Limb Asymmetry Characteristics Amongst Men's and Women's NCAA Division II Soccer Athletes

Running head: Limb Asymmetries in Soccer Athletes

ABSTRACT

Differences in the performance and function of one limb with respect to the other is known as interlimb asymmetry, while intralimb asymmetry deals with differences in muscle forces within the same limb. Both forms of asymmetry are common in the sport of soccer due to its distinct characteristics. These differences in strength between dominant and nondominant limbs or muscle groups may lead to increased injury rates in soccer athletes. The purpose of this study was to compare the magnitude of interlimb and intralimb asymmetry between NCAA Division II men's and women's soccer players. Thirty participants (male = 15, female =15) completed a testing protocol in which concentric knee extensor and flexor peak torque was measured. Three isometric contractions lasting five seconds each were completed by all participants for each action on the dominant and nondominant limb. Interlimb asymmetries were observed in each gender (Male: Quad (Q) = 10.62 ± 8.89%, Hamstring (H) = 13.33 ± 8.43%. Females: Q = 7.70 ± 7.63% H = 8.56 ± 6.04%) in both the Q and H muscle groups with the dominant limb being stronger. When comparing the sexes, males possessed significantly larger ($p = 0.04$) interlimb hamstring imbalances as compared to females. While females observed slightly elevated intralimb (H:Q) ratios for both limbs as compared to males, no significant differences were observed in H:Q ratio between the groups in the dominant ($p = 0.485$) or nondominant leg ($p = 0.195$). Results of interest indicate that male participants possessed larger magnitude of both inter and intralimb imbalance as compared to females, and males may benefit from focused training aimed at reducing interlimb asymmetries specifically in the hamstring group. This research only investigated isometric contractions which may pose as a limitation to the inference of results.

Key words: strength imbalance, injury rate, soccer performance, football

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INTRODUCTION

Differences in the performance and function of one limb with respect to the other is known as interlimb asymmetry, while intralimb asymmetry involves differences in muscle forces within the same limb (Bishop et al., 2016). It is not uncommon for athletes participating in sport to show varying degrees of asymmetry, however, the sport of soccer with its distinct physical, technical, positional, and limb favouring tendencies can lead to higher magnitudes of asymmetry compared to other sports (Read et al., 2018). The unilateral movements commonly utilized in soccer such as kicking, jumping, and changing direction may lead to unique loading patterns that can result in increased inter and intralimb asymmetry as compared to other team sports (Nicholson et al., 2022). Previous research has investigated limb asymmetry and the potential effects it may have on injury risk and performance (Bishop et al., 2021; Guan et al., 2022; Jaiyesimi et al., 2008, Pardos-Mainer et al., 2021).

In soccer, muscular strength of the knee joint is vital in supporting the individuals body weight and center of mass while performing dynamic movements (Myer et al., 2004). With regard to intralimb asymmetry in soccer, particular attention has been paid to hamstring and

quadricep discrepancies (H:Q ratio) due the hypothesized relationship with injury risk (Beato et al., 2021; Bishop et al., 2021; Jeon et al., 2016). Typical H:Q ratios in athletes can range from 0.5 to 0.8 with H:Q ratios less than 0.6 potentially leading to an increased risk of anterior cruciate ligament (ACL) and hamstring injury in participants (Dauty, 2016; Sangnier & Tourny-Challet, 2007; Yildiz & Kale, 2018). Interlimb, or bilateral H:Q ratio differences have been investigated with some research finding differences in field athletes when compared to court athletes (Cheung et al., 2012) with others finding no differences between the sexes (Yilmaz et al., 2023).

Interlimb asymmetry is not uncommon in humans and can occur across a number of factors such as strength, flexibility, balance, and power (Bishop et al., 2016). These asymmetries, typically exacerbated by overuse, can be caused by injury, dominant limb choice, playing position, or anthropometric imbalances (Heil et al., 2020). While easy to identify, understanding the associated consequences of such asymmetries is challenging due to inconsistent findings within the research (Guan et al., 2022). With regard to knee injuries, research has clearly shown females to be at a higher risk when compared to males, yet understanding the mechanisms that lead to this discrepancy still remain unclear (Zech et al., 2022). Intralimb imbalances between the hamstring and quadriceps muscle groups are hypothesized to play a major role in the increased risk of knee injury in females. While H:Q ratio is commonly accepted as a risk factor, recent research suggests H:Q ratio may not to be an independent risk factor or ACL injury further confusing researchers and practitioners (Kellis et al., 2023).

Needless to say, research outcomes specific to muscular imbalances and athletic performance are varied, with no clear guidelines for practitioners or athletes to follow. The goal

of this research project is to directly compare intra and interlimb imbalances between male and female athletes of similar age and experience level. In doing so, the researchers hope to increase the body of knowledge on muscular imbalances and help coaches and athletes better optimize training strategies. The physiological demands between men's and women's soccer differ as female athletes typically cover a shorter total distance but at higher relative intensities when compared to males (Stolen et al., 2005). Women's soccer is one the fastest growing sports in the world, therefore determining potential differences in limb asymmetry between genders may provide valuable insight regarding training methodological differences between the sexes (Crossley et al., 2020; Guan et al., 2022; Kong & Burns 2009).

Further research could provide insight for future programming of injury prevention protocols, rehabilitation techniques, strength and conditioning plans, and planning of training sessions. Therefore, the purpose of this study is to determine the magnitude of limb asymmetry between National Collegiate Athletic Association (NCAA) Division II collegiate men's and women's soccer players. The increasing popularity of women's soccer and the conflicting research regarding gender differences in asymmetry magnitude provides the basis for the need of this research study. Furthermore, these results will contribute to the body of research that currently exists while providing relevant information to players, coaches, trainers, and other healthcare professionals regarding potential differences between male and female soccer players.

MATERIALS & METHODS

To examine gender differences in isometric limb asymmetry a quantitative comparative design was utilized. Participants were measured for isometric knee extensor and flexor strength to determine potential imbalances by performing three maximal isometric knee extension and flexion contractions for each leg. Participants recruited for this research project were male and

female NCAA Division II soccer players. All research procedures were approved by the University's Institutional Review Board prior to participant recruitment.

Participants

Thirty participants (n = 30) including fifteen males (n = 15) and fifteen females (n = 15) were recruited using convenience sampling. Participants were screened to include those who: 1) were current NCAA Division II soccer players 2) identify by primary position as outfielders, 3) were 18-24 years of age, 4) were deemed healthy as determined by a medical questionnaire and PAR Q+ questionnaire, and 5) had a minimum of 5 years' experience playing competitive soccer. Participants were also screened to include those without: 1) lower-limb muscle or joint injury in past year that has resulted in more than five missed training sessions and 2) musculoskeletal injuries that limit the ability to perform the isometric strength testing. All participants were instructed that they were free to remove themselves from the study at any time.

Study Protocol

A single laboratory visit was utilized to complete all testing protocols. All testing was completed following 24 hours with no soccer training. Height (cm), mass (kg) and body composition (BF%) were collected using a Seca mBCA 554 body composition analyzer (GmbH. Hamburg, Germany). Participants completed a 5-minute warm-up at a self-selected cadence on an electronically braked cycle ergometer (Ergomedic 828E; Monark Exercise AB, Vansbro, Sweden). Following the warm-up protocol, participants completed isometric strength testing on an isokinetic dynamometer (Biodex Medical Systems, Inc.,Shirley NY, USA). Three maximal isometric contractions were performed for knee extension and flexion on each leg. Each isometric contraction was performed for 5 seconds with one minute of rest given between

repetitions. The determination of testing order for limb and joint action performed first was at random. For all knee extension measurements seat orientation was 90°, seatback tilt was 80°, and knee angle was set at 90° of knee flexion with the lateral femoral epicondyle aligned with the axis of the dynamometer. For all knee flexion measurements seat orientation was 90°, seatback tilt was 80°, and knee angle was set at 60° of knee flexion with the lateral femoral condyle aligned with the axis of the dynamometer. Participants were given the opportunity to familiarize themselves with all testing protocols prior to data collection. Peak torque (N • m) exerted for each repetition on dominant and nondominant legs for flexion and extension was recorded with the highest score on each limb and joint action being included for analysis.

Statistical Analysis

Statistical software (IBM SPSS Statistics v.24, Armonk, NY) was used to analyze all asymmetry measures between the sexes. Interlimb asymmetry was calculated using the following equation adapted by Impellizzeri et al. (2007): Asymmetry = (stronger-weaker) / stronger * 100. Intralimb (H:Q) asymmetry was calculated by dividing peak torque achieved by the hamstrings by peak torque achieved by the quadriceps. A one-way analysis of variance (ANOVA) was used to determine if statistical differences exist between groups for intra and interlimb asymmetry. The significance level was set *a priori* at 0.05.

RESULTS

Fifteen male and fifteen female NCAA Division II soccer players completed the IRB approved testing protocol with no adverse events recorded. All participants reported as being right leg dominant, therefore no differentiation between dominant and non-dominant limb was

required for reporting purposes. Descriptive characteristics of male participants (*n* = 15*)* and female (*n* = 15) are noted in Table 1.

Table 1

Descriptive Characteristics of Male and Female Participants

Characteristics	Male	Female
Age (yrs)	21.8 ± 1.3	19.3 ± 1.0
Height (cm)	178.2 ± 7.6	164.8 ± 4.8
Weight (kg)	76.5 ± 8.4	64.8 ± 6.6
Body Composition (BF%)	16.0 ± 3.2	26.9 ± 4.3
Competitive Soccer Experience (yrs)	16.3 ± 2.3	13.9 ± 1.8

Note. Values are presented as mean ± SD; yrs = years, BF % = percentage of body fat.

Interlimb Asymmetry

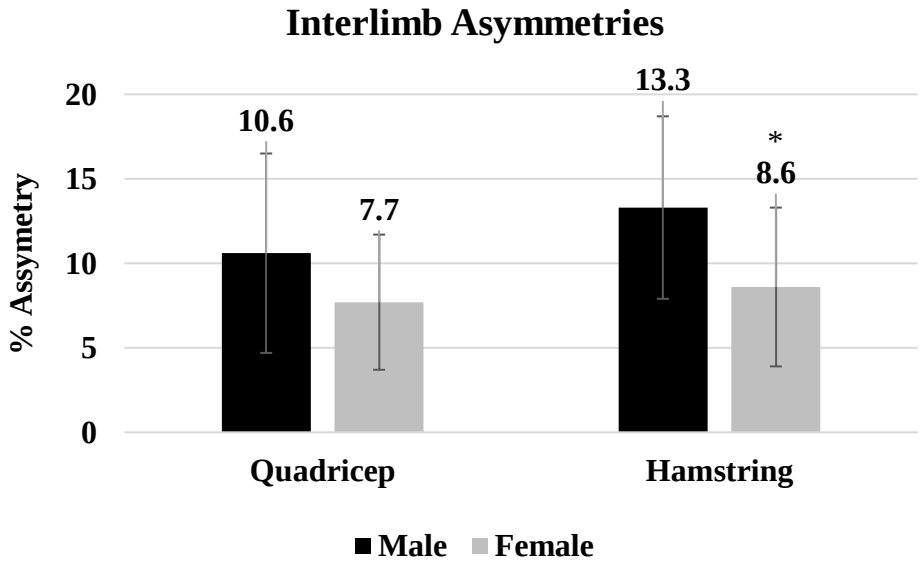
Values used in the comparative analysis for asymmetry of the quadricep and hamstring muscles were derived from the equation: asymmetry = (stronger limb -weaker limb) / stronger limb * 100 (Impellizzeri et al., 2007). While not statistically different (p = 0.34), interlimb asymmetries for the quadriceps muscle group were elevated in the male participants. Male

participants possessed an average quadricep interlimb asymmetry magnitude of 10.62% ± 5.99 compared to 7.70% ± 4.63 for female participants.

With regards to hamstring interlimb asymmetry, male participants reported a significantly higher ($p = 0.04$) asymmetry compared to the female participants (13.33% ± 5.45 vs 8.56% ± 4.74). These results indicate higher discrepancies of strength in the hamstring muscle group between the dominant and nondominant limbs in males. Values for interlimb imbalances for male and female participants can be seen in Figure 1.

Figure 1

Interlimb Asymmetry Magnitudes



Note. Interlimb asymmetry values for male and female hamstring and quadricep muscle groups. Hamstring interlimb asymmetry was significantly lower ($p = 0.04$) in the female participants. * denotes significantly different than Male values.

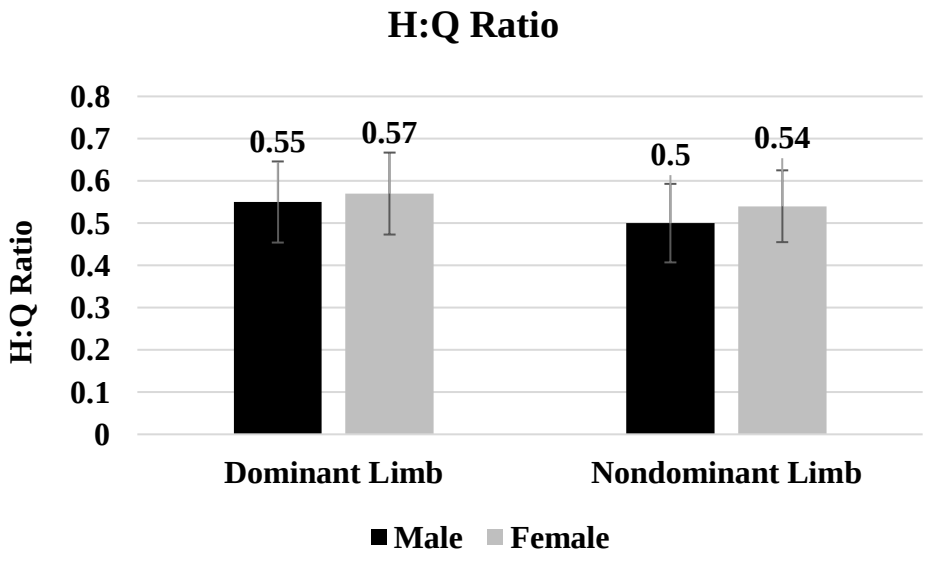
Intralimb Asymmetry

H:Q ratio asymmetry was calculated by dividing peak torque achieved by the hamstrings by peak torque achieved by the quadriceps. While females showed elevated H:Q ratios for both

limbs as compared to males, no significant differences were observed in H:Q ratio between the genders in the dominant (p = 0.485) or nondominant legs (p = 0.195). Values for H:Q ratios between sexes for can be found in Figure 2.

Figure 2

H:Q Ratio Amongst Participants



Note. H:Q ratios for male and female participants. No significant differences were observed.

DISCUSSION

The purpose of this study was to investigate the magnitude of intra and interlimb asymmetry between NCAA Division II collegiate men's and women's soccer players. The key

findings of this investigation were: 1) a significantly higher interlimb hamstring asymmetry in male participants as compared to the female participants, and 2) no significant differences in H:Q ratio between male and female participants. Amongst the measured participants, it appears that the male participants exhibited higher levels of both interlimb and intralimb asymmetry as compared to female participants.

Interlimb asymmetry is commonly referred to as the differences in the performance and function of one limb or muscle group with respect to the other (Bishop et al., 2016). It is not uncommon for soccer athletes to exhibit varying degrees of interlimb asymmetry as a result of the repetitive movement patterns performed while playing the sport (Nicholson et al., 2022; Read et al., 2018). These imbalances may have a negative effect on performance and increase an individual's risk of experiencing a lower-body injury (Coratella et al., 2018; Izovska et al., 2019). Researchers have observed a positive correlation between interlimb strength asymmetries and decreased sprint time as well as change of direction time in elite under 21 male and female soccer players (Coratella et al., 2018). Izovska et al. (2019) observed that independent of gender soccer players possessing more than a 10% bilateral knee extensor asymmetry experienced higher rates of lower-body injuries. Based on this information, it appears that the male participants who participated in the current study would be at higher risk of experiencing negative outcomes such as decreased performance and increased injury risk as compared to the female participants.

Carey et al. (2001) observed that elite lever soccer athletes complete approximately 83% of their touches on the ball with their dominant limb. This unbalanced preference of one limb over the other is likely one of the determining factors in the magnitude of imbalance observed in soccer athletes (DeLang et al., 2021). For both the male and female participants who took part in

the study, the dominant limb produced higher levels of torque for all measured variables as compared to the nondominant limb. While common, these imbalances do seem to pose an injury risk as multiple researchers have observed increased injury risk in the dominant limb in soccer athletes (DeLang et al., 2021; Hägglund et al., 2013; Serner et al., 2015). Given this information, it appears that interlimb imbalances should be an area of focus for strength and conditioning and sports medicine staff as it relates to potentially reducing the risk of injury in soccer athletes.

Research suggests that female athletes may be up to 8 times more likely to experience and ACL tear as compared to their male counterparts (Mancino et al., 2023). Females typically possess greater imbalances between hamstring and quadricep strength as compared to males, and this increased imbalance has been hypothesized to play a large role in the increased incidence of ACL injuries observed in females although this is highly debated (Hewett et al., 2008; Knapik et al., 1991). In a review by Hewett et al. (2008), researchers observed females H:Q ratio was 8.8% lower when compared to males across all velocities indicating reduced hamstring strength as compared to the quadriceps. Females in the current study measured higher for both the dominant and nondominant limbs for H:Q ratio indicating less intralimb asymmetry as compared to the male participants. These results differ from previous research in which it has been established that males typically possess a higher H:Q ratio as compared to females (Behan et al., 2018; De Ste Croix et al., 2017; O'Sullivan & Tanaka, 2021). Given the known injury discrepancies between male and female participants and a growing knowledge of injury prevention techniques as it relates to the knee joint, one likely explanation for higher H:Q ratios observed in females may be an increased focus on preventative training. Participants in the current study averaged more than 15 years of experience playing competitive soccer and have also had varied access to structured strength and conditioning programs over this time frame.

Isokinetic and isometric methodologies are frequently used in measuring both inter and intralimb imbalances. While some research suggests gender differences between the varying speeds of contraction, the use of only isometric measures alone is a potential limitation of the current research study (Hewett et al., 2008). The use of NCAA Division II soccer athletes as participants limits the scope of the findings to individuals of similar ages and with similar training backgrounds. Participants in the current research study had over 15 years of experience participating in competitive soccer. Given the repeated movement patterns that are typically performed within the sport of soccer in addition to individuals preferring to use their dominant limb, the imbalances observed can only be conferred to individuals possessing a similar training background in soccer although some recent research suggests imbalance magnitude is not affected by training ages in male soccer athletes (Śliwowski et al., 2024).

While research regarding muscular imbalance and negative performance or injury outcomes is mixed, there is little debate that a minimizing the magnitude of imbalances should be a focus of any training regime. The current research findings observed varying levels of intra and interlimb imbalances in both male and female Division II soccer athletes. The magnitude of imbalances an individual experiences may depend on a number of factors including playing position, playing style, and training age (Nicholson et al., 2022). It is the recommendation of the researchers that coaches and training staff should aim to identify imbalances and track those variables over time in order to determine if an individual's current training practices are increasing or decreasing any observed imbalances. While intra and interlimb imbalances appear to be a consequence of repetitive movements thus a common occurrence in soccer, minimizing these imbalances should be a priority in training.

Competing Interests: The authors declare that they have no competing interests.

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