loaded, free-weight exercises are recommended to develop trunk strength and stability [40]. This points to the importance of including more dynamic and sport-specific stability training in sports science curricula to better prepare students for athletic challenges and reduce injury risks. Such curriculum updates are crucial for enhancing performance and ensuring the well-being of sports science students.

The disparities in lower limb performance, as revealed by the Hurdle Step (HS) and Rotatory Stability (RS) tests, underscore the necessity of targeted interventions. Contrary to the common belief that bilateral asymmetries hinder athletic performance, Maloney's [41] critical review offers an intriguing perspective that challenges the prevailing notion regarding the negative impact of bilateral asymmetries on athletic performance. This suggests that sports science education might benefit from embracing individualized training programs that accommodate natural asymmetries rather than seeking to eliminate them. Contrary to initial observations, our study revealed no significant gender differences in movement quality. However, a higher injury risk was noted in female participants. This observation aligns with Ristolainen et al.'s [42] findings, indicating that female athletes are more prone to certain injury types. These results suggest that biomechanical and physiological differences between genders might influence this increased injury likelihood in females. Addressing these differences requires an integrative approach in sports science curricula, incorporating gender-specific physical conditioning and risk management strategies to mitigate these injury risks effectively.

In conclusion, while our study contributes valuable insights into the functional movement qualities of sports science students, it also highlights the importance of a more robust statistical analysis to substantiate claims regarding gender-specific injury risks. Future research should focus on overcoming these limitations, employing a comprehensive statistical framework to explore the nuanced relationships between gender, functional movement, and injury risk. This endeavor will enrich our understanding and inform the development of more effective, personalized injury prevention strategies in sports science education.

5. Implications

This study presents multifaceted implications that provide significant insights into the functional movement quality of sports science students, particularly in terms of injury risk prevention and gender-specific vulnerabilities. While the Functional Movement Screen (FMS) is primarily used to assess balance, mobility, and stability, the findings transcend individual scores to encompass broader implications for injury prevention and curriculum development.

The investigation uncovers a heightened injury risk among female sports science students, notwithstanding the absence of significant gender differences in movement quality. This outcome suggests a potential need for gender-specific injury prevention strategies in sports science education. Subsequent research endeavors could delve into the underlying factors contributing to the observed elevated injury risk among females, potentially paving the way for developing tailored interventions to mitigate these risks.

Furthermore, the study identifies disparities in lower limb performance and stability scores among sports science students. These findings underscore the importance of integrating individualized training programs into sports science curricula. By addressing natural asymmetries and emphasizing dynamic stability exercises, educational institutions can better equip students for the physical demands of athletic performance while concurrently diminishing the likelihood of injuries. Moreover, the investigation accentuates the advantages of incorporating balance exercises, flexibility training, and a focus on joint health within sports science curricula. These findings advocate for a curriculum enriched with activities promoting balance, flexibility, and joint health, enhancing functional movement quality among sports science students. Integrating such components into educational programs can augment athletic performance and contribute to long-term injury prevention and overall well-being.

6. Recommendations

Based on the findings of this study, the following recommendations are proposed to inform future research and enhance practices within the domain of sports science education:

Curriculum Enhancement: To address the varied scores in balance, mobility, and stability, a comprehensive update of the sports science curriculum is essential. This should include stability-focused exercises and in-depth theoretical knowledge, incorporating the latest research findings on dynamic stability exercises and training for static and dynamic stability.

Individualized Training: Tailoring training programs to individual needs is crucial, especially for addressing imbalances identified in HS and RS tests. Customized training should correct lateral imbalances and asymmetries to foster overall development and reduce injury risks, adapting to each student's biomechanical and physiological profile.

Expanding Research Methods: Beyond the Functional Movement Screen (FMS), research should embrace a broader range of assessment tools to understand human movement patterns comprehensively. This is especially important for examining gender differences in movement quality and injury susceptibility to refine training and educational strategies.

Gender-Specific Training and Injury Prevention: Research should also focus on gender-specific aspects of sports and injury prevention, considering biomechanical, physiological, and hormonal differences that may impact training and injury risks in male and female athletes.

Implementing these recommendations can significantly enhance sports science education, aligning it with current scientific understanding and improving training effectiveness, injury prevention, and athletic performance.

7. Conclusions

This study offers a detailed analysis of functional movement patterns and musculoskeletal (MSK) injury risks in sports science students, moving beyond conventional fitness assessments. Utilizing Functional Movement Screen (FMS) scores and extensive statistical evaluations illuminates key aspects of movement quality and injury susceptibility in this demographic.

Significant findings include diverse movement qualities, highlighting the need for a comprehensive sports science education approach focusing on physical fitness and movement quality for injury prevention and enhanced athletic performance.

The study also contributes to the dialogue on gender differences in sports science, indicating that gender has no substantial impact on movement quality. This challenges existing beliefs and emphasizes the need for personalized training and injury prevention strategies.

In conclusion, this research lays the groundwork for future studies and educational tactics, advocating for curriculum improvements emphasising movement quality and injury prevention based on individual needs and a thorough understanding of functional movement. It encourages ongoing exploration in this vital field to develop more effective training and injury prevention methods in sports science education.

Appendix

Appendix 1: Assessment of Inter-Rater Reliability Using Intraclass Correlation Coefficients (ICCs)

We use a two-way random-effects model (ICC 2,1) to assess inter-rater reliability and calculate intraclass correlation coefficients (ICCs). Table 1 presents the ICCs for single and average measures from two different tests, illustrating the consistency and dependability of evaluations provided by two raters.

Table 1 uses a two-way random-effects model (ICC 2,1), indicating that the effects of raters and measures are considered random.

In the First Test, Single Measures, An ICC of 0.914 suggests high reliability in the ratings of different raters. The 95% confidence interval (CI) from 0.788 to 0.966 indicates that if the study were repeated with different raters from the same population, we would expect the ICC to fall within this range 95% of the time. The F test is significant ($p = .001$), further supporting the reliability of the ratings. First Test, Average Measures: The ICC increases to 0.955, which shows an even higher level of agreement among raters when average measures are considered. The narrower CI of 0.881 to 0.983 reinforces this high reliability. The significance of the F test remains strong.

In the Second Test, Single Measures, The ICC is slightly higher at 0.922 than the first, indicating consistently high reliability across tests. The CI range of 0.813 to 0.968 remains tight, suggesting confidence in this estimate. Second Test, Average Measures: The ICC is again higher for average measure at 0.959, which indicates that averaging the ratings can reduce the impact of any random effects that might influence individual ratings. The CI of 0.897 to 0.984 and the significant F test value corroborate the high inter-rater reliability.

The note indicates that people's and measures' effects are random, which means the model accounts for variability among raters and the items being rated. Type A ICCs are calculated based on absolute agreement, suggesting that the raters are in strong agreement not just in rank order but also in the actual values of their ratings. Type C ICCs, based on consistency, would exclude between-measure variance from the denominator variance; however, this does not appear to be directly applicable to the results presented in Table 1.

In conclusion, the high ICC values across single and average measures, narrow confidence intervals and significant F test results indicate excellent inter-rater reliability. This suggests that the ratings are consistent and reproducible across different raters, lending credibility to the evaluation process used in the study.

Delving into test-retest and intra-rater reliability, Table 2 presents a nuanced analysis of the consistency in evaluations performed by the respective raters across the two testing intervals. The ICC (3,1) model quantified the reliability, which endorses a two-way mixed-effects analytical framework.

Table 1. Intraclass Correlation Coefficients (ICCs) for Evaluative Consistency Across Bifurcated Tests

Test Number	Measure Type	ICC (2,1)	95% CI Lower Bound	95% CI Upper Bound	F Test Value	df1	df2	Sig
First Test	Single Measures	0.914	0.788	0.966	25.222	19	19	.001
First Test	Average Measures	0.955	0.881	0.983	25.222	19	19	.001
Second Test	Single Measures	0.922	0.813	0.968	24.548	19	19	.001
Second Test	Average Measures	0.959	0.897	0.984	24.548	19	19	.001

Note: The (ICC 2,1) values represent a two-way random-effects model where the effects attributable to subjects and the specific measures under consideration are treated as random components. Type A ICCs reflect an absolute agreement metric, while Type C ICCs are predicated on a consistency framework. Importantly, the calculation of Type C ICCs omits the between-measure variance from the variance component in the denominator, focusing solely on within-measure consistency.

Table 2. Intraclass Correlation Coefficient Raters One and Two for the First and Second Test

Rater	Measure Type	ICC (3,1)	95% CI Lower Bound	95% CI Upper Bound	F Test Value	df1	df2	Sig
1	Single Measures	.937	.848	.975	29.345	19	19	.001
1	Average Measures	.968	.918	.987	29.345	19	19	.001
2	Single Measures	.799	.566	.915	8.896	19	19	.001
2	Average Measures	.889	.722	.956	8.896	19	19	.001

Note: The ICC (3,1) delineates a mixed-effects model in which subject effects are modelled as random and measurement effects as fixed. The Type A ICC, employed herein, quantifies absolute agreement without assuming interaction effects, which remain un-estimated due to methodological constraints.

Table 2 presents the test-retest and intra-rater reliability assessment for two raters across two tests. It employs a two-way mixed-effects model (ICC 3,1), suggesting that the people effects (i.e., differences among raters) are considered random. In contrast, the effects of the measures are treated as fixed. This model choice is appropriate when the raters are a random sample from a larger population of possible raters and when the measure (e.g., the test or item being rated) is the same across all raters and is the primary interest of the reliability estimation. The ICC (3,1) also allows for assessing the consistency of ratings within raters across time, which indicates both intra-rater and test-retest reliability.

In Rater 1, Single Measures, The ICC of .937 indicates an excellent level of agreement in this rater's scores between the two testing occasions, suggesting very high intra-rater reliability. The confidence interval is quite narrow (.848 to .975), indicating that we can be very confident about the reliability of this estimate. The F test result is significant (p = .001), confirming the strong reliability of the rater's evaluations. Rater 1, Average Measures, With an ICC of .968, the average measures for Rater 1 display even higher reliability than the single measures. This is typical because average scores are more stable and less affected by random error. The confidence interval (.918 to .987) remains narrow, reflecting high precision in the reliability estimate. The significance of the F test remains robust, supporting the reliability.

In Rater 2, Single Measures: The ICC for Rater 2's single measures is .799, which is still considered good reliability but is noticeably lower than that of Rater 1. The wider confidence interval (.566 to .915) suggests more uncertainty about this estimate, which could indicate variability in Rater 2's scoring consistency over time. Rater 2, Average Measures, the ICC improves to .889 for the average measures, which, as with Rater 1, indicates that averaging across measures improves reliability by reducing the impact of random errors. The confidence interval (.722 to .956) is narrower than for the single measures but still wider than for Rater 1, reflecting greater variability in Rater 2's ratings.

The note clarifies that the ICC estimates are based on absolute agreement and do not assume an interaction effect because it is not estimable. This is important as it affects the interpretation of the ICC values - with absolute agreement, the focus is on how close the ratings are in absolute terms, not just their rank order.

In summary, Table 2 shows excellent intra-rater and test-retest reliability for Rater 1, with high consistency in their ratings across tests. Rater 2 shows good reliability but with more variability than Rater 1. Overall, the table suggests that the ratings are reasonably stable over time and consistent within each rater, which is crucial for the reliability of the study's measurements.

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Conflict of Interest

The authors state no conflict of interest.

Disclosure Statement

No author has any financial interest or received any financial benefit from this research.

Declaration of generative AI and AI-assisted technologies in the writing process

While preparing this work, the authors used ChatGPT / All-around Writer (Professional Edition) to proofread and improve the language. Also, the authors used Mendeley Reference Management Software for citation. After using these tools/services, the authors reviewed and edited the content as needed and bear full responsibility for the post's content.

REFERENCES

[1] Cieza A, Causey K, Kamenov K, Hanson SW, Chatterji S,

Vos T. "Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019", The Lancet, vol. 396, no. 10267, pp. 2006-2017, 2020. doi:10.1016/S0140-6736(20)32340-0

[2] WHO. Musculoskeletal health. World Health Organization. Published July 14, 2022. Accessed January 2, 2024. https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions#

[3] Asgari M, Alizadeh S, Sendt A, Jaitner T. "Evaluation of the Functional Movement Screen (FMS) in Identifying Active Females Who are Prone to Injury. A Systematic Review", Sports Medicine Open. vol. 7, no. 1, 2021. doi:10.1186/s40798-021-00380-0

[4] Fitton Davies K, Sacko RS, Lyons MA, Duncan MJ. "Association between Functional Movement Screen Scores and Athletic Performance in Adolescents: A Systematic Review", Sports (Basel, Switzerland). vol. 10, no. 3, 2022. doi:10.3390/sports10030028

[5] Cohen KE, Morgan PJ, Plotnikoff RC, Callister R, Lubans DR. "Fundamental movement skills and physical activity among children living in low-income communities: A cross-sectional study", International Journal of Behavioral Nutrition and Physical Activity, vol. 11, no. 1, 2014. doi:10.1186/1479-5868-11-49

[6] Goossens L, Cardon G, Witvrouw E, Steyaert A, De Clercq D. "A multifactorial injury prevention intervention reduces injury incidence in Physical Education Teacher Education students", European Journal of Sport Science, vol. 16, no. 3, pp. 365-373, 2016. doi:10.1080/17461391.2015.1015619

[7] Bliekendaal S, Goossens L, Stubbe JH. "Incidence and risk factors of injuries and their impact on academic success: A prospective study in PETE students", Scandinavian Journal of Medicine & Science in Sports, vol. 27, no. 12, pp. 1978-1985, 2017. doi:10.1111/sms.12838

[8] Z. Sun, "Construction of Analytical Model in a College Students' Sports Training Injuries", Revista Brasileira de Medicina do Esporte, vol. 28, no. 5, pp. 451–455, 2022. doi: 10.1590/1517-8692202228052021_0516.

[9] A. Atikovic, A. N. Mujanović, and E. Mujanovic, "Sports Injuries of the Student Population at the Faculty for Physical Education and Sport: A Review of Injury-Risk and Injury-Prevention," in 2nd International Scientific Congress Organized by Slovenian Gymnastics Federation, 2015, pp. 94–100. [Online]. Available: https://www.researchgate.net/publication/274253726

[10] Fagher K, Lexell J. "Sports-related injuries in athletes with disabilities", Scandinavian Journal of Medicine & Science in Sports, vol. 24, no. 5, pp. e320-e331, 2014. doi:10.1111/sms.12175

[11] Fliciński J. Wystepowanie i Czynniki Ryzyka Dolegliwości Bólowych Ze Strony Układu Ruchu Oraz Urazów Sportowych u Studentów Instytutu Kultury Fizycznej Uniwersytetu Szczecińskiego [Occurrence and Risk Factors of Musculoskeletal Pain and Sport Injuries in Students of Physical Education in University of Szczecin].; 2008.

[12] Cameron KL, Owens BD. "The Burden and Management of Sports-Related Musculoskeletal Injuries and Conditions Within the US Military", Clinics in Sports Medicine, vol. 33, no. 4, pp. 573-589, 2014. doi:10.1016/j.csm.2014.06.004

[13] O'brien W, Khodaverdi Z, Bolger Lisa, Tarantino G, Conor Philpott, Neville RD. "The Assessment of Functional Movement in Children and Adolescents: A Systematic Review and Meta-Analysis", Sports Medicine, vol. 52, pp. 37-53, 2022. doi:10.1007/s40279-021-01529-3

[14] Nicolozakes CP, Schneider DK, Roewer BD, Borchers JR, Hewett TE. "Influence of body composition on functional movement ScreenTM scores in college football players", Journal of Sport Rehabilitation, vol. 27, no. 5, pp. 431-437, 2018. doi:10.1123/jsr.2015-0080

[15] Philpott C, Donovan B, Belton S, Lester D, Chambers F, O'Brien W. "Motor Competence Among Irish Adolescents: An Investigation of Sex Differences and Relatedness Between Fundamental Movement Skills and Functional Movement," Perceptual and Motor Skills, vol. 130, no. 1, pp. 27-53, 2023. doi:10.1177/00315125221137182

[16] Ziegler J, Reiter A, Gattringer H, Müller A. "Simultaneous identification of human body model parameters and gait trajectory from 3D motion capture data", Medical Engineering & Physics, vol. 84, pp. 193-202, 2020. doi:10.1016/j.medengphy.2020.08.009

[17] Dos'Santos T, Thomas C, McBurnie A, Comfort P, Jones PA. "Biomechanical Determinants of Performance and Injury Risk During Cutting: A Performance-Injury Conflict?" Sports Medicine, vol. 51, no. 9, pp. 1983-1998, 2021. doi:10.1007/s40279-021-01448-3

[18] McBurnie AJ, Dos'Santos T, Jones PA. "Biomechanical Associates of Performance and Knee Joint Loads During A 70-90° Cutting Maneuver in Subelite Soccer Players", Journal of Strength and Conditioning Research, vol. 35, no. 11, pp. 3190-3198, 2021. doi:10.1519/JSC.0000000000003252

[19] Gribble PA, Brigle J, Pietrosimone BG, Pfile KR, Webster KA. "Intrarater Reliability Of The Functional Movement Screen", Journal of Strength and Conditioning Research, vol. 27, no. 4, pp. 978-981, 2013. doi:10.1519/JSC.0b013e31825c32a8.

[20] Beardsley C., Contreras B. "The Functional Movement Screen A Review", Strength and Conditioning Journal, vol. 36, no. 5, pp. 72-80, 2014.

[21] Hincapié C.A., Tomlinson G.A., Hapuarachchi M., Stankovic T., Hirsch S., Carnegie D., Richards D., Frost D., Beach T.A.C. "Functional Movement Screen Task Scores and Joint Range-of-motion: A Construct Validity Study", International journal of sports medicine, vol. 43, no. 7, pp. 648-656, 2022. doi:10.1055/a-1708-9735

[22] T. Raj, R. Shankar, and M. Suhaib, "A review of some issues and identification of some barriers in the implementation of FMS," International Journal of Flexible Manufacturing Systems, vol. 19, no. 1, pp. 1–40, 2007. doi: 10.1007/s10696-007-9015-7.

[23] Syafei M, Budi DR, Listiandi AD, et al. Functional Movement Screening: An Early Detection of The Student Injury Risk in Sport Class", Jurnal Pendidikan Jasmani dan Olahraga, vol. 5, no. 2, 2020. doi:10.17509/jpjo.v5i2.25466

[24] Moran RW, Schneiders AG, Mason J, Sullivan SJ. "Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-

analysis", British Journal of Sports Medicine, vol. 51, no. 23, pp. 1661-1669, 2017. doi:10.1136/bjsports-2016-096938

[25] Alemany JA, Bushman TT, Grier T, et al. "Functional Movement Screen: Pain versus composite score and injury risk", Journal of Science and Medicine in Sport, vol. 20, pp. S40-S44, 2017. doi:10.1016/j.jsams.2017.08.001

[26] Everard E, Lyons M, Harrison AJ. "Examining the association of injury with the Functional Movement Screen and Landing Error Scoring System in military recruits undergoing 16 weeks of introductory fitness training", Journal of Science and Medicine in Sport, vol. 21, no. 6, pp. 569-573, 2018. doi:10.1016/j.jsams.2017.05.013

[27] Kodesh E, Shargal E, Kislev-Cohen R, Funk S, Dorfman L, Samuelly G., Hoffman JR, Sharvit N. "Examination of the Effectiveness of Predictors for Musculoskeletal Injuries in Female Soldiers", Journal of Sports Science and Medicine, vol. 14, no. 3, pp. 515-521, 2015.

[28] Bonazza NA, Smuin D, Onks CA, Silvis ML, Dhawan A. "Reliability, Validity, and Injury Predictive Value of the Functional Movement Screen A Systematic Review and Meta-analysis", American Journal of Sports Medicine, vol. 45, no. 3, pp. 725-732, 2017. doi:10.1177/0363546516641937

[29] R. Shultz, S. C. Anderson, G. O. Matheson, B. Marcello, and T. Besier, "Test-retest and interrater reliability of the functional movement screen," Journal of Athletic Training, vol. 48, no. 3, pp. 331–336, May 2013, doi: 10.4085/1062-6050-48.2.11.

[30] M. A. Sanchez-Lastra, J. M. Moldes, J. C. Diz, R. I. Mart ńez-Lemos, and C. Ayán, "Feasibility and reliability of the Functional Movement Screen battery in adults with intellectual disability," Journal of Intellectual Disability Research, vol. 66, no. 6, pp. 568-575, 2022, doi: 10.1111/jir.12916.

[31] Dorrel BS, Long T, Shaffer S, Myer GD. "Evaluation of the Functional Movement Screen as an Injury Prediction Tool Among Active Adult Populations: A Systematic Review and Meta-analysis", Sports Health, vol. 7, no. 6, pp. 532-537, 2015. doi:10.1177/1941738115607445

[32] Rowan CP, Kuropkat C, Gumieniak RJ, Gledhill N, Jamnik VK. "Integration Of The Functional Movement Screen Into The National Hockey League Combine", Journal of Strength and Conditioning Research, vol. 29, no. 5, pp. 1163-1171, 2015. doi:10.1519/JSC.0000000000000757

[33] Bushman TT, Grier TL, Canham-Chervak M, Anderson MK, North WJ, Jones BH. "The Functional Movement Screen and Injury Risk: Association and Predictive Value in Active Men", American Journal of Sports Medicine, vol. 44, no. 2, pp. 297-304, 2016. doi:10.1177/0363546515614815

[34] Chorba R, CDJ, B, L. E. OCA,, Landis JA. "Use of a Functional Movement Screening Tool to Determine Injury Risk in Female Collegiate Athletes", North American Journal of Sports Physical Therapy, vol. 5, no. 2, pp. 47-54, 2010.

[35] Zemková E, Zapletalová L. "The Role of Neuromuscular Control of Postural and Core Stability in Functional Movement and Athlete Performance", Frontiers in Physiology, vol. 13, 796097, 2022. doi:10.3389/fphys.2022.796097

[36] Huang X, Yan Z, Ma Y, Liu H. "The influence of different levels of physical activity and sports performance on the accuracy of dynamic lower limbs balance assessment among Chinese physical education college students", Frontiers in Physiology, vol. 14, 1184340, 2023. doi:10.3389/fphys.2023.1184340

[37] Behm David. The Science and Physiology of Flexibility and Stretching. Routledge; 2018. doi:10.4324/9781315110745

[38] Hamilton A. Flexibility training: the role of stretching in sports performance. Sports Performance Bulletin - Strength conditioning & flexibility. Published 2022. Accessed January 4, 2024. https://www.sportsperformancebulletin.com/training/strength-conditioning--flexibility/flexibility-training-the-role-of-stretching-in-sports-performance

[39] Willardson JM. "Core Stability Training: Applications to Sports Conditioning Programs", Journal of Strength and Conditioning Research, vol. 21, no. 3, pp. 979-985, 2007. doi:10.1519/R-20255.1.

[40] Clark DR, Lambert MI, Hunter AM. "Contemporary perspectives of core stability training for dynamic athletic performance: a survey of athletes, coaches, sports science and sports medicine practitioners", Sports Medicine - Open, vol. 4, no. 1, 2018. doi:10.1186/s40798-018-0150-3

[41] Maloney SJ. "The Relationship Between Asymmetry And Athletic Performance: A Critical Review", Journal of Strength and Conditioning Research, vol. 33, no. 9, pp. 2579-2593, 2019. doi:10.1519/JSC.0000000000002608

[42] Ristolainen L, Heinonen A, Waller B, Kujala UM, Kettunen JA. "Gender Differences in Sport Injury Risk and Types of Injuries: A Retrospective Twelve-Month Study on Cross-Country Skiers, Swimmers, Long-Distance Runners and Soccer Players", Journal of Sports Science and Medicine, vol. 8, no. 3, pp. 443-451, 2009.