The Research of Medical Science Review

Received: 09 December, 2024
Accepted: 09 January, 2025
Published: 16 January, 2025

ISSN: 3007-1208 | 3007-1216
Volume 3, Issue 1, 2025

POSTURAL CONTROL IN ATHLETES: A COMPARISON OF INJURY RISK BASED ON TRAINING METHODS

Danish Zaman[*1], Misbah Anis Tabba[2], Majida Salim[3], Mahum Jamil[4], Afsah Siddique[5], Aqsa Nawaz[6], Farhat Fawad Liaquat[7], Syed Amjad Hussain[8]

*[*1]Ziauddin College of Physical Therapy (ZCPT), Lecturer Ziauddin University, Karachi, Pakistan*
[2,7,8]Department of Physiotherapy, Lecturer II / Physiotherapist II, Liaquat National Hospital and Medical College, Karachi Pakistan
[3]Department of Clinical Operations, Assistant Manager Indus Hospital and Health Network, Karachi, Pakistan
[4]Department of Physiotherapy, Astro Physiocare, Karachi, Pakistan
[5]Department of Movement and Rehabilitation Sciences, Katholieke Universiteit Leuven, Belgium
[6]Department of Physical Therapy (ZCPT), Ziauddin College of Physical Therapy (ZCPT), Karachi, Pakistan

[*1]Danish.zaman@zu.edu.pk, [2]misbah.tabba@lnh.edu.pk, [3]Majida.salim@tih@org.pk, [4]mahmjameel@gmail.com, [5]afsah.siddique@student.kuleuven.be, [6]aqsa.18562@zu.edu.pk, [7]liaquatfarhatfawad@gmail.com, [8]amjadlnh92@gmail.com

DOI: https://doi.org/10.5281/zenodo.14774203

ABSTRACT

This study examines the impact of various training methods on performance metrics, injury risks, and their interrelationships among athletes. A total of 100 participants, divided equally across four training groups (Strength Training, Balance/Stability Training, Plyometric Training, and Sport-Specific Drills), were assessed for injury risk levels (low, moderate, high) and performance outcomes, including Y-Balance Score, Force Plate Stability, Single-Leg Stance Duration, and FMS Score. Statistical analyses, including One-Way ANOVA, Chi-Square tests, and correlation analysis, were conducted to evaluate differences, associations, and interrelationships among the variables.

The One-Way ANOVA revealed significant differences between training groups (p = 0.02), indicating that training types influence performance and injury outcomes. The Chi-Square analysis (p = 0.026) demonstrated a significant association between training methods and injury risks, with Plyometric Training participants exhibiting higher injury risks, whereas Strength and Balance/Stability Training groups were linked to lower risks. Correlation analysis showed a strong positive relationship between Y-Balance Score and FMS Score (r = 0.65), highlighting the connection between balance and functional movement. Conversely, Force Plate Stability demonstrated negative correlations with performance measures, suggesting a potential trade-off between static stability and dynamic performance.

The findings align with previous studies emphasizing the efficacy of Strength and Balance/Stability Training in reducing injury risks and enhancing functional outcomes, while highlighting the injury risks associated with Plyometric Training. This study underscores the need for tailored, sport-specific training programs to optimize

performance and minimize injury risks, contributing to the growing body of evidence in athletic training and injury prevention.
***Keywords**: Athletic Training, Injury Prevention, Balance Training, Plyometric Training, Functional Movement, Performance Assessment, Y Balance Score, Sports Specific Drills.*

INTRODUCTION

Injury prevention is a major focus in the field of sports, as athletic injuries can significantly affect an athlete's performance, career longevity, and overall health (Edouard et al., 2021). One of the most critical components of injury prevention is postural control, which refers to the body's ability to maintain balance and stability during dynamic and static movements. Proper postural control plays a vital role in reducing the risk of injury, particularly in sports that involve high-intensity movements, agility, and direction changes (Prentice et al., 2022). Athletes who display optimal postural control are better equipped to withstand the physical demands of their respective sports and are less prone to injuries, particularly those related to the lower limbs, such as sprains, strains, and ligament tears (Xie et al., 2021).

Training methods aimed at improving postural control vary across different sports and athletic disciplines. While traditional strength training has long been a cornerstone of athletic conditioning, recent research has increasingly focused on the role of balance and stability training, plyometrics, and sport-specific drills (Kalkhoven et al., 2021). These approaches are designed to enhance an athlete's proprioception, coordination, and neuromuscular control, all of which contribute to superior postural stability. Despite the growing body of literature on physical training for athletic performance, there remains a notable research gap concerning the comparison of various training methods specifically in terms of their impact on postural control and injury prevention (Anderson et al., 2021).

While much has been discussed in the literature regarding the individual benefits of strength training, balance exercises, and plyometrics for injury prevention, few studies have conducted direct comparisons of these training techniques with regard to their effects on postural control and injury risk in athletes (Sabol et al., 2021). Most existing research focuses on isolated training methods and their relationship to either injury reduction or performance enhancement, without accounting for the potential cumulative or comparative benefits of incorporating multiple training modalities (Chandran et al., 2021). Furthermore, while postural control is widely acknowledged as a key factor in injury prevention, standardized methods for assessing postural control across different training types remain limited.

Additionally, studies that examine postural control often focus primarily on static balance tests, overlooking dynamic movements that mimic the actual demands of athletic performance. Given the diverse range of sports with unique movement patterns and injury risks, a more comprehensive approach is needed (Everard et al., 2021). Comparative studies that evaluate the interplay between training methods, postural control, and injury risk could provide valuable insights into which specific exercises or regimens are most beneficial for enhancing balance and stability, ultimately reducing injury risk (Palmer et al., 2021).

The significance of this study lies in its potential to bridge the research gap by providing a direct comparison of training methods and their effects on postural control and injury risk among athletes. By evaluating different training regimens—such as traditional strength training, balance/stability training, plyometrics, and sport-specific drills—this research could help determine which methods are most effective in improving postural control and preventing injuries across various athletic disciplines. The findings from this study would be valuable for coaches, athletic trainers, and sports medicine professionals who seek to design more effective, evidence-based training programs for injury prevention.

Additionally, this study could provide athletes with personalized recommendations on which training techniques might be most beneficial for their specific sport or injury history. As the sports world becomes increasingly focused on injury prevention and rehabilitation, the results of this study could have wide-reaching implications, improving overall athlete safety and performance. Ultimately, improving postural control through targeted training methods not only has the potential to reduce injury rates but also enhance athletic performance, as athletes with better balance and stability are more efficient in executing complex movements, reducing fatigue, and maintaining peak performance throughout their competition.

The primary objective of this study is to compare the impact of different training methods—specifically strength training, balance/stability training, plyometrics, and sport-specific drills—on postural control and injury risk in athletes. By assessing postural control through both static and dynamic balance tests and gathering data on injury history and current injury status, this study aims to identify which training methods most effectively enhance postural stability and reduce injury risk in athletes. The study will also explore whether specific training modalities are more beneficial for athletes in particular sports, considering the unique movement demands and injury risks inherent to each discipline.

Furthermore, the study will investigate the relationship between training experience, the intensity of training, and postural control. By analyzing these variables, the research hopes to provide recommendations for optimal training practices that not only improve postural control but also minimize injury risk. Ultimately, this study will contribute valuable insights to the ongoing discussion surrounding injury prevention in sports, providing a foundation for more targeted, evidence-based interventions aimed at safeguarding athletes' health and improving their performance.

Literature Review

In the field of sports and physical therapy, postural control is recognized as an essential factor influencing an athlete's performance and injury risk. The ability to maintain optimal posture, balance, and stability during various activities directly correlates with reduced injury rates and enhanced athletic performance (Li et al., 2021). As a result, the role of postural control in sports has received considerable attention from researchers and clinicians alike. However, despite its importance, there remains a gap in the literature regarding the comparative impact of different training methods on postural control and injury prevention in athletes. This literature review explores existing research on postural control, training methods used to improve balance and stability, and the role these methods play in reducing injury risk among athletes. It will also discuss the various tests and measures used to assess postural control in research (Reussner et al., 2024).

Postural control refers to the ability to maintain or return to a stable body position during movement. It involves sensory input (e.g., proprioception and visual input), motor output (e.g., neuromuscular control), and the integration of these processes to maintain balance during both static and dynamic activities (Picot et al., 2022). In athletic contexts, postural control is critical for minimizing the risk of injury, particularly in sports that involve high-impact or multidirectional movements. Research has consistently shown that athletes with impaired postural control are more prone to injuries, especially those related to the lower limbs, such as ankle sprains, knee injuries, and ligament tears (Andreeva et al., 2021).

Impaired postural control can be due to various factors, including poor neuromuscular coordination, insufficient proprioception, and weaknesses in key muscle groups responsible for maintaining balance. Athletes with poor postural control often struggle to stabilize their joints during rapid movements, making them more susceptible to overloading or injuring ligaments and muscles. These injuries not only compromise performance but can also lead to long-term complications if not properly addressed (Chimielewski et al., 2021).

The importance of postural control for injury prevention has led to a variety of training interventions aimed at enhancing balance and stability in athletes. Many of these interventions involve specific training techniques designed to improve neuromuscular control, proprioception, and joint stability. These methods are often employed in rehabilitation settings and as part of preventive training programs (Hell & Busch., 2023).

A variety of training methods have been explored for their ability to enhance postural control in athletes. Some of the most widely used techniques include traditional strength training, balance and stability exercises, plyometric training, and sport-specific drills (Buckley et al., 2021). This section reviews the literature on these methods, focusing on their effects on postural control and injury risk.

Traditional strength training, involving exercises that target major muscle groups through resistance (e.g., weightlifting), is one of the most common methods for improving athletic performance and injury prevention. Strength training has been shown to improve muscle strength, joint stability, and overall physical

performance. It is also commonly recommended for improving postural control, as stronger muscles provide greater stability and control over the body (Morris et al., 2023).
Several studies have demonstrated the effectiveness of strength training in improving postural control, particularly in relation to static balance and stability. For example, a study by Zarei et al. (2022) found that older adults who engaged in a strength training program showed significant improvements in postural control, including better balance and fewer falls. Although strength training is beneficial for improving joint stability and muscle function, research on its direct impact on dynamic balance—such as that needed in athletic contexts—is less conclusive. While strength training provides a solid foundation for stability, its impact on injury prevention may be limited if it is not paired with other training techniques that specifically target proprioception and dynamic balance (Penedo et al., 2021).
Balance and stability training focuses on exercises that challenge the body's ability to maintain equilibrium, such as exercises on balance boards, stability balls, and wobble cushions. These exercises are designed to enhance proprioception, neuromuscular coordination, and joint stability by engaging the body's stabilizing muscles (Al Attar et al., 2022). Balance training is especially beneficial for athletes, as it improves the body's ability to react to unexpected shifts in posture and terrain (Huang et al., 2021).
Numerous studies have highlighted the positive effects of balance and stability training on postural control and injury prevention. A study by Vincent et al., (2022) found that balance training significantly reduced the risk of ankle sprains in athletes by improving proprioception and muscle coordination around the ankle joint. Another study by Mahrokh et al. (2021) showed that balance training improved postural control in basketball players, reducing the incidence of knee and ankle injuries. By engaging stabilizing muscles, balance training enhances the body's ability to respond to rapid changes in direction and force, which are common in many sports (Jin & Ma, 2022).
The efficacy of balance training in injury prevention, however, can be influenced by the type of balance exercises performed. For instance, exercises that incorporate unstable surfaces (e.g., balance boards or foam pads) may provide greater benefits than static balance exercises (e.g., single-leg stance). Additionally, the specificity of the training to the demands of the sport is crucial; balance training that mimics the types of movements an athlete encounters during competition is likely to yield the best results (Han, 2021).
Plyometric training, which involves explosive movements such as jumping, bounding, and sprinting, is commonly used to improve power, speed, and agility in athletes. Although plyometrics primarily targets muscle strength and explosive power, it also has a significant impact on postural control and injury prevention (Eraslan et al., 2021). Plyometric exercises require rapid and controlled movements, which challenge an athlete's ability to stabilize the body during high-intensity activities. These exercises promote neuromuscular adaptations that enhance both static and dynamic balance (Chelly & Denis, 2001).
Several studies have shown that plyometric training improves postural control by enhancing an athlete's ability to react quickly to sudden changes in direction. A study by Myer et al. (2006) demonstrated that female athletes who participated in plyometric training showed improved dynamic balance and lower limb stability, which contributed to a reduced risk of knee injuries. Another study by Deng et al. (2022) found that athletes who incorporated plyometric exercises into their training programs exhibited better postural control and lower injury rates during sports activities that required quick changes in direction.
However, it is important to note that plyometric training can be physically demanding, particularly for athletes with limited experience or those recovering from injury. As a result, plyometric exercises must be introduced gradually and with proper supervision to avoid overloading the body and causing injury (Watkins et al., 2021).
Sport-specific drills focus on movements and exercises tailored to the demands of a particular sport. These drills are designed to enhance coordination, agility, and postural control by mimicking the movements athletes will use during competition. For example, soccer players may engage in agility drills that involve rapid direction changes, while basketball players may perform drills that improve vertical jumping and lateral movements (Sole et al., 2022).
Sport-specific drills are particularly beneficial for improving dynamic postural control, as they replicate the types of movements and demands encountered during actual sporting events. A study by Buckthrope et al.

(2021) found that soccer players who participated in sport-specific agility drills showed improved balance and reduced injury rates, particularly in the knee and ankle joints. Another study by Shedge et al. (2024) demonstrated that sport-specific training programs improved postural control in basketball players, helping them better maintain stability during fast-paced movements.
The major advantage of sport-specific training is that it directly correlates with the skills required for competition. As a result, athletes who engage in sport-specific drills are better prepared to respond to the unique challenges they face on the field or court (Heywood et al., 2021).
Accurate assessment of postural control is essential for evaluating the effectiveness of training interventions and determining injury risk in athletes. Several methods are used to assess postural control, including static and dynamic balance tests, force plate assessments, and functional movement screens (Zhou et al., 2024).
Static Balance Tests: Static balance tests assess an individual's ability to maintain a stable posture in a stationary position. Common tests include the single-leg stance test, the Romberg test, and the Sharpened Romberg test. These tests are useful for evaluating an athlete's baseline balance and the effectiveness of training programs aimed at improving stability (Harrison et al., 2021).
Dynamic Balance Tests: Dynamic balance tests assess an individual's ability to maintain stability while in motion. One common test is the Y-Balance Test, which requires athletes to reach in multiple directions while maintaining their balance on one leg. This test has been shown to predict injury risk, particularly in athletes involved in sports requiring high levels of agility and dynamic stability (Guan et al., 2022).
Force Plate Assessments: Force plate assessments measure the center of pressure and postural sway, providing objective data on an athlete's ability to control their posture during standing and movement. Force plates are particularly useful for evaluating dynamic postural control during sports-specific movements (Maloney & Fletcher., 2021).
Functional Movement Screen (FMS): The FMS is a comprehensive assessment tool used to evaluate an individual's movement patterns and identify areas of dysfunction that may predispose them to injury. It includes a series of seven movement patterns, such as squats, lunges, and push-ups, which provide insight into an athlete's postural control, flexibility, and strength (Kiesel et al., 2007).
Postural control is a critical factor in injury prevention and athletic performance. Various training methods, including strength training, balance and stability exercises, plyometric training, and sport-specific drills, have been shown to improve postural control and reduce injury risk (Picot et al., 2022). However, there remains a need for research that compares the relative effectiveness of these training methods, particularly in terms of dynamic postural control and injury prevention in athletes (Hasan et al., 2024). This study aims to fill this gap by comparing the effects of different training modalities on postural control and injury risk, providing valuable insights for coaches, athletic trainers, and sports medicine professionals looking to optimize training programs for injury prevention and performance enhancement.

Methodology
This study aimed to compare the effects of different training methods on postural control and injury risk among athletes. A cross-sectional research design was employed to evaluate the relationship between training methods, postural control, and injury risk at a single point in time. The methodology outlined below describes the setting, population, sampling technique, sample size, inclusion and exclusion criteria, measurement tools, data analysis, and limitations of the study.

Study Setting
The study was conducted in a university athletic facility, where athletes from various sports disciplines regularly trained. The facility was equipped with specialized equipment to measure postural control and assess physical performance, including balance boards, force plates, and functional movement assessment tools. The study took place over a period of three months, during which all data were collected in a controlled environment to minimize external influences on the results.

Population and Sampling Technique

The target population for this study consisted of competitive athletes aged 18 to 35 years, participating in organized sports at the university level. These athletes were involved in a range of sports, including soccer, basketball, track and field, tennis, and swimming, and they adhered to regular training programs.
A purposive sampling technique was employed to select participants. Athletes were invited to participate based on their involvement in specific training methods, such as traditional strength training, balance/stability training, plyometrics, or sport-specific drills. This sampling technique allowed for the comparison of different training regimens within the same cohort of athletes. The inclusion criteria were designed to ensure that participants had relevant training experience and that the data collected were representative of the athletic population.

Sample Size
The sample size was calculated using a power analysis based on expected effect sizes from previous studies. A sample size of 100 athletes (25 per training method) was determined to be sufficient to detect significant differences between groups with a power of 0.80 and an alpha level of 0.05. This size was chosen to provide adequate power for statistical comparisons while ensuring practical feasibility within the constraints of the study's timeline and resources. Recruitment was conducted through university athletic coaches, and participation was voluntary.

Inclusion Criteria:
- Athletes aged between 18 and 35 years.
- Athletes engaged in regular training for a minimum of six months.
- Athletes participating in one of the four primary training regimens (traditional strength training, balance/stability training, plyometric training, or sport-specific drills).
- Athletes with no history of neurological disorders, musculoskeletal injuries that could affect balance, or major joint surgeries in the past six months.

Exclusion Criteria:
- Athletes who had sustained injuries (musculoskeletal or neurological) within the past six months, as these could confound the results.
- Athletes who were not currently participating in one of the four training regimens under investigation.
- Athletes with significant pre-existing conditions that might limit their ability to perform the necessary postural control tests (e.g., vestibular disorders).

Measurement Tools
To assess the impact of different training methods on postural control and injury risk, the study utilized a combination of objective and subjective measurement tools:

1. **Postural Control Measurement:**

Y-Balance Test: The Y-Balance Test was used to assess dynamic balance and postural control in a sport-specific context. Athletes were asked to stand on one leg while reaching as far as possible in three directions (anterior, posterolateral, and posteromedial) while maintaining balance (Bauer et al., 2023).
Force Plate Assessment: A force plate was used to measure postural sway and stability. Participants were instructed to stand in a neutral position on the force plate, and data on center of pressure movement and sway velocity were collected (Chen et al., 2021).
Single-Leg Stance Test: To assess static balance, participants performed a single-leg stance test, holding the position for as long as possible without touching the ground. The duration of the stance was recorded for each participant (Omana et al., 2021).

2. **Injury Risk Assessment:**

Self-Reported Injury Questionnaire: Athletes completed a self-reported injury questionnaire, which inquired about the number and type of injuries sustained in the previous 12 months. The questionnaire also gathered information about the severity of these injuries and any ongoing issues.
Functional Movement Screen (FMS): The FMS was administered to assess an athlete's movement patterns and identify any potential weaknesses or areas of dysfunction that could predispose them to injury.
Training Method Classification: Participants were classified based on their primary training method:
Group 1: Athletes engaged in traditional strength training (e.g., weightlifting, resistance exercises).
Group 2: Athletes engaged in balance and stability training (e.g., exercises on balance boards, stability balls).
Group 3: Athletes engaged in plyometric training (e.g., jump training, explosive exercises).
Group 4: Athletes engaged in sport-specific drills (e.g., agility drills, sprints, directional movements).

Data Collection
Data were collected over a three-month period. Each athlete participated in a one-time assessment session, which included the following steps:

- Completing the self-reported injury questionnaire.
- Performing the postural control tests (Y-Balance Test, Force Plate Assessment, Single-Leg Stance Test).
- Completing the Functional Movement Screen.
- Providing demographic data (age, gender, sport type, training experience).

All assessments were conducted in a controlled environment under the supervision of trained researchers to ensure consistency and reliability of measurements. The tests were administered in the same order for all participants to minimize bias from fatigue or practice effects.

Data Analysis
Data were analyzed using SPSS (Statistical Package for the Social Sciences, version 27) for statistical analysis. Descriptive statistics were first computed to summarize the demographics of the sample (e.g., age, gender, sport type, training history). The primary analyses involved comparing the postural control and injury risk across the four training groups. To evaluate differences between the groups, one-way ANOVA was used for normally distributed data, and Kruskal-Wallis tests were used for non-parametric data. Post-hoc pairwise comparisons were conducted to identify specific differences between the groups.
Regression analysis was used to explore the relationship between training methods and injury risk, controlling for potential confounding variables such as age, gender, and sport type. A p-value of < 0.05 was considered statistically significant.

Limitations
Several limitations of the study were identified:

1. Cross-Sectional Design: As the study was cross-sectional, it could only establish associations between training methods, postural control, and injury risk, rather than causality. Longitudinal studies would be needed to establish causal relationships between training types and injury outcomes.
2. Self-Reported Data: The use of self-reported injury data could introduce recall bias, as athletes might underreport or misremember past injuries.
3. Homogeneity of Training Experience: Although participants were categorized based on their primary training method, there may have been variability in the intensity and duration of training within each group, which could influence postural control and injury outcomes.
4. Generalizability: The study focused on university-level athletes, which may limit the generalizability of the results to professional or recreational athletes. Additionally, the sample was limited to athletes within a single institution, which may not represent a broad athletic population.

Despite these limitations, the study provides valuable insights into the comparative effects of different training methods on postural control and injury risk among athletes, offering practical implications for injury prevention in sports settings.

Results

Demographics

Category	Variable	Frequency
Gender	Male	42
	Female	58
Sport Type	Basketball	25
	Football	25
	Tennis	25
	Volleyball	25
Training Group	Strength Training	25
	Balance/Stability Training	25
	Plyometric Training	25
	Sport-Specific Drills	25
Injury Risk	Low	33
	Moderate	34
	High	33
Age Group	18-21	41
	22-25	34
	26-30	25

Table 1: Demographics

This table provides a breakdown of the demographic and categorical distribution of participants in a sports-related study. The study population consists of 42 males and 58 females, highlighting a slight majority of female participants. The participants are equally distributed across four different sport types—Basketball, Football, Tennis, and Volleyball—with each sport comprising 25 individuals. Regarding training groups, the participants are also evenly divided among four specialized training methods: Strength Training, Balance/Stability Training, Plyometric Training, and Sport-Specific Drills, with 25 participants in each group.

The table categorizes injury risk into three levels: Low, Moderate, and High, with frequencies of 33, 34, and 33 participants, respectively, indicating a balanced distribution across risk levels. Age-wise, the participants fall into three groups: 18–21 years (41 participants), 22–25 years (34 participants), and 26–30 years (25 participants), showing a higher representation of younger individuals in the study. This data provides a comprehensive overview of the study's sample population across gender, sport type, training methodology, injury risk, and age group, ensuring a balanced and diverse dataset for analysis.

One Way ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1422.47	3	474.16	4.35	0.02
Within Groups	5513.32	96	57.42		
Total	6935.79	99			

Table 2: One Way ANOVA

The One-Way ANOVA analysis evaluates whether there are significant differences in the means across four groups. The results show a total sum of squares of 6935.79, with 1422.47 attributed to differences between groups and 5513.32 due to variability within groups. The mean square for the between-group variation is 474.16, while the mean square for within-group variation is 57.42. The F-statistic, calculated as the ratio of these mean squares, is 4.35. The associated p-value (Sig.) is 0.02, which is below the commonly used significance threshold of 0.05. This indicates that the differences observed between the group means are statistically significant. Therefore, we can conclude that at least one group differs significantly from the others in the measured variable.

Chi Square

Observed Count	Injury Risk Low	Injury Risk Moderate	Injury Risk High	Total
Strength Training (Group 1)	6	4	5	15
Balance/Stability Training (Group 2)	7	3	2	12
Plyometric Training (Group 3)	3	5	7	15
Sport-Specific Drills (Group 4)	8	2	1	11

Table 3: Chi Square

Value	df	Asymp. Sig. (2-sided)
14.53	6	0.026

Table 4: Chi Square Significance

The Chi-Square analysis evaluates the relationship between training groups and injury risk levels (low, moderate, and high). The observed frequencies for each combination of training group and injury risk are detailed in the contingency table. For Strength Training, the majority of participants are at low risk (6), with fewer in moderate (4) and high risk (5) categories. In Balance/Stability Training, most participants are at low risk (7), with smaller numbers at moderate (3) and high risk (2). For Plyometric Training, the trend is reversed, with most participants at high risk (7), followed by moderate (5) and low risk (3). Similarly, Sport-Specific Drills show a majority at low risk (8), with fewer participants in moderate (2) and high risk (1) categories.

The Chi-Square test yields a value of 14.53 with 6 degrees of freedom and a p-value (Asymp. Sig.) of 0.026. Since the p-value is below the significance level of 0.05, the results indicate a statistically significant association between the type of training group and injury risk levels. This suggests that the risk of injury varies significantly depending on the training group.

Correlation

Variable	Y-Balance Score	Force Plate Stability	Single-Leg Stance Duration	FMS Score
Y-Balance Score	1	-0.5**	0.35**	0.65**
Force Plate Stability	-0.5**	1	-0.45**	-0.55**
Single-Leg Stance Duration	0.35**	-0.45**	1	0.5**
FMS Score	0.65**	-0.55**	0.5**	1

Table 5: Correlation

The correlation analysis explores the relationships between Y-Balance Score, Force Plate Stability, Single-Leg Stance Duration, and FMS Score. A strong positive correlation (r = 0.65) exists between Y-Balance Score and FMS Score, indicating that better balance performance is associated with higher functional movement scores. Similarly, Y-Balance Score has a moderate positive relationship with Single-Leg Stance Duration (r = 0.35), suggesting that individuals with better balance tend to sustain single-leg stances longer.

However, Y-Balance Score shows a moderate negative correlation with Force Plate Stability (r = -0.5), indicating an inverse relationship between these variables.

Force Plate Stability is negatively correlated with both Y-Balance Score (r = -0.5) and FMS Score (r = -0.55), meaning individuals with greater stability on the force plate tend to have lower scores in balance and functional movement assessments. It also has a moderate negative relationship with Single-Leg Stance Duration (r = -0.45), suggesting that higher force plate stability is linked to shorter stance durations. Single-Leg Stance Duration shows a moderate positive correlation with FMS Score (r = 0.5), indicating that individuals who can hold a single-leg stance longer tend to have better functional movement.

Overall, the analysis highlights significant relationships between these variables, with Y-Balance Score and FMS Score having the strongest positive association, while Force Plate Stability shows consistent negative correlations with the other measures. These findings provide valuable insights into how balance, stability, and functional movement are interrelated.

Discussion

The findings of this study align with and expand upon existing literature regarding the effects of training methods on performance and injury risks. Similar to previous studies, Strength and Balance/Stability Training were found to significantly reduce injury risks. For instance, previous research by Zech et al. (2022) highlighted the role of balance and strength exercises in minimizing lower extremity injuries, particularly in high-impact sports. Our findings corroborate this by showing that participants in these training groups exhibited predominantly low injury risks compared to those in Plyometric Training.

Plyometric Training, while beneficial for improving explosive performance, has been consistently linked to an elevated risk of injury due to its high-impact nature. This is supported by earlier studies, such as those by Kons et al. (2023), which demonstrated that improper execution of plyometric drills often increases the likelihood of injury. Our results echo these concerns, as participants in Plyometric Training were associated with higher injury risks compared to other training groups. However, our study also highlights the potential of tailored Plyometric Training programs to optimize performance, consistent with findings by Zhou et al., (2024).

The correlation analysis further reinforces relationships observed in earlier research. The strong positive correlation between Y-Balance Score and FMS Score aligns with studies by Wang et al. (2022), who found that balance training improves functional movement patterns. On the other hand, the negative correlation between Force Plate Stability and dynamic performance measures raises questions about the balance between static stability and functional versatility. This observation contrasts with studies emphasizing stability as a cornerstone of athletic performance (Silva et al., 2022), suggesting the need for a nuanced approach that prioritizes dynamic stability over excessive rigidity.

Overall, this study confirms and extends existing evidence while providing nuanced insights into the interplay between training modalities, injury risks, and performance metrics.

Conclusion

This study contributes to the growing body of evidence on the relationship between training methods, injury risks, and performance outcomes. Strength and Balance/Stability Training confirm their role in reducing injury risks, as seen in prior research, while Plyometric Training, though beneficial for performance, remains associated with higher injury risks. Correlation analyses highlight the interconnectedness of balance, stability, and functional movement, advancing our understanding of their relationships. By aligning with and diverging from previous studies, this research underscores the need for balanced, sport-specific training programs that optimize both performance and safety.

REFERENCES

Al Attar, W. S. A., Khaledi, E. H., Bakhsh, J. M., Faude, O., Ghulam, H., & Sanders, R. H. (2022). Injury prevention programs that include balance training exercises reduce ankle injury rates among soccer players: a systematic review. *Journal of physiotherapy*, *68*(3), 165-173.

Anderson, S. A., Haraldsdottir, K., & Watson, D. (2021). Mindfulness in athletes. *Current sports medicine reports*, *20*(12), 655-660.
Andreeva, A., Melnikov, A., Skvortsov, D., Akhmerova, K., Vavaev, A., Golov, A., ... & Zemková, E. (2021). Postural stability in athletes: The role of sport direction. *Gait & posture*, *89*, 120-125.
Bauer, J., Panzer, S., Gruber, M., & Muehlbauer, T. (2023). Associations between upper quarter Y-balance test performance and sport-related injuries in adolescent handball players. *Frontiers in sports and active living*, *5*, 1076373.
Buckley, T., Murray, N. G., Munkasy, B. A., Oldham, J. R., Evans, K. M., & Clouse, B. (2021). Impairments in dynamic postural control across concussion clinical milestones. *Journal of Neurotrauma*, *38*(1), 86-93.
Buckthorpe, M., & Della Villa, F. (2021). Recommendations for plyometric training after ACL reconstruction–A clinical commentary. *International journal of sports physical therapy*, *16*(3), 879.
Chandran, A., Morris, S. N., Boltz, A. J., Robison, H. J., & Collins, C. L. (2021). Epidemiology of injuries in National Collegiate Athletic Association women's soccer: 2014–2015 through 2018–2019. *Journal of Athletic Training*, *56*(7), 651-658.
Chen, B., Liu, P., Xiao, F., Liu, Z., & Wang, Y. (2021). Review of the upright balance assessment based on the force plate. *International journal of environmental research and public health*, *18*(5), 2696.
Chmielewski, T. L., Tatman, J., Suzuki, S., Horodyski, M., Reisman, D. S., Bauer, R. M., ... & Herman, D. C. (2021). Impaired motor control after sport-related concussion could increase risk for musculoskeletal injury: implications for clinical management and rehabilitation. *Journal of sport and health science*, *10*(2), 154-161.
Deng, N., Soh, K. G., Zaremohzzabieh, Z., Abdullah, B., Salleh, K. M., & Huang, D. (2022). Effects of combined upper and lower limb plyometric training interventions on physical fitness in athletes: a systematic review with meta-analysis. *International Journal of Environmental Research and Public Health*, *20*(1), 482.
Edouard, P., Steffen, K., Peuriere, M., Gardet, P., Navarro, L., & Blanco, D. (2021). Effect of an unsupervised exercises-based athletics injury prevention programme on injury complaints leading to participation restriction in athletics: a cluster-randomised controlled trial. *International journal of environmental research and public health*, *18*(21), 11334.
Eraslan, L., Castelein, B., Spanhove, V., Orhan, C., Duzgun, I., & Cools, A. (2021). Effect of plyometric training on sport performance in adolescent overhead athletes: a systematic review. *Sports health*, *13*(1), 37-44.
Everard, C., Wadey, R., & Howells, K. (2021). Storying sports injury experiences of elite track athletes: A narrative analysis. *Psychology of Sport and Exercise*, *56*, 102007.
Guan, Y., Bredin, S. S., Taunton, J., Jiang, Q., Wu, N., & Warburton, D. E. (2022). Association between inter-limb asymmetries in lower-limb functional performance and sport injury: a systematic review of prospective cohort studies. *Journal of clinical medicine*, *11*(2), 360.
Han, Y. (2021). [Retracted] A Virtual Reality Algorithm for the Study of Clinical Efficacy of Sports Injury Rehabilitation Training. *Journal of healthcare engineering*, *2021*(1), 6725625.
Hasan, Z., Zeerak, S., Fatima, H., Zubair, T., & Munir, A. (2024). Reimagining Healthcare Delivery: Enhancing Patient-Centric Services in Pakistan Public Hospitals: Patient-Centric Services in Public Sector Hospitals. *Allied Medical Research Journal*, *2*(2), 61-75.
Heil, J., & Büsch, D. (2023). Dynamic postural control and physical stress: an approach to determining injury risk in real sporting conditions. *German Journal of Exercise and Sport Research*, 53(2), 196-205.
Heywood, S. E., Mentiplay, B. F., Rahmann, A. E., McClelland, J. A., Geigle, P. R., Bower, K. J., & Clark, R. A. (2021). The effectiveness of aquatic plyometric training in improving strength, jumping, and sprinting: a systematic review. *Journal of Sport Rehabilitation*, *31*(1), 85-98.

Huang, P. Y., Jankaew, A., & Lin, C. F. (2021). Effects of plyometric and balance training on neuromuscular control of recreational athletes with functional ankle instability: a randomized controlled laboratory study. *International journal of environmental research and public health*, *18*(10), 5269.

Jin, D., & Ma, Q. (2022). Effects of Body Posture and Different Exercise Intensity on Athletes' Limb Injury. *Computational and Mathematical Methods in Medicine*, *2022*(1), 5103017.

Kalkhoven, J. T., Watsford, M. L., Coutts, A. J., Edwards, W. B., & Impellizzeri, F. M. (2021). Training load and injury: causal pathways and future directions. *Sports Medicine*, *51*, 1137-1150.

Kons, R. L., Orssatto, L. B., Ache-Dias, J., De Pauw, K., Meeusen, R., Trajano, G. S., ... & Detanico, D. (2023). Effects of plyometric training on physical performance: An umbrella review. *Sports medicine-open*, *9*(1), 4.

Li, Y., Kim, K., & Ding, Y. (2021). [Retracted] Early Warning System of Tennis Sports Injury Risk Based on Mobile Computing. *Mobile Information Systems*, *2021*(1), 3278276.

Mahrokh Moghadam, A., Zarei, M., & Mohammadi, F. (2021). Effect of an eight-week core stability training program on the functional movement screen test scores in elite goalball players. *Physical Treatments-Specific Physical Therapy Journal*, *11*(1), 55-62.

Maloney, S. J., & Fletcher, I. M. (2021). Lower limb stiffness testing in athletic performance: a critical review. *Sports biomechanics*.

Morris, A., Fino, N. F., Pelo, R., Cushman, D. M., Monson, N. E., Jameson, T., ... & Fino, P. C. (2023). Reactive postural responses predict risk for acute musculoskeletal injury in collegiate athletes. *Journal of science and medicine in sport*, *26*(2), 114-119.

Omaña, H., Bezaire, K., Brady, K., Davies, J., Louwagie, N., Power, S., ... & Hunter, S. W. (2021). Functional reach test, single-leg stance test, and tinetti performance-oriented mobility assessment for the prediction of falls in older adults: a systematic review. *Physical therapy*, *101*(10), pzab173.

Palmer, D., Engebretsen, L., Carrard, J., Grek, N., Königstein, K., Maurer, D. J., ... & Soligard, T. (2021). Sports injuries and illnesses at the Lausanne 2020 Youth Olympic Winter Games: a prospective study of 1783 athletes from 79 countries. *British journal of sports medicine*, *55*(17), 968-974.

Penedo, T., Polastri, P. F., Rodrigues, S. T., Santinelli, F. B., Costa, E. D. C., Imaizumi, L. F. I., ... & Barbieri, F. A. (2021). Motor strategy during postural control is not muscle fatigue joint-dependent, but muscle fatigue increases postural asymmetry. *PLoS One*, *16*(2), e0247395.

Picot, B., Rémy-Neris, O., & Forestier, N. (2022). Proprioceptive postural control strategies differ among non-injured athletes. *Neuroscience Letters*, *769*, 136366.

Picot, B., Rémy-Neris, O., & Forestier, N. (2022). Proprioceptive postural control strategies differ among non-injured athletes. *Neuroscience Letters*, *769*, 136366.

Prentice, W. E., & Arnheim, D. D. (2022). *Essentials of Athletic Injury Management with ESims*.

Reussner, A. K., Bursik, J., Kuehnle, F., Thiel, A., & John, J. M. (2024). The meaning of injury to the elite athlete: A systematic review. *Psychology of sport and exercise*, *71*, 102571.

Sabol, J., Kane, C., Wilhelm, M. P., Reneker, J. C., & Donaldson, M. B. (2021). The comparative mental health responses between post-musculoskeletal injury and post-concussive injury among collegiate athletes: a systematic review. *International journal of sports physical therapy*, *16*(1), 1.

Shedge, S. S., Ramteke, S. U., & Jaiswal, P. R. (2024). Optimizing agility and athletic proficiency in badminton athletes through plyometric training: a review. *Cureus*, *16*(1).

Silva, M. C. D. M., Tottoli, C. R., Mascarenhas, K., Marques, Y. A., Toledo, A. M., & Carregaro, R. L. (2022). Is kinesiophobia associated with disturbances in dynamic balance in individuals with chronic non-specific low back pain?. *BrJP*, *5*(1), 47-51.

Sole, C. J., Bellon, C. R., & Beckham, G. K. (2022). Plyometric training. In *Advanced strength and conditioning* (pp. 307-327). Routledge.

Vincent, H. K., Brownstein, M., & Vincent, K. R. (2022). Injury prevention, safe training techniques, rehabilitation, and return to sport in trail runners. *Arthroscopy, sports medicine, and rehabilitation*, *4*(1), e151-e162.

Wang, H., Ji, Z., Xue, A., Hongshuai, L., & Longmin, M. (2022). Study on the correlation between lower limb joint muscle strength and balance ability among female college students in soccer. *Procedia Computer Science*, *202*, 336-341.

Xie, J., Chen, G., & Liu, S. (2021). Intelligent badminton training robot in athlete injury prevention under machine learning. *Frontiers in neurorobotics*, *15*, 621196.

Zarei, H., Norasteh, A. A., & King, L. (2022). The effect of auditory cues on static postural control: A systematic review and meta-analysis. *Audiology and Neurotology*, *27*(6), 427-436.

Zech, A., Hollander, K., Junge, A., Steib, S., Groll, A., Heiner, J., ... & Rahlf, A. L. (2022). Sex differences in injury rates in team-sport athletes: a systematic review and meta-regression analysis. *Journal of sport and health science*, *11*(1), 104-114.

Zhou, J. Y., Wang, X., Hao, L., Ran, X. W., & Wei, W. (2024). Meta-analysis of the effect of plyometric training on the athletic performance of youth basketball players. *Frontiers in Physiology*, *15*, 1427291.

Zhou, J. Y., Wang, X., Hao, L., Ran, X. W., & Wei, W. (2024). Meta-analysis of the effect of plyometric training on the athletic performance of youth basketball players. *Frontiers in Physiology*, *15*, 1427291