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Review

A Systematic Scoping Review of Isokinetic Testing in High-Level Female Soccer Players: Methodological Considerations

Antonio Cicchella * and **Zhenyu Li**

Department for Quality of Life Studies, University of Bologna, 47921 Rimini, Italy; zhenyu.li@studio.unibo.it
* Correspondence: antonio.cicchella@unibo.it

Abstract

There is a lack of clarity on the isokinetic testing of professional female soccer players (PFSPs) concerning the proper use of isokinetic testing, and the existing data, useful for rehabilitation purposes, are confusing. This review aims to highlight the main methodological issues and provide guidance for performing reliable isokinetic strength (IS) based on evidence data. Following the PRISMA guidelines, we selected 18 out of 98 papers dealing with healthy PFSPs surveying four databases. It emerged that there is a large difference between subjects even in comparable test conditions (e.g., usage of the same isokinetic device). The more reliable testing speed ranges from 60°/s to 180°/s. Employing lower or higher velocities does not add information to test results. Interlimb differences in healthy PFSP are confirmed to be approximately 10 percent. The H/Q ratio does not differ through the different calculation methods, considering eccentric values or not, in any considered menstrual cycle phase. It emerged that more methodological rigor is necessary in PFSP isokinetic testing.

Keywords: isokinetic testing; professional female soccer players; H/Q ratio; methodology

1. Introduction

1.1. Background of the Review

In recent years, the representation of female athletes in scientific research has gradually increased. Nevertheless, compared with the extensive body of literature on male athletes, female athletes remain underrepresented in sports science research [1]. Only about 20 percent of football studies focused on women, and only about 15 percent on professional women players (in earlier years) in one earlier bibliometric review [1]. For instance, women's football has been severely neglected in the field of scientific research, especially in biomechanical studies [2]. Most existing biomechanical research mainly focuses on the male sports domain. The training guidance provided to female athletes is still based on data obtained only from male players [3], and these training guidelines ignore the significant differences in joint range of motion and flexibility [4], body composition [5], and muscle strength [6] between genders.

Previous studies have shown that sex-related differences in neuromuscular control, movement strategies, and fatigue responses may influence both athletic performance and injury susceptibility in female soccer players [7]. Compared with males, female athletes appear to rely more on hip and core stabilization strategies during dynamic tasks, while also exhibiting different neuromuscular responses under fatigue conditions [8]. These neuromuscular characteristics may contribute to altered lower-limb biomechanics,

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including increased dynamic knee valgus and a potentially greater risk of anterior cruciate ligament (ACL) injuries during high-intensity movements [9]. Strength is one of the fundamental physical characteristics that affects all athletic performance, and there are differences in strength levels and the indicators used for evaluating athletic performance between male and female athletes. Previous studies have shown that female athletes generally exhibit lower concentric peak torque values of the knee extensors and flexors compared with males, particularly at angular velocities between 60°/s and 180°/s, with reported normalized peak torque values commonly ranging between approximately 1.2 and 2.8 Nm/kg depending on muscle group and testing velocity [10]. Despite these sex-related neuromuscular differences, training strategies in female soccer are still frequently adapted from male-based protocols [3,11].

In addition, several studies reported lower H/Q ratios at low angular velocities in female soccer players [12], which may reflect reduced hamstring contribution during knee stabilization tasks and potentially increase susceptibility to ACL-related injury mechanisms during high-intensity movements. Most existing studies have small sample sizes and are limited to players from a single team, making it difficult to generalize the research results to athletes of different competitive levels or backgrounds [13]. Additionally, some studies only focus on static strength assessment and lack isokinetic or functional movement tests that better reflect actual athletic performance [14].

To address the limitations in the evaluation of female athletes, objective assessment tools are of vital importance. Isokinetic testing is widely used to evaluate neuromuscular characteristics such as peak torque, inter-limb asymmetry, and hamstring-to-quadriceps (H/Q) ratios in athletes [15]. The isokinetic test also plays a key role in diagnosing muscle imbalance between the quadriceps and hamstrings, as well as between the two legs [16].

In female soccer players, the interpretation of these measurements may be influenced by several sex-specific factors, including menstrual cycle phase, fatigue responses, and individual biomechanical characteristics. Previous studies have suggested that hormonal fluctuations across the menstrual cycle may affect muscle function, coordination, and perceived fatigue, potentially contributing to variability in isokinetic outcomes [17]. When assessing strength in women, in addition to the knowledge of menstrual cycle phase, it is also important to know iron status [18]. Additionally, due to anatomical differences, women are more prone to ACL injuries than men [19]. However, many studies did not adequately control or report these variables, limiting the comparability of findings across investigations [20]. In addition, differences in testing protocols, competitive level, and participant characteristics may further influence the interpretation of isokinetic data in female soccer populations.

In the relevant literature from the past decade (2015–2025), most studies did not adequately consider variables specific to women, such as the menstrual cycle, hormone levels, or physiological and psychological states [21]. Although some studies suggested that these factors had a limited impact on isokinetic strength (IS), they could still affect muscle status and the variability of the data. Even though some studies have taken into account the effects brought about by different phases of the menstrual cycle, their assessment methods usually lack biochemical verification of hormone levels and are merely based on calendar calculations [22].

In addition, the ratio of hamstring muscles to quadriceps muscles (H:Q ratio) can not only reflect the risk of injury but also predict functional performance. Among them, the eccentric strength of the hamstring muscles plays a crucial role in movement control [23]. In recent years, some scholars have proposed that the H/Q ratio based on the rate of torque development (RTD) should replace the traditional H/Q ratio as an indicator for evaluating dynamic knee joint stability and movement performance. Previous studies suggested that

RTD-based H/Q ratios may be associated with deceleration capacity and dynamic knee stabilization during high-intensity movements [24], particularly during rapid braking tasks requiring eccentric hamstring activation.

1.2. Purpose of the Review

This systematic review aims to analyze the methodological approaches used in isokinetic testing among high-level female soccer players and to summarize the principal neuromuscular variables commonly assessed, including peak torque, inter-limb asymmetry, and hamstring-to-quadriceps (H/Q) ratios. In addition, this review examines how these variables have been associated with functional and performance-related outcomes reported in the literature, such as change-of-direction ability, deceleration capacity, and injury-related risk indicators. Finally, this review aims to identify methodological inconsistencies across studies and provide practical considerations for the standardization of isokinetic assessment protocols in female soccer players.

2. Methods

This systematic review search was conducted in June 2025 and covered studies published from June 2015 to June 2025. The search was carried out in four databases: PubMed, Scopus, Web of Science, and Google Scholar. The search was independently conducted by two authors, using the same search and exclusion strategies, and the data of the included studies were extracted, synthesized, and compared. Given that one of the objectives of this review is to reveal methodological issues in isokinetic tests of healthy female football players, the quality of the studies was set as one of the inclusion criteria, and only peer-reviewed academic journal articles were included.

The identification process of the research was accomplished through abstract retrieval, using various keyword combinations, including: “female soccer players”, “IS”, “lower limbs”, “flexor”, “extensor”, and “asymmetry”. Additionally, “woman” was used as a synonym for “female”, and “football” and “soccer” were used interchangeably. The search employed a combined search strategy and removed duplicate records using the Zotero literature manager and it supplicate plugin. The databases were searched in order from narrow to broad: Scopus → PubMed → Web of Science → Google Scholar. During the screening stage, all titles and abstracts were carefully reviewed, and all relevant literature was included for further analysis. Furthermore, the two independent reviewers screened the references of the original research and reviewed articles to identify more studies that met the criteria. The studies that meet the following criteria are included in this review:

1. The subjects had no history of knee disorders for at least 6 months before the test.
2. The studies that assess lower limb muscle strength need to use isokinetic dynamometers.
3. The results reports contain peak torque values, muscle asymmetry assessment or comparison data between flexor and extensor muscles.
4. The studies were published between June 2015 and June 2025, and the full-text papers are in English.

We limited the search to the last 10 years, because of the technological advancement in isokinetic machines, which could hinder the reliability of previous studies.

The implementation of this review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [25]. Exclusion criteria are as follows:

1. Research not written in English.
2. Research involving injured athletes.
3. Studies with mixed-gender samples but without separately reporting data for females.
4. Case reports, review articles, conference abstracts, or sources that have not undergone peer review.

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The research screening is conducted in two stages: first, a preliminary screening is carried out based on the titles and abstracts; second, a re-screening of the full texts is performed according to the inclusion and exclusion criteria.

In terms of data extraction and quality assessment, this review adopted the research quality assessment tool developed by the National Heart, Lung, and Blood Institute (NHLBI) of the United States in 2013 to evaluate the internal validity of the studies included in the systematic review [26]. A total of 18 studies were included, and they were classified into two categories based on the research design:

1. Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.
2. Quality Assessment Tool for Controlled Intervention Studies.

Each type of study was evaluated using the corresponding NHLBI checklist. To enhance the operability of the quantitative comparison, this study adopted a 10-point scoring method based on the randomized controlled trial (RCTs) scoring system and assigned different weights according to the importance of each assessment item [27]. Finally, only studies with high quality in the quality assessment were included in the analysis and comparison. All data were extracted from the tables or text of the literature and summarized and organized into five final data tables and two graphs. To calculate asymmetry, we used a formula to compare the different studies:

$$\text{Asymmetry } (\%) = \frac{|PT_D - PT_{ND}|}{\max(PT_D,\ PT_{ND})} \times 100 \quad (1)$$

In terms of bias risk, differences in the age, competitive level and background of the participants in different studies may affect the results. Moreover, many studies did not specify the menstrual cycle stage of female athletes, which constitutes a potential source of bias. At the same time, the definition of "professional athletes" and "elite athletes" is often not clear, which may affect the comparability between the study subjects and thus requires further clarification in future research. The review was registered in the Prospero database on 28 July 2025 with registration number CRD420251073152.

3. Results

The search strategy of this study was carried out in accordance with the PRISMA methodology for systematic reviews [28]. A total of 98 articles were retrieved from four databases initially, and 18 studies were finally included in the systematic review analysis.

A total of 18 studies met the inclusion criteria (Figure 1).

Overall, the risk of bias for ethnicity in these studies was low, as most of the studies were conducted in Western countries on Caucasian subjects. Additionally, the participants were mainly professional or elite female football players, whose training levels were relatively consistent with their competitive performances, thus ensuring the comparability among the studies.

The research types are divided into two categories. The majority are Observational Cohort and Cross-Sectional Studies (n = 17), and there is one Controlled Intervention Study (n = 1). The quality assessment of the research adopts a 10-point scoring system, improved based on the NHLBI checklist [26] for randomized controlled trials (RCTs) [27]. Different from the simple "yes/no" counting method, this study uses a weighted scoring method, assigning different weights according to the importance of each indicator. The quality assessment of the research is reported in Table 1.

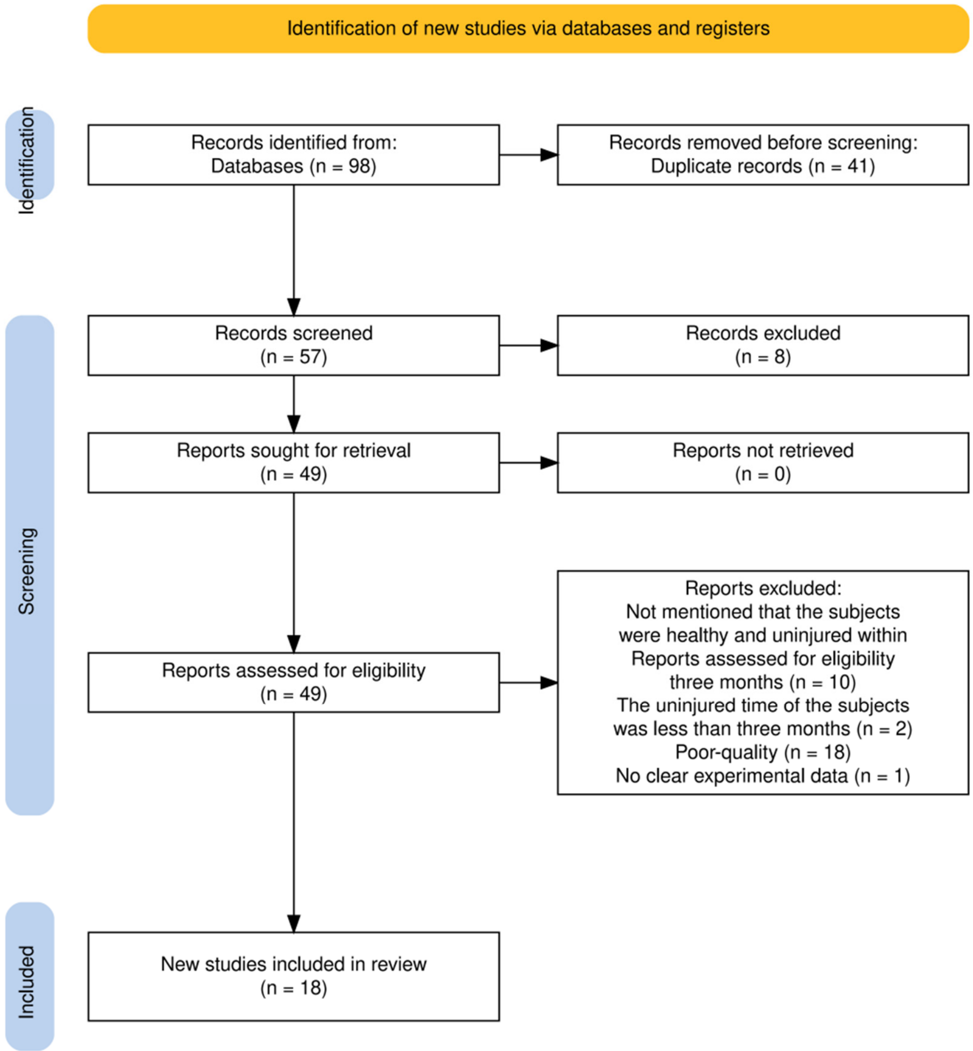

Figure 1. Search strategy.

Table 1. The quality assessment of the research.

Research Type	Study n.	Author	Score
Observational Cohort	1 [29]	Gheller et al. 2025	8
	2 [30]	Jones et al. 2022	8
	3 [31]	López-ValenciaN et al. 2019	9
	4 [32]	Östenberg et al. 1998	8
	5 [10]	Yilmaz et al. 2023	10
	6 [33]	Freitas et al. 2024	8
	7 [34]	Soyal et al. 2023	8
	8 [12]	Andrade et al. 2012	9
	9 [35]	Brígido-Fernández et al. 2022	8
	10 [36]	Maly et al. 2015	8
	11 [24]	Zhang et al. 2021	8
	12 [37]	Jenner et al. 2024	10
	13 [38]	Rodrigues et al. 2023	8
	14 [39]	Jenkins et al. 2013	9
	15 [23]	Ogando et al. 2023	8
	16 [40]	Fallon Verbruggen et al. 2024	8
	17 [41]	Risberg et al. 2018	8
Cross-Sectional	18 [42]	Delextrat et al. 2018	9

The assessment results showed that most of the studies were rated as "Fair" (scores < 8, n = 30), while 18 studies were rated as "Good" (scores = 8–10). To ensure the methodological rigor of this systematic review, only the studies rated as "Good" were included in the final analysis. A summary of the main characteristics of the studies is reported in Table 2.

Table 2. Studies included in the review and subjects' characteristics (Starters: players who are on the field at the beginning of the match).

Study n.	Device	Age (Years ± sd)	N	Level	Country	Height (cm)	Weight (kg)
1 [29]	Biodex Multi-Joint System Pro 4	22.7 ± 3.5	16	Prof	Brazilian	164.2 ± 8.7	60.4 ± 12.7
2 [30]	Kin-Com	21.7 ± 4.3	19	Elite	England	167 ± 7	60.5 ± 6.1
3 [31]	Biodex System 4	20.1 ± 4.2	44	Prof	Spanish	161.4 ± 5.2	57.2 ± 9.7
4 [32]	Cybex II	20.3 ± 4.1	101	semi-prof	Swedish	166.9 ± 4.9	61.3 ± 7.3
5 [10]	Cybex Humac Norm	23.35 ± 4.33	26	Prof	Turkey	163.92 ± 3.39	57.23 ± 6.39
6 [33]	Cybex Humac Norm II	22.04 ± 4.37	22	Prof	Brazilian	166 ± 5	62.24 ± 5.68
7 [34]	Cybex NORM	23.43 ± 4.52	21	Prof	Turkey	163.57 ± 3.59	57.10 ± 5.88
8 [12]	Biodex	25.3 ± 7.2	17	Prof	Brazilian	163 ± 5	59.8 ± 6.6
9 [35]	IsoMed 2000	21.9 ± 4.19	68	Prof	Spanish	163 ± 5	59.75 ± 6.19
10 [36]	Cybex Humac NORM	24.19 ± 3.66	17	National	Czech	168.37 ± 6.76	62.13 ± 6.05
11 [24]	Contrex (CMV AG)	24.7 ± 4.2	14	National	French	166.1 ± 5.9	63.1 ± 7.7
12 [37]	Biodex System 3 Pro	21.2 ± 3.3	8	Prof	Spanish	167 ± 4	59.90 ± 4.37
13 [38]	Biodex System 4	23.06 ± 5.63	50	Prof	Brazilian	163 ± 6	62.15 ± 10.14
14 [39]	Biodex System 4	20.3 ± 1.6 (Starters) 20.1 ± 0.7 (Non-starters)	17	Elite	American	170.1 ± 4.4 (Starters) 164.0 ± 2.8 (Non-starters)	64.8 ± 4.6 (Starters) 62.6 ± 3.0 (Non-starters)
15 [12]	Biodex System 4	19–29	15	National	Brazilian	171.33 ± 5.92	63.66 ± 5.88
16 [40]	Cybex NORM	Elite: 24.14 ± 4.35 Sub-elite: 19.45 ± 0.95	30	Sub-elite /Elite	Czech	169.15 ± 6.48	62.64 ± 7.79
17 [41]	Technogym REV 9000	20.6 ± 4.2	200	Elite	Norwegian	166.9 ± 5.7	63.7 ± 7.7
18 [42]	Biodex System 2	S: 21.8 ± 4.0 SE: 23.7 ± 7.2	21	Collegiate	England	166.2 ± 5.9 165.2 ± 6.9	59.9 ± 9.6 60.5 ± 7.3

Table 2 summarizes the main characteristics of the included studies. Regarding country distribution, five studies were conducted in Brazil [12,29,38], two in Turkey [10,34], two in England [30,42], two in Spain [31,35], and two in the Czech Republic [36,40]. The United States [39], France [24], Norway [41], and Sweden [32] were each represented by one study. Concerning the isokinetic machines used, eight studies employed Biodex [12,29,31,37–39,42], six used Cybex [10,32–34,36,40], and Kin-Com [30], IsoMed [35], Technogym [41], and Contrex [24] were each used in one study only. Two studies involved large cohorts, with 101 and 200 participants [32,41]. Across all studies, six player levels were identified: College, Sub-elite, Elite, Semi-professional, Professional, and National level. Across the included studies, six competitive levels were identified: collegiate, sub-elite,

elite, semi-professional, professional, and national-level players. Participant characteristics varied across studies, with mean age ranging from 19 to 24.7 years, mean height from 161.4 to 171.3 cm, and mean body mass from 57.2 to 63.7 kg (Table 2). A total of 18 studies met the inclusion criteria and were included in the final review. Table 3 reports the results for study objectives.

Table 3. Study objective.

Study n.	Study Objective
1	Assess inter-limb asymmetries in physical and morphological metrics in female soccer players.
2	Explore how eccentric knee strength influences cutting mechanics in female players.
3	Examine neuromuscular predictors of unilateral dynamic balance and sex differences in professional football players.
4	Assess the association between isokinetic knee extensor strength (60°/s, 180°/s) and functional performance in lower-limb tasks.
5	Compare sex differences in knee strength (angle-specific and peak torque) and assess bilateral deficits and H/Q ratios across velocities.
6	Assess how concentric strength asymmetries (PTCON at 60°/s) relate to sprint and agility performance in female players.
7	Examine the link between lower limb IS and vertical jump metrics in elite female players.
8	Assess the effects of sport modality, gender, and angular velocity on H/Q ratio, with implications for injury risk and training.
9	Provide normative PT and MW values across velocities and compare dominant vs. non-dominant leg strength.
10	Assess IS imbalances and their relevance to injury risk and performance.
11	Examine how PT, RTD, and H/Q ratios relate to sprint deceleration performance in female soccer players.
12	Verify the consistency of knee strength assessments for training and injury prevention in female team sport athletes.
13	Assess whether sex-related differences in muscle strength and BFLH morphology explain lower HSI rates in female football players.
14	Assess whether concentric/eccentric strength and functional H:Q ratios distinguish playing status in elite female soccer players.
15	Explore the relationship between H:Q ratio and match performance metrics in elite and U-20 female soccer players.
16	Assess strength differences by performance level and explore how age and training experience relate to strength in female footballers.
17	Provide normative quadriceps and hamstring strength data and compare sport- and limb-based differences for rehab and injury prevention.
18	Evaluate the impact of hamstring endurance training on neuromuscular fatigue and injury risk in female footballers.

Table 3 presents the main research objectives of the studies included. Among them, three studies evaluated the asymmetry of muscle strength in both legs [29,33,41]; five studies measured IS through isokinetic tests to provide reference standard data for rehabilitation and injury prevention [10,12,24,39]. Several studies investigated the associations between isokinetic variables and functional or biomechanical performance outcomes in female soccer players, including dynamic balance, change-of-direction ability, vertical jump performance, sprint deceleration, and movement control mechanisms. These outcomes are particularly relevant because they reflect neuromuscular functions frequently involved in high-intensity soccer actions. Across the included studies, peak torque, inter-limb asymmetry, and H/Q ratios were the variables most commonly examined in relation to these functional tasks. In addition, some studies explored the relationship between isokinetic outcomes and competitive level, age, and anthropometric characteristics. Table 4 summarizes the peak torque values normalized to body weight (Nm/kg) and asymmetry indices reported across the included studies.

Table 4. Peak Torque (Nm/kg). Con: Concentric; Ecc: Eccentric; D: Dominant leg; ND: Non-Dominant leg; Right: Right leg; Left: Left leg; SE: Strength-Endurance training; S: Strength training; Starters: players who are on the field at the beginning of the match.

<table>
<tr><th>Study n.</th><th>Velocity</th><th>Mode</th><th>Muscle Group</th><th>PT (Nm/kg)</th><th>PT (Mean, Nm/kg)</th><th>Asymmetry (%)</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">60°/s</td><td>Con</td><td>Extensor</td><td>D: 2.89 ± 0.74 | ND: 2.86 ± 0.63</td><td rowspan="2">2.20 ± 0.51</td><td>1.37</td></tr>
<tr><td>Con</td><td>Flexor</td><td>D: 1.56 ± 0.33 | ND: 1.46 ± 0.30</td><td>6.79</td></tr>
<tr><td>Ecc</td><td>Flexor</td><td>D: 2.51 ± 0.58 | ND: 2.33 ± 0.48</td><td>2.42 ± 0.53</td><td>7.44</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">60°/s</td><td rowspan="2">Ecc</td><td>Extensor</td><td>3.49 ± 0.53 (mean of the two legs)</td><td rowspan="2">/</td><td rowspan="2">/</td></tr>
<tr><td>Flexor</td><td>1.69 ± 0.30 (mean of the two legs)</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">30°/s
60°/s
180°/s
240°/s
300°/s</td><td rowspan="2">Con</td><td>Flexor</td><td>60°/s: 0.8 ± 0.2 | 180°/s: 0.6 ± 0.2
240°/s: 0.6 ± 0.2 | 300°/s: 0.6 ± 0.2</td><td rowspan="2">60°/s: 1.25 ± 0.3
180°/s: 0.85 ± 0.3
240°/s: 0.80 ± 0.25
300°/s: 0.78 ± 0.25</td><td>/</td></tr>
<tr><td>Extensor</td><td>60°/s: 1.7 ± 0.4 | 180°/s: 1.1 ± 0.3–0.4
240°/s: 1.0 ± 0.3 | 300°/s: 0.9–1.0 ± 0.3</td><td>300°/s: 10.0
($p < 0.05$)</td></tr>
<tr><td rowspan="2">Ecc</td><td>Flexor</td><td>30°/s: 2.6 ± 0.6 | 60°/s: 2.5–2.6 ± 0.6
180°/s: 2.4 ± 0.6</td><td rowspan="2">30°/s: 1.83 ± 0.45
60°/s: 1.80 ± 0.45
180°/s: 1.73 ± 0.45</td><td>30°/s: 3.8
60°/s: 3.8</td></tr>
<tr><td>Extensor</td><td>30°/s: 1.0–1.1 ± 0.2–0.3 | 60°/s:
1.0–1.1 ± 0.2–0.3
180°/s: 1.0–1.1 ± 0.3</td><td>30°/s, 60°/s,
180°/s: 9.1</td></tr>
<tr><td rowspan="2">4</td><td>60°/s</td><td rowspan="2">Con</td><td rowspan="2">Extensor</td><td>D: 1.49 ± 0.47 | ND: 1.38 ± 0.45</td><td>D & ND: 1.44 ± 0.46</td><td>8.0</td></tr>
<tr><td>180°/s</td><td>D: 1.01 ± 0.31 | ND: 0.94 ± 0.30</td><td>D & ND: 0.98 ± 0.31</td><td>6.0</td></tr>
<tr><td rowspan="4">5</td><td rowspan="2">60°/s</td><td rowspan="4">Con</td><td>Extensor</td><td>D: 2.33 ± 0.35 | ND: 2.20 ± 0.45</td><td rowspan="2">1.78 ± 0.32</td><td>10.12 ± 7.89
($p < 0.05$)</td></tr>
<tr><td>Flexor</td><td>D: 1.28 ± 0.25 | ND: 1.27 ± 0.23</td><td>11.65 ± 9.83
($p < 0.05$)</td></tr>
<tr><td rowspan="2">180°/s</td><td>Extensor</td><td>D: 1.41 ± 0.25 | ND: 1.37 ± 0.25</td><td rowspan="2">1.10 ± 0.20</td><td>10.50 ± 8.59
($p < 0.05$)</td></tr>
<tr><td>Flexor</td><td>ND: 0.81 ± 0.15</td><td>7.96 ± 7.02</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">60°/s</td><td rowspan="2">Con</td><td>Extensor</td><td>D: 2.86 ± 0.49 | ND: 2.61 ± 0.67</td><td rowspan="2">2.18 ± 0.50</td><td>8.62</td></tr>
<tr><td>Flexor</td><td>D: 1.70 ± 0.37 | ND: 1.54 ± 0.44</td><td>9.50</td></tr>
<tr><td rowspan="4">7</td><td rowspan="2">60°/s</td><td rowspan="4">Con</td><td>Flexor</td><td>Right: 2.29 ± 0.38 | Left: 2.13 ± 0.43</td><td rowspan="2">1.60 ± 0.29</td><td>7.1</td></tr>
<tr><td>Extensor</td><td>Right: 1.26 ± 0.24 | Left: 1.24 ± 0.23</td><td>1.6</td></tr>
<tr><td rowspan="2">240°/s</td><td>Flexor</td><td>Right: 1.36 ± 0.21 | Left: 1.33 ± 0.22</td><td rowspan="2">0.83 ± 0.18</td><td>2.5</td></tr>
<tr><td>Extensor</td><td>Right: 0.86 ± 0.20 | Left: 0.80 ± 0.16</td><td>7.4</td></tr>
<tr><td rowspan="4">8</td><td rowspan="2">60°/s</td><td rowspan="4">Con</td><td>Flexor</td><td>1.52 ± 0.30 (mean of the two legs)</td><td rowspan="2">2.18 ± 0.38</td><td rowspan="4">/</td></tr>
<tr><td>Extensor</td><td>2.83 ± 0.45 (mean of the two legs)</td></tr>
<tr><td rowspan="2">300°/s</td><td>Flexor</td><td>1.00 ± 0.15 (mean of the two legs)</td><td rowspan="2">1.20 ± 0.18</td></tr>
<tr><td>Extensor</td><td>1.39 ± 0.20 (mean of the two legs)</td></tr>
</table>

Table 4. *Cont.*

Study n.	Velocity	Mode	Muscle Group	PT (Nm/kg)	PT (Mean, Nm/kg)	Asymmetry (%)
9	60°/s 180°/s 240°/s	Con	Flexor	60°/s: D: 1.47 (1.29–1.59) | ND: 1.30 (1.22–1.44) 180°/s: D: 1.09 (0.97–1.20) | ND: 1.01 (0.91–1.11) 240°/s: D: 0.99 (0.89–1.09) | ND: 0.91 (0.81–1.02)	60°/s: 1.99 180°/s: 1.45 240°/s: 1.26	60°/s: 8.2 180°/s: 6.6 240°/s: 7.1
			Extensor	60°/s: D 2.66 (2.46–2.84) | ND 2.53 (2.37–2.72) 180°/s: D: 1.88 (1.72–2.09) | ND: 1.82 (1.69–1.99) 240°/s: D: 1.57 (1.43–1.76) | ND: 1.55 (1.39–1.64)		60°/s: 5.0 180°/s: 3.1 240°/s: 3.6
10	60°/s 120°/s 180°/s 240°/s 300°/s	Con	Extensor	60°/s: D 2.77 ± 0.33 | ND 2.77 ± 0.29 120°/s: D 2.24 ± 0.28 | ND 2.24 ± 0.22 180°/s: D 1.80 ± 0.23 | ND 1.81 ± 0.21 240°/s: D 1.50 ± 0.18 | ND 1.53 ± 0.21 300°/s: D 1.31 ± 0.17 | ND 1.37 ± 0.30	60°/s: 2.19 ± 0.25 120°/s: 1.84 ± 0.21 180°/s: 1.51 ± 0.19 240°/s: 1.29 ± 0.17 300°/s: 1.12 ± 0.21	180°/s: 0.6 240°/s: 2.0 300°/s: 4.4
			Flexor	60°/s: D 1.60 ± 0.22 | ND 1.61 ± 0.15 120°/s: D 1.41 ± 0.20 | ND 1.44 ± 0.12 180°/s: D 1.17 ± 0.19 | ND 1.25 ± 0.14 240°/s: D 1.03 ± 0.17 | ND 1.07 ± 0.13 300°/s: D 0.88 ± 0.19 | ND 0.92 ± 0.17		60°/s: 0.6 120°/s: 2.1 180°/s: 6.4 240: 3.7 300: 4.3
11	60°/s	Con	Extensor	D 2.05 ± 0.33 | ND 2.06 ± 0.31	1.61 ± 0.29	0.4
			Flexor	D 1.14 ± 0.22 | ND 1.17 ± 0.27		2.1
	240°/s		Extensor	D 1.43 ± 0.32 | ND 1.45 ± 0.34	1.16 ± 0.29	1.7
			Flexor	D 0.88 ± 0.25 | ND 0.87 ± 0.25		0.6
	30°/s	Ecc	Extensor	D 2.55 ± 0.55 | ND 2.59 ± 0.52	2.08 ± 0.37	1.7
			Flexor	D 1.55 ± 0.18 | ND 1.60 ± 0.22		3.3
12	60°/s	Con	Extensor	2.30 ± 0.39 (mean of the two legs)	1.77 ± 0.31	5.0
			Flexor	1.23 ± 0.22 (mean of the two legs)		2.3
	120°/s		Extensor	1.90 ± 0.30 (mean of the two legs)	1.50 ± 0.25	2.5
			Flexor	1.10 ± 0.20 (mean of the two legs)		3.0
13	60°/s	Con	Extensor	Left: 2.83 ± 0.20 | Right: 2.84 ± 0.31	2.19 ± 0.26	0.45
			Flexor	Left: 1.51 ± 0.20 | Right: 1.58 ± 0.32		4.3
		Ecc	Flexor	Left: 2.39 ± 0.46 | Right: 2.38 ± 0.28	2.39 ± 0.37	0.3
14	60°/s	Con	Extensor	Starters: 2.38 ± 0.38 | Non-starters: 2.28 ± 0.36	2.16 ± 0.23	/
			Flexor	Starters: 1.97 ± 0.10 | Non-starters: 1.98 ± 0.06		
	240°/s	Ecc	Extensor	Starters: 1.37 ± 0.19 | Non-starters: 1.35 ± 0.21	1.69 ± 0.14	
			Flexor	240°/s: Starters: 2.15 ± 0.06 | Non-starters: 1.87 ± 0.10		
15	60°/s	Con	Flexor	Right: Elite: 1.93 ± 0.26 | U-20: 1.60 ± 0.22 Left: Elite: 1.95 ± 0.24 | U-20: 1.57 ± 0.17	2.48 ± 0.36	Elite: 1.1 U-20: 3.9
			Extensor	Right: Elite: 3.24 ± 0.48 | U-20: 3.19 ± 0.62 Left: Elite: 3.19 ± 0.43 | U-20: 3.17 ± 0.22		Elite: 1.2 U-20: 0.9

Table 4. *Cont.*

Study n.	Velocity	Mode	Muscle Group	PT (Nm/kg)	PT (Mean, Nm/kg)	Asymmetry (%)
16	60°/s 180°/s 300°/s	Con	Extensor	60°/s: Elite D: 2.45 ± 0.25 | Sub-elite D: 2.48 ± 0.23 Elite ND: 0.53 ± 0.27 | Sub-elite ND: 2.59 ± 0.27 180°/s: Elite D: 1.75 ± 0.15 | Sub-elite D: 1.71 ± 0.19 Elite ND: 1.73 ± 0.17 | Sub-elite ND: 1.78 ± 0.15 300°/s: Elite D: 1.37 ± 0.11 | Sub-elite D: 1.31 ± 0.15 Elite ND: 1.37 ± 0.15 | Sub-elite ND: 1.34 ± 0.10	60°/s: 1.90 ± 0.23 180°/s: 1.34 ± 0.17 300°/s: 1.02 ± 0.14	Elite: 60°/s: 3.6 | 180°/s: 0.8 Sub-elite: 60°/s: 3.6 | 180°/s: 2.7 300°/s: 2.1
			Flexor	60°/s: Elite D: 1.37 ± 0.27 | Sub-elite D: 1.24 ± 0.18 Elite N: 1.31 ± 0.25 | Sub-elite ND: 1.21 ± 0.24 180°/s: Elite D: 1.04 ± 0.19 | Sub-elite D: 0.88 ± 0.13 Elite ND: 0.98 ± 0.18 | Sub-elite ND: 0.84 ± 0.16 300°/s: Elite D: 0.80 ± 0.12 | Sub-elite D: 0.62 ± 0.11 Elite ND: 0.76 ± 0.15 | Sub-elite ND: 0.59 ± 0.14		Elite: 60°/s: 3.9 | 180°/s: 5.5 300°/s: 4.5 Sub-elite: 60°/s: 2.0 | 180°/s: 2.7 300°/s: 4.1
17	60°/s	Con	Extensor	D: 2.3 ± 0.3 | ND: 2.3 ± 0.3	1.83 ± 0.25	1.2
			Flexor	D: 1.4 ± 0.2 | ND: 1.3 ± 0.2		2.7
18	120°/s	ECC	Flexor	S group mean: D 1.18 | ND 1.13 SE group mean: D 1.31 | ND 1.27	1.22 ± 0.08	S group: 4.2 SE group: 3.1
		Con	Flexor	S group mean: D 0.77 | ND 0.74 SE group mean: D 0.86 | ND 0.83	1.18 ± 0.26	S group: 3.9 SE group: 3.5
			Extensor	D: 1.47 | ND: 1.42 (only one group)		3.4%

In Table 5, the results for the H/Q ratio at different velocities are summarized.

Table 5. H/Q: (hamstrings/quadriceps) ratio; CON: concentric mode; ECC: eccentric mode; Right: Right leg; Left: Left leg; SE: Strength-Endurance training; S: Strength training; Functional H/Q: Eccentric PT of hamstrings/Concentric PT of quadriceps. Results are reported as the mean between the two legs.

Study n.	Mode Vel°/s	CON 60	CON 120	CON 180	CON 240	CON 300	ECC 30	ECC 60	ECC 180	Functional H/Q Ratio
1		0.54						0.87		
3		0.47		0.55	0.60	0.67	2.36	2.27	2.18	
5		0.55–0.59		0.62						
6		0.59								
7		Right: 0.55 Left: 0.59			Right:0.63 Left: 0.61					
8		0.54				0.72				
9		0.54		0.57	0.62					
10		0.59	0.65	0.67–0.70	0.70–0.71	0.68–0.71				
11		0.56			0.60–0.61					Ecc30/Con60: 0.75 Ecc30/Con240: 0.76–1.13
12		0.54	0.60							
13		0.54–0.56								Ecc60/Con60: 0.84–0.85
14										Ecc60/Con60: 0.84–0.89 Ecc240/Con240:1.42–1.58
15		Elite: 0.60 U-20: 0.52								
16		Elite: 0.56/0.52 Sub-elite: 0.50/0.47		Elite: 0.60/0.56 Sub-elite: 0.52/0.48		Elite: 0.59/0.56 Sub-elite: 0.48/0.44				
17		0.59–0.60								
18										Hecc 120/Qcon 120: 0.81–0.94 (S) 0.82–0.91 (SE)
Mean		0.55 ± 0.04	0.63	0.58 ± 0.06	0.64 ± 0.04	0.59 ± 0.10	2.36	1.57 ± 0.70	2.18	

In Table 6, the dominant/nom-dominant ratios are reported.

Table 6. Dominant/non-dominant leg differences. EXT: extension; FLEX: flexion; CON: concentric; ECC: eccentric. Results are reported as %.

Study n.	Mode Vel.°/s	EXT CON 60	EXT CON 180	EXT CON 240	FLEX CON 60	FLEX CON 180	FLEX CON 240	EXT ECC 60	FLEX ECC 60
1		11.9			9.2				11.1
2								3.49	1.69
5		10.1	10.5		11.7	8.0			
6		5.74			11.20				
7		8.90		9.67	11.57		7.90		
15		1.6							
Mean		7.65 ± 3.83	10.5	9.67	10.92 ± 1.09	8.0	7.90	3.49	6.40 ± 4.71

Figure 2 shows the strength velocity curve for concentric contraction. The graph for eccentricity was not reported because few papers used the same velocities.

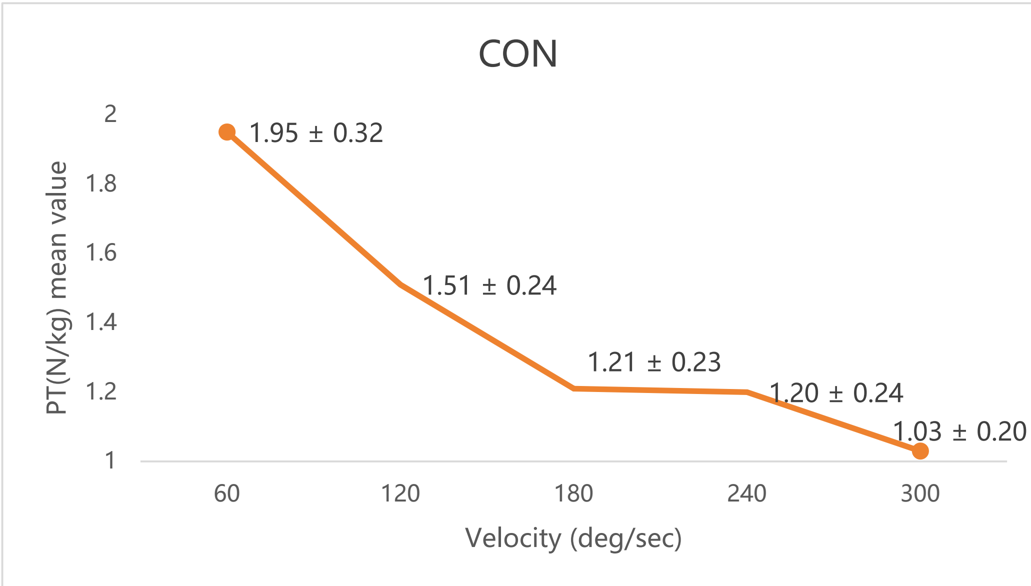

Figure 2. Mean and standard deviation of the strength/velocity curve.

Figure 2 displays the strength–velocity curve for concentric contractions, showing a progressive decline in strength from 60°/s to 300°/s. Notably, no difference was observed between 180°/s and 240°/s, suggesting that testing both speeds may be redundant—only one may suffice. Seven studies performed eccentric strength assessments [24,29,31,38,39,42,43]. However, the eccentric protocols showed substantial methodological variability across studies, particularly regarding testing velocities and contraction modes. Some angular velocities, such as 30°/s, were reported in only one study, preventing reliable comparisons or the construction of generalized eccentric strength–velocity trends. Despite these limitations, eccentric isokinetic assessments remain clinically and functionally relevant because they may help identify strength deficits, inter-limb asymmetries, and hamstring weakness associated with neuromuscular impairment and potential injury-related risk factors [44]. In particular, H/Q ratios and eccentric hamstring strength have frequently been investigated as indicators of knee joint stability and muscular imbalance in female soccer players.

Figure 3 shows the dominant vs. non-dominant limb differences across velocities.

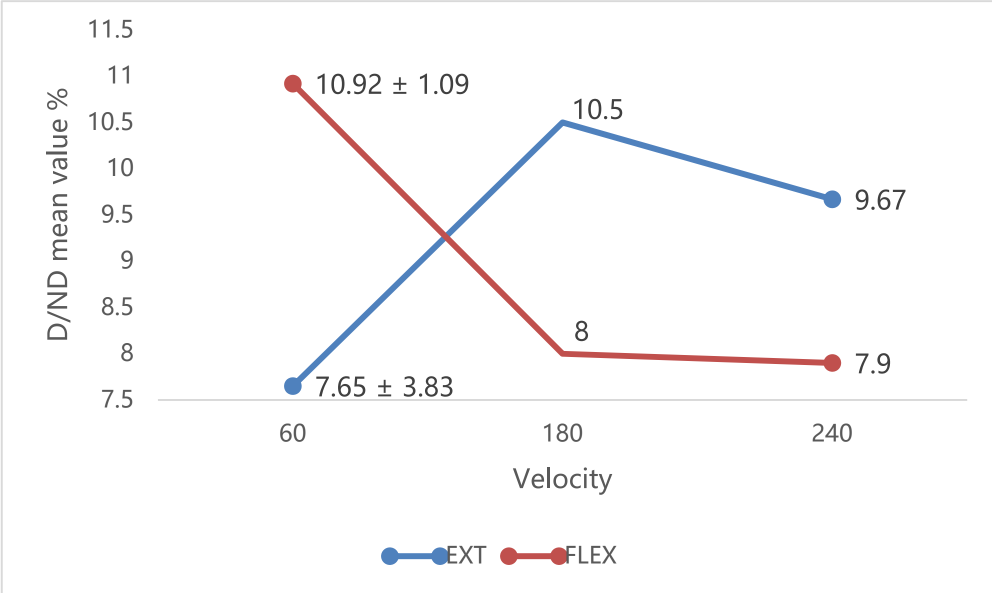

Figure 3. Dominant/non-dominant mean value in %.

It can be observed that in all the studies, the values of the flexor muscles were more uniform than those of the extensor muscles. This indicates that we can infer that the training had a more significant effect on the quadriceps femoris muscles, resulting in larger differences among different subjects; while the hamstring muscles, due to relatively less training stimulation, showed relatively consistent values among different individuals [45]. Differences were observed between 60°/s and 180°/s, while no significant differences were found between 180°/s and 240°/s, further supporting the limited value of testing both speeds. Figure 3 also illustrates the D/ND ratio across different velocities, revealing a consistent decline from 60°/s to 180°/s for both extension and flexion.

The studies included in this review suggest that isokinetic variables may be associated with several functional and neuromuscular characteristics relevant to female soccer performance. Moderate associations were reported between knee flexor/extensor strength and vertical jump performance, whereas eccentric knee extensor strength appeared to be related to deceleration and change-of-direction capacity during high-intensity actions [24,34]. However, the relationship between isokinetic variables and functional performance outcomes was not consistent across all studies. For example, although inter-limb asymmetries were identified in jumping and isokinetic assessments [29], other investigations reported no significant association between lower-limb asymmetry and sprint or directional performance [33]. These findings indicate that the relationship between isokinetic outcomes and soccer performance is likely task-specific and influenced by multiple biomechanical and neuromuscular factors.

Several studies also highlighted the relevance of hamstring strength and H/Q ratios in relation to injury-related risk indicators. Female soccer players frequently demonstrated lower hamstring strength relative to quadriceps strength, particularly at lower angular velocities, as well as greater asymmetry during high-speed contractions [12,35,36]. These findings may support the implementation of individualized strength-training strategies, especially eccentric hamstring interventions and bilateral neuromuscular training programs. In addition, short-term strength-endurance interventions appeared to attenuate post-match reductions in hamstring strength [42], suggesting a possible role for fatigue-management strategies in female soccer conditioning programs.

Isokinetic assessments were also commonly used for rehabilitation follow-up and performance monitoring because of their relatively high reliability in lower-limb strength evaluation [37]. Some studies reported that elite or starting players demonstrated greater eccentric hamstring strength at high angular velocities compared with lower-level or substitute players [39], potentially reflecting neuromuscular adaptations associated with competitive demands. Nevertheless, the ecological validity of isokinetic testing in relation to actual soccer performance remains limited, and these assessments should be interpreted as complementary tools within a broader multidimensional evaluation framework.

4. Discussion

This study targeted professional female soccer players, aiming to explore the main application areas of isokinetic testing in this population, to assess potential methodological biases, and to provide standardized benchmark data of reference value for clinical practice and training. Strength is a fundamental physical characteristic in sports, and isokinetic testing is recognized as the gold standard for assessing muscle strength. Muscle strength is closely related to various athletic performances, such as changing direction, shooting, jumping, and so on [46]. The widespread use of isokinetic force measurement equipment enables researchers to systematically analyze the mechanism of the relationship between strength and athletic performance. However, especially in the female athlete population, this association has not been fully studied and understood, and the dynamic laws of strength development remain unclear [47].

4.1. Female-Specific Methodological Considerations

Only a limited number of studies included in this review adequately monitored or reported menstrual cycle phase during isokinetic assessments. Although the influence of hormonal fluctuations on muscle performance in female athletes remains inconsistent across the literature, the menstrual cycle phase may contribute to variability in neuromuscular and strength-related outcomes [48]. Most studies relied on self-reported calendar tracking rather than biochemical verification of hormonal status, which may reduce the reliability and comparability of findings. Therefore, future studies should consider standardized menstrual cycle monitoring procedures when evaluating isokinetic variables in female soccer players [18,49]. More broadly, the current literature remains limited by methodological heterogeneity, including differences in testing velocities, contraction modes, familiarization procedures, and participant competitive levels. These inconsistencies reduce inter-study comparability and highlight the need for more standardized isokinetic assessment protocols in female soccer research.

4.2. Peak Torque and Between-Study Variability

Peak torque (PT) values normalized to body weight demonstrated substantial variability across the included studies, even under comparable testing conditions and using similar dynamometers. In general, PT values declined progressively as angular velocity increased, which is consistent with the expected force–velocity relationship observed during concentric muscle contractions. However, marked inter-study variability was identified, particularly at lower angular velocities such as 60°/s. These differences may reflect methodological heterogeneity related to participant competitive level, familiarization procedures, testing protocols, or training background rather than device-related factors alone.

From a functional perspective, lower-limb strength characteristics assessed through isokinetic testing may be associated with several soccer-specific neuromuscular tasks, including jumping, sprint acceleration/deceleration, and change-of-direction performance. Previous studies reported moderate associations between knee extensor/flexor strength and vertical jump capacity, whereas eccentric strength variables appeared to be more closely related to deceleration and directional control during high-intensity movements [24,34].

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Therefore, PT assessments may provide useful information regarding neuromuscular performance profiles in female soccer players, although these relationships remain task-specific and influenced by multiple biomechanical factors [50].

Regarding inter-limb asymmetry [51], most studies reported asymmetry indices below 10%, which is generally considered within the normal competitive fluctuation range. Nevertheless, a small number of studies identified asymmetry values exceeding 10–15% at specific angular velocities, particularly during high-speed concentric contractions of the knee extensors and flexors. These findings may indicate the presence of neuromuscular imbalance and support the use of bilateral strength assessments within injury-prevention and rehabilitation monitoring programs.

4.3. H/Q Ratios and Velocity-Related Neuromuscular Characteristics

H/Q ratios demonstrated considerable variability across studies and testing protocols. In concentric assessments, reported H/Q values ranged from approximately 0.47 at 60°/s to 0.72 at 300°/s [12,40] H/Q ratios demonstrated considerable variability across studies and testing protocols. In concentric assessments, reported H/Q values ranged from approximately 0.47 at 60°/s to 0.72 at 300°/s [24,38,39,42]. However, comparisons between studies remain difficult because of substantial methodological heterogeneity in contraction modes and angular velocities used for calculations.

From a functional perspective, H/Q ratios are frequently interpreted as indicators of knee joint stabilization capacity and neuromuscular balance during high-intensity soccer actions, particularly sprinting, deceleration, landing, and change-of-direction movements. Eccentric hamstring function may be especially relevant during braking and directional tasks, where rapid control of anterior tibial translation is required. Nevertheless, the relationship between H/Q ratios and actual performance outcomes remains inconsistent across the literature and appears to be influenced by task specificity, testing velocity, and athlete characteristics.

Some studies also suggested sex-related differences in velocity-dependent H/Q adaptations. In female athletes, H/Q ratios appeared to remain relatively stable across increasing angular velocities, whereas male athletes tended to demonstrate greater increases at higher testing speeds [52]. These findings may reflect differences in neuromuscular activation strategies and movement mechanics between sexes. However, current evidence remains insufficient to support clear superiority of functional versus conventional H/Q calculations in female soccer populations.

4.4. Inter-Limb Asymmetry and Injury-Relevant Thresholds

Table 5 presents comparisons between dominant and non-dominant limbs. At 60°/s, the difference in extension strength ranged from 5.74 percent [33] to 11.9 percent [29], and in flexion strength from 9.2 percent [29] to 11.57 percent [34]. The ratio of the strength between the dominant leg and the non-dominant leg (Table 6) showed high consistency across different angular velocities under concentric contraction conditions. The differences in extensor muscles were all within 10 percent, while the differences in flexor muscles were slightly higher. This result is consistent with previous research conclusions [53]. Under eccentric contraction mode, the difference in extensor muscles was approximately 3.49 percent, while the difference in flexor muscles ranged from 6.40 percent to 11 percent. Higher ratios of dominant/non-dominant leg were observed during eccentric flexion movements, which can be explained as follows: Eccentric contraction can stimulate high-intensity muscle strength, thereby revealing potential strength imbalances in the hamstring muscles.

Although several studies identified inter-limb asymmetries in female soccer players, the relationship between asymmetry indices and functional performance outcomes remains inconsistent across the literature. Some investigations reported no significant association between isokinetic asymmetry and sprint or jumping performance [33], whereas eccentric strength variables appeared to be more closely associated with change-of-direction and cutting-related tasks [24]. These findings suggest that the functional impact of asymmetry may depend on the specific neuromuscular demands of the task being evaluated.

In addition, eccentric hamstring asymmetries were more frequently observed during high-intensity contractions, potentially reflecting neuromuscular imbalances that may not be detectable during lower-speed concentric assessments. Previous studies also suggested that dynamic balance performance may be associated with lower-limb strength characteristics, particularly hip and hamstring function, although current evidence remains limited and task-specific [31]. Therefore, bilateral isokinetic assessment may provide useful complementary information for neuromuscular profiling and individualized training or rehabilitation monitoring in female soccer players.

5. Conclusions

This review summarizes the latest research literature on the IS of female football players with medium to highly competitive levels. A limitation of our review can reside in the limited availability of eccentric data, the different population, and the lack of regular Asian subjects. Another limitation is that we only considered Western literature, thus excluding Asian soccer players. The research results show that the number of studies specifically analyzing this group is limited of high quality, and there are very few studies considering large sample sizes. Studies involving the assessment of eccentric strength are even scarcer, and the data from eccentric tests are both scattered and lack consistency. Moreover, this review found that the results of isokinetic tests conducted at 180°/s and 240°/s do not show significant differences. Therefore, conducting tests at both speeds may not be necessary. The current results of eccentric tests, due to insufficient samples and inconsistent data, are not yet sufficient to establish reliable standardized reference values. The results of this study can provide valuable references for reference standards in rehabilitation and training.

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