

Gender Differences in Lower Limb Strength Symmetry: A Comparative Study among Elite Pakistani Soccer Players

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ABSTRACT

This study compares the dominant and non-dominant leg strength between male and female elite soccer players in Pakistan. While gender-based differences in absolute strength were evident, relative strength asymmetry followed a similar pattern across genders. Both male and female players demonstrated stronger dominant legs, with asymmetry percentages exceeding the 10-15% threshold for many participants. The study suggests that while male athletes tend to exhibit higher absolute strength, both male and female athletes need targeted interventions to correct strength imbalances, reduce injury risk, and enhance overall performance in soccer.

Keywords: Lower limb strength, Soccer, Injury prevention, Asymmetry, Performance, Pakistan

INTRODUCTION

Muscle power is defined as the amount of work a muscle can produce per unit of time. High muscle power is understood as the capacity to exert high levels of strength as quickly and explosively as possible. Muscle power is considered a key factor for performance of jumps, kicks, shots on target, and acceleration, which are relevant for sports such as soccer, football, rugby, volleyball, basketball, and swimming. Some have speculated that professional athletes who practice a specific sport that requires a constant preference of one leg over the other during training or competition (single-leg-dominant athletes), such as soccer, could develop significant muscular power asymmetry between their dominant and non-dominant legs. However, no reported studies have evaluated power symmetry in professional young adult soccer players. In our study when we refer to football it means we are referring to soccer.

The main difference between Power Training vs Strength Training is that strength refers to the ability to overcome resistance, while power refers to the ability to overcome resistance in the shortest period of time. Muscle Power and Muscle Strength is not the same thing. Muscle power is defined as the product of dynamic muscular force and muscle contraction velocity. Muscle strength is defined as the maximum amount of force a muscle can exert against some form of resistance in a single effort.

The central goal of strength training in a highly competitive sport is to improve the players specific and relevant athletic inherent in their respective sport. To achieve this outcome, different strength training modes with i) distinct movement patterns (traditional resistance exercises, ballistic exercises, plyometrics, weight lifting and sports specific strength based actions) ii) different combinations of the temporal organization of strength training loads (e.g micro cycle and training sessions variations iii) distinct loads, iv) a wide range of movement velocities, v) specific biomechanical characteristics, and vi) different training surfaces have to be adopted with the final end point of achieving an improvement in players performance in relevant motor tasks (e.g jumping, sprinting and changing direction).

Certain training methods combine different exercise modes (e.g., weight training, plyometric training, and sport-specific force-based actions) and allow for optimal power development and transfer to athletic activities due to both the neural and morphological adaptations typically associated with advanced training. In fact, the intrinsic characteristics of soccer activity patterns (a varied range of motor actions that involve both breaking and propulsive forces as well as distinct contraction modes and velocities that require the all force-velocity potential of the neuromuscular system) that highlight the importance of the principle of specificity in strength and muscle power training cannot be understated. With the majority of soccer injuries occurring at the lower extremities, the development of muscle strength symmetry and balanced ratio in the function of knee flexors and extensors can decrease the incidence rate of soccer injuries.

A combination of different methods, including high-intensity strength training involving traditional resistance exercises (squats) and plyometrics, TRE and sprint training, and complex strength training (CT), have all recently received considerable attention. Although some similarities exist between the previous modes of strength and power training, there are important differences. The definitions of key terms are as under:-

- **Dominant leg:** the leg preferred by a player for skilled actions such as kicking or passing (Fousekis et al., 2020).
- **Non-dominant leg:** The supporting or stabilizing leg used during balance and weight-bearing movements (Maloney et al., 2021).
- **One-Repetition Maximum (1RM):** The maximum load that can be lifted once with correct form, commonly used to assess dynamic strength (Suchomel et al.,2021). Professional soccer, repeated use of the preferred (dominant) leg for technical actions such as shooting, passing, or dribbling may cause adaptations that increase asymmetry between limbs (Bishop et al., 2020). Although some asymmetry is considered functionally normal, excessive strength differences can negatively affect biomechanical efficiency and movement control (Benjanuvatra et al., 2021). Consequently, assessing and comparing dominant and non-dominant leg strength provides critical insight into an athlete's neuromuscular balance and overall performance readiness.

Pakistan's national soccer players, who participate in regional and international competitions, represent an under-researched population in sports science literature. Despite growing global emphasis on evidence-based conditioning, there is limited research quantifying bilateral leg strength among Pakistani soccer athletes using standardized testing such as isokinetic dynamometry and one repetition maximum (RM) assessments. The lack of empirical data constrains the development of targeted strength and injury-prevention programs.

With this research the soccer coaches of universities and colleges all over Pakistan will know about the strength of Lower limbs of National Soccer Players of Pakistan Soccer Team and they will know at what level they need to prepare their players strength in dominant leg and non-dominant leg. They will also be

able to bring the strength of non-dominant leg at par with dominant leg strength. This will in future give rise to more fit players at District, Division and Provincial level.

In sports science, the concept of lower limb symmetry that is, the relative equality in strength, power or function between the dominant and non-dominant legs has gained increased attention. Imbalances between limbs may impair performance and elevate injury risks (Helme et al., 2021).

Lower limb strength plays a decisive role in skills such as sprinting, jumping, tackling and kicking all of which depend on neuro muscular balanced function between dominant and non-dominant legs (Maloney et al., 2021).

Disparities and irregularities in strength among lower extremities can affect not only athletic performances but also incline athletes to misuse injuries and muscular strain (Read et al., 2023). This study helps significantly in filling the gap by methodically probing dominant and non-dominant leg strength among Pakistan's national soccer players using unconventional measurable methods. The results from this study will have positive impact on the Pakistan football community. Evaluating and understanding real time training camps of strength can have very good effect on athlete's muscles of dominant and non-dominant legs. (Read et al., 2023). In National soccer even very little improvement in speed, jumping, heading and shooting can play a vital role to change the results of a competitive soccer match (Maloney, 2023). This study compares the strength of the dominant and non-dominant legs in elite male and female soccer players in Pakistan to identify whether there is any significant gender-based differences in strength imbalances and how these imbalances impact performance and injury risk.

Objective

To compare the lower limb strength asymmetry between male and female elite soccer players in Pakistan and examine its impact on performance and injury risk.

Hypothesis

H_{1a}: Male soccer players will exhibit significantly higher absolute strength than female players, but both genders will demonstrate similar patterns of lower limb strength asymmetry, which will affect performance and injury risk similarly across both groups.

LITERATURE REVIEW

Strength Training and Performance Enhancement

Strength training is an important factor in the overall performance of the athlete in terms of muscle strength, power, and endurance (Suchomel et al., 2016). Organized resistance training such as weight lifting, body weight training and resistance band workouts gradually over work the muscles. These stimuli get accustomed to the organism and lead to hypertrophy and elevation of the efficiency of muscle fibers and, thus, enhance performance in various physical activities and athletic sports. In athletes, strong muscles produce additional stability, faster sprinting speed, greater heights of vertical leaps, and greater power that are critical factors of competitive ability (Slattery et al., 2015).

In addition to muscle growth, neuromuscular coordination is also improved with strength training. In that regard, the nervous system demonstrates enhanced engagement of the correct musculature during optimal time points, which enhances movement effectiveness and helps to reduce the level of energy wastage (Kumar & Vinayakan, 2024). As a result, athletes can precisely do technical skills and experience less

fatigue. Additionally, strength training will help in joint stability and strengthening connective tissues and hence decreasing occurrence of injuries. This is especially relevant among sports people who engage in sports of high-impact or repetitive motion (Boahen, 2021).

Limb Symmetry and Performance Outcomes

Soccer players start training at early ages and with the passage of time and quality training their lower limbs develop symmetry. However, this is not true with majority of players as mostly use one leg during soccer matches and this trait develops asymmetry in them but if they train both limbs equally then limb symmetry is possible and such players are elite players which means they can perform same function with ease with both limbs whenever desired. If there is symmetry in both limbs such players are less injury prone and their performance is better. The professional soccer players who have ability to shoot at goal with both limbs are more handsomely paid because they are more dangerous in front of the goal area and defenders don't know where and on which side they will dribble or in which direction they will shoot as a player who can shoot with both feet is more lethal than a player who has asymmetry and can only shoot with one foot. It becomes easier as a defender to cover one side during a one-on-one encounter between a forward and a defender. Soccer is a very fast game and decisions have to be made in split seconds and in a few seconds the results of the match can change. Modern coaches prefer players who can pass with both feet and accurately as this gives players more options when they are in positions where it is difficult to pass but these players can give long passes with both feet and help their team to maintain possession. In soccer, where movement demands are multidirectional, explosive, and repetitive, small deviations in bilateral strength or power can accumulate into meaningful performance deficits. The ability of an athlete to maintain functional bilateral balance not only affects isolated physical tasks but also influences whole-body coordination, tactical execution, and neuromuscular control. Consequently, understanding how symmetry affects playing routine provides important insights for coaches, strength professionals, and rehabilitation specialists when designing evidence-based training interventions.

Continuous use of one limb i.e the dominant-leg for soccer specific skills develops neuromuscular adaptations such as increased cortical representation and motor unit firing efficiency (Zemkova et al., 2021) which may enhance skill precision but widen inter limb strength differences.

Isokinetic testing remains the gold standard for isolated muscle assessment. Studies consistently report 5-15% higher torque in the dominant leg, depending on the angular velocity (Sliwowski et al., 2024., Stella et al., 2022).

- $\leq 10\%$ is generally acceptable (Ramos, 2022).
- $> 15\%$ may increase injury risk or reduce sprint efficiency (Crosier et al., 2023). Bouafif et al., (2024) reported high reliability ($ICC > 0.90$) for unilateral isokinetic tests at $60^\circ/s$ and $180^\circ/s$, supporting their use in elite athlete profiling. However, isokinetic dynamometers are costly and less accessible in developing countries like Pakistan, emphasizing the need for local normative data.
- An ideal method to determine leg dominance in relation to task performance is still lacking (van Melick N, Meddeler BM, Hoogeboom TJ, Nijhuis-van der Sanden MWG, van Cingel REH 2017).

Dynamic unilateral strength can be measured through 1 RM leg press and split squat testing. Espada et al. (2023) found modest correlations ($r=0.55$) among isokinetic torque and unilateral 1RM in elite

soccer players, which means that both procedures capture overlying but separate neuromuscular traits. Bouafif et al. (2024) established positive durable comparative reliability (ICC=0.93) but bigger coefficient of variation (~6%), highlighting the need for adjustment because 1 RM tests reflect sport specific dynamic capacity, such conditioning camps use them to complement isokinetic measures (de Hoyó et al., 2019).

Soccer training practicals (single-leg countermovement jump, hop tests, sprint split times) deliver ecologically valid symmetry estimates.

Paravlic et al. (2024) showed that isodynamic and jump irregularities display small-to-moderate connections ($r = 0.28-0.41$), suggesting diverse primary instruments.

Fresh longitudinal information suggests athletes with determined >10 % inter-limb jump irregularity establish lesser match-running distances and higher hamstring-strain incidence (Maly et al., 2024; Jiménez-Reyes et al., 2021).

Combining isokinetic, dynamic, and functional assessments offers a holistic asymmetry profile (Stella et al., 2022).

Lower-limb symmetry represents an essential performance determinant in football. Repetitive unilateral skills—particularly kicking and change-of-direction—produce morphological and neural adaptations that can result in measurable asymmetries (Rahnama et al., 2005; Sliwowski et al., 2017). Recent advances in isokinetic dynamometry, one-repetition maximum (1 RM) testing, and functional asymmetry assessment have improved understanding of how these imbalances influence performance and injury risk (Paravlic et al., 2024; Bouafif et al., 2024). Most large datasets come from Europe, North America or elite Middle Eastern academies. Pakistan's national players may differ in training exposures, pitch conditions, footwear and injury management as well as strength training techniques. It is dream of every football player of Pakistan whether male or female to play for Pakistan National Team. Millions of footballers try to progress and reach their dream but only few of best of the best reach the National Team. In our study our targeted population are the top players who have played in tier 1 of either female championships or male Pakistan Premier League with at least three years' experience of playing in top level for female players and five years' experience in case of male players. Furthermore, the international players will also be included in this research.

Concept of Limb Symmetry in Sports

Dominant and non-dominant symmetry states that both the lower limbs have same muscular strength, neuromuscular activation, and biomechanical yield. In sports science, symmetry is considered a marker of balanced musculoskeletal function and efficient kinetic-chain movement (Brown & O'Donoghue, 2022). Soccer is such a sport where the dominant leg assumes a dominant role and develops asymmetry due to repeated training in tasks such a shooting, dribbling and jumping.

Symmetry is essential not only for athletic performance but also for maintaining optimal joint health and minimizing the risk of chronic overuse injuries. Excessive asymmetry typically above 10–15% has been associated with compensatory movement patterns, reduced neuromuscular efficiency, and increased risk of soft-tissue injuries (Meyer et al., 2023). Thus, examining limb symmetry is a core aspect of athlete profiling, rehabilitation monitoring, and performance optimization in football.

Soccer is the world's most famous sport and in Pakistan it is second most popular game among the youth population after cricket. The best and perfect model to find leg dominance with relation to

performance of tasks is still absent. It is suitable to ask adult players, “If you would shoot a ball on a target, which leg would you use to shoot the ball?” to fix leg dominance in mutual mobilizing tasks (Van Melick N et al., 2017).

Recent advances in one repetition maximum (1 RM) testing and functional asymmetry assessment have improved understanding of how these imbalances influences performance and injury risk (Bouafif et al., 2024., Paravlic et al., 2024).

METHODOLOGY

The study employed a quasi-experimental design to assess real-world strength differences and their relationship to soccer performance. Due to delays caused by the COVID-19 pandemic, the study duration was extended to 36 months. Data was collected across three sports facilities: Punjab Football Stadium Lahore, Punjab University Football Ground, and Gujranwala Sports Ground. The study focused on elite soccer players from Pakistan, consisting of 40 male and 40 female athletes, all with at least five years of competitive playing experience. The participants, aged 18 to 38 years, were divided into two categories: male players who had played in national or international soccer competitions, and female players who participated in Inter-University competitions.

The testing protocol involved a structured sequence of functional strength tests to assess the symmetry between dominant and non-dominant legs. Participants completed a 5-minute warm-up on a cycle ergometer (Keiser M3+) followed by 10 controlled bodyweight squats. Leg dominance was identified using two functional tests: a hopping test, where the leg with the farthest hop was declared dominant, and a juggling test, where the foot with the most successful juggles was considered dominant. Strength was assessed through unilateral squats and an incremental leg press test. In the unilateral squats, participants lifted weights using each leg separately, with progressively increasing weights until failure. In the leg press test, participants performed presses with both legs and then individually, with the resistance increasing until failure.

Data collection was done using a researcher-developed proforma that recorded anthropometric data (height, weight, leg length, foot size, etc.) and strength measures (maximum weight lifted in various positions). The proforma was designed to ensure systematic and reliable data collection. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were calculated for both dominant and non-dominant leg strength. The Kolmogorov-Smirnov test was used to check the normality of the data. Since the data was not normally distributed, the Wilcoxon signed-rank test was applied to compare strength differences between the dominant and non-dominant legs.

RESULTS

Table 1

Descriptive Statistics for Weight Lifted by Dominant and Non-Dominant Leg (n = 80) in Sitting Position

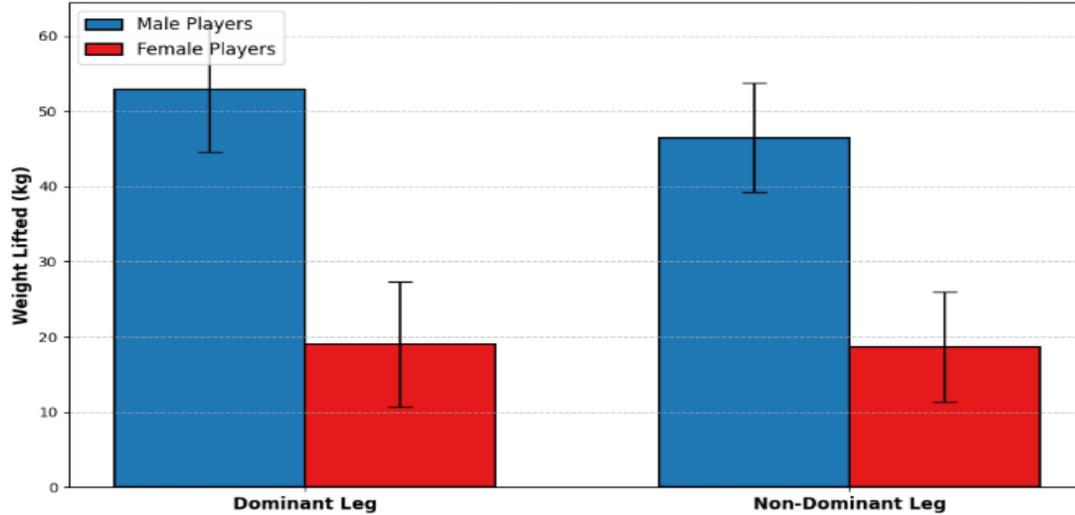
Variable	Male Players (M ± SD)	Female Players (M ± SD)
Dominant Leg (kg)	52.9 ± 8.4	19.00 ± 8.26
Non-Dominant Leg (kg)	46.47 ± 7.29	18.62 ± 7.34

Median (kg)	50.0 ± 8.8	15.00 ± 5.0
Minimum (kg)	40.00	10.00
Maximum (kg)	75.0	50.0
Range (kg)	35.0	40.0
Skewness	1.07	1.91
Kurtosis	1.24	4.57

Note. The table presents descriptive statistics for the weight lifted by both the dominant and non-dominant legs in a sitting position for 80 soccer players, divided into male and female groups. Male players lifted an average of 52.9 kg (± 8.4) with their dominant leg and 46.47 kg (± 7.29) with their non-dominant leg. The median for the dominant leg was 50.0 kg, indicating a slight positive skew in the data, with the maximum value reaching 75.0 kg and the minimum at 40.0 kg, yielding a range of 35.0 kg. Female players lifted an average of 19.0 kg (± 8.26) with their dominant leg and 18.62 kg (± 7.34) with their non-dominant leg. The median for females was 15.0 kg, suggesting a stronger positive skew than the males. Female participants had a maximum of 50.0 kg and a minimum of 10.0 kg, resulting in a range of 40.0 kg. The skewness for males (1.07) and females (1.91) indicates that both groups exhibit positive skew, with more players lifting lower weights. The kurtosis values (1.24 for males and 4.57 for females) show that the female data is more leptokurtic, indicating a higher concentration of extreme values than the male data, which is more evenly distributed around the mean.

Figure 1

Descriptive Statistics for Weight Lifted by Dominant and Non-Dominant Legs (Sitting Position)



Note. The bar chart illustrates the weight lifted by both the dominant and non-dominant legs in a sitting position for male and female soccer players. Male players lifted significantly higher weights compared to female players, with an average of approximately 50 kg for the dominant leg and 45 kg for the non-dominant

leg, while female players lifted about 20 kg and 19 kg, respectively. The error bars indicate considerable variability in the data, especially for male players, who showed a wider range of weight lifted. This highlights a clear difference in strength between male and female players, with males demonstrating greater lifting capacity on both legs.

DISCUSSION

This study, which examined lower limb strength asymmetry between male and female elite soccer players in Pakistan, aligns with previous research on strength imbalances in athletes. The findings support the notion that soccer players develop a dominant leg through repeated unilateral actions such as kicking, dribbling, and shooting, leading to significant strength disparities between the two legs. Similar patterns have been reported in various studies, such as those by Fousekis et al. (2020) and Maloney et al. (2021), who found that strength imbalances between dominant and non-dominant legs are common among soccer players, with asymmetry exceeding the 10-15% threshold contributing to both performance deficits and an increased risk of injury. Furthermore, the study's results regarding gender differences in strength asymmetry correspond with the research by Sliwowski et al. (2024) and Paravlic et al. (2024), who indicated that while males exhibit higher absolute strength, the relative asymmetry patterns are similar across genders. These findings emphasize the need for balanced strength development in both legs to reduce the likelihood of injury, particularly non-contact injuries, which are prevalent in soccer. By incorporating strength training that targets both limbs equally, as suggested by previous studies (Rahnama et al., 2005; Sliwowski et al., 2017), soccer players can optimize their performance and reduce injury risk.

CONCLUSION

The study confirms the existence of lower limb strength asymmetry in elite Pakistani soccer players, with males exhibiting higher absolute strength than females. However, both genders experience similar patterns of strength asymmetry, highlighting the need for tailored strength training programs that address these imbalances. The results of this research could inform the design of more effective injury prevention and performance enhancement strategies for soccer players in Pakistan. Additionally, these findings contribute valuable insights into the understanding of bilateral strength symmetry in sports science, particularly in under-researched regions like Pakistan.

SUMMARY

This study examines gender differences in lower limb strength asymmetry between elite male and female soccer players in Pakistan. The research found significant differences in absolute strength, with male players showing higher strength levels than female players. However, both genders demonstrated similar patterns of strength asymmetry, with the dominant leg consistently stronger than the non-dominant leg. These findings underline the need for targeted strength training interventions to address leg strength imbalances in soccer players. Imbalances exceeding 10-15% were linked to increased injury risk and reduced performance efficiency. The study also emphasizes the importance of balanced strength development in both legs to optimize performance and reduce injury risks.

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