The Hamstring and ACL Injury Incidence during a Season Is Not Directly Related to Preseason Knee Strength Ratios in Elite Male Soccer Players

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Abstract: Background and Objectives: The aim of this study was to identify preseason isokinetic strength differences in the knee flexors and extensors and their ipsilateral/bilateral ratios and, furthermore, to compare the results among players who subsequently overcame a hamstring strain injury (HSI) or anterior cruciate ligament (ACL) rupture during the season and those who did not. Materials and Methods: A total of 134 professional soccer players underwent isokinetic strength assessment at a velocity of 60°·s⁻¹ (knee flexors and extensors) for the dominant and non-dominant lower limb to determine preseason peak torque values and bilateral and ipsilateral strength ratios. Subsequently, the incidence of injuries during the season was recorded, and players were divided into groups according to ACL rupture injuries (n = 10), hamstring strains (n = 10), and a control group of non-injured players who were selected on a random basis (n = 20). A retrospective approach was used to analyze and compare the preseason strength characteristics and whether some variance among groups was relevant among the injured leg and non-injured leg groups. Results: The results of our study show that low-angular velocity preseason testing did not result in a player’s HSI or ACL injury during the season. The difference between the monitored groups ranged from 1.5% to 3%. The comparison showed low evidence for significant differences. Conclusions: An angular velocity of 60°·s⁻¹ within concentric muscle contraction alone was not linked to subsequent injury of the hamstring or anterior cruciate ligament and acted as an insufficient factor of injury risk in adult professional soccer players.

Keywords: ACL; football; hamstring injury; isokinetic peak torque; performance; strength asymmetry

1. Introduction

Aside from health complications, avoiding injuries is very important in preventing exclusion from game processes up to indefinite periods and reducing the performance of the team, as well as jeopardizing the player’s career [1,2]. Soccer is characterized by rapid changes in the movement intensity and direction every 6 s, while most accidents lead to lower limb injury (71%) and occur more often (6–11 times) during matches than training [3–6]. The injury incidence has risen more than 4% in the last 17 years and may be due to increased game intensity over the past few decades [7,8], high and unpredictable opponent offensive and defensive activity (strategy), stress factors, maximal player efforts to engage in risky situations, or fatigue. These factors of in-season match conditions can have a significant effect on cumulative fatigue and the fluctuation of acute strength levels, which may not respond to the results of the preseason.
The thigh area is most often injured in the English Premier League, with hamstring muscle strains accounting for 39.5% of all muscle strains and 16.3% of all injuries [2]. Another study across nine European leagues (English, Italian, Spanish, Dutch, French, Portuguese, Belgian, Scottish, and Ukrainian) points to thigh injury strains, representing 17% of all injuries, with posterior thigh strains (hamstrings: 12%) more common than anterior ones (quadriceps: 5%). Other injury subtypes were adductor pain or strains (9%), ankle sprains (7%), and medial collateral ligament (MCL) injuries (5%). Knee extension with the active quadriceps and femoral tibia in rotation are characteristic in anterior cruciate ligament (ACL) injuries, 70% of which occur during the deceleration phase of impacts or rapid turns, when motion force and moments increase rapidly [9]. As the ACL limits anterior translation of the tibia with respect to the femur, aside from optimal knee posture and relative lower limb strength levels, neuromuscular control must remain at the optimal strength capacity and activation of dynamic knee joint stabilization during motions at the high velocities known for soccer (e.g., short sprints, jumps, accelerations, decelerations, and cuts) in both fresh and impending fatigue situations [5,10]. Even 6 months after ACL reconstruction, we observe significant functional deficiencies and bilateral differences between the healthy and injured lower limbs in athletes, while a well-chosen rehabilitation program can help improve kinematic and kinetic deficits in the knee [11]. Optimal neuromuscular performance may reduce the recurrence of an ACL injury, as it improves proprioception, joint stabilization, and overall movement control [12,13]. For this reason, ACL injury prevention programs should be focused on strength and neuromuscular training from the youth categories [12,14,15]. The hamstring muscle supports the ACL in this function and is rapidly stretched and active in concentric and eccentric work during sprints, decelerations, rapid isometric holds during cuts, or static stands [5,16,17]. The occurrence of hamstring injuries can also be affected by recurrent hamstring strain injury (HSI), the older age of an athlete [18], hip imbalances, increased neural tension, inadequate rehabilitation programs, and loss of extensibility [19].

Dauty et al. [20] found that the combination of tests for preseason isokinetic strength asymmetries using bilateral, ipsilateral, and mixed ratios could statistically detect up to 79% of all hamstring injuries. Lower preseason isokinetic hamstring strength and a lower hamstring-to-quadriceps (H:Q) ratio showed 5.6 times higher risk of hamstring injury during the soccer season [21]. If the asymmetry between the knee extensors exceeds 10%, it increases the risk of musculoskeletal injuries by 16 times and ligament and meniscus injuries by up to 28 times [22]. If there is a strength imbalance in the knee flexors (over 10%), the risk of injury increases 12 times [22]. Moreover, it has been reported that greater strength asymmetries have a negative effect on skill performance in elite soccer [23]. Kim et al. [24] stated that isokinetic testing with a low angular speed (60°·s⁻¹) is a strong predictor for a non-contact leg injuries in National College American Association athletes. Additionally, Sugiura et al. [25] reported significant relationships between hamstring injuries in elite sprinters and hamstring muscle weakness only at lower speeds of testing.

Furthermore, we must see from this retrospective view the conditions in which the injuries occurred and during what period of the year the diagnostics are performed. How does the specificity of risk movement influence the approach to diagnostics and the determination of the crucial risk of injury indicators? While the studies above have found the associations between forces at slow isokinetic speeds and lower limb injury incidence, slow-velocity strength capacity alone may not fully represent the level of neural activity [5] and the forces generated at multiple soccer-specific speeds.

Consequently, rapid soccer motions require analysis of the force production and ratios at higher isokinetic speeds in the preseason period but also continuous monitoring during the season, when the players, performing at maximal efforts and loads in a match, can be monitored but cannot be fully controlled. In addition, the epidemiology of soccer injuries has shown different injury patterns according to various soccer nations or performance levels [2,26] but not yet in the highest Czech national league. We hypothesize that slow-speed isokinetic force production in the preseason is not related to lower limb injury
incidence in soccer during the season of the highest Czech league. Therefore, the aim of this study was to determine the association between the preseason low-velocity isokinetic strength differences and the conventional strength ratios of the lower limbs to the isolated ACL and hamstring injury in-season incidence among professional soccer players.

2. Materials and Methods

2.1. Study Design

A cross-sectional design with a retrospective approach was used. Measurements were performed prior to the beginning of the 2017–2018 regular season. None of the players underwent any exhausting physical loads 2 days prior to testing. Prior to testing, players received an injury report and filled out information about injuries in the pre-season. Only non-injured players in pre-season were included in the study. The incidence of player injuries was monitored over two seasons, and the results before that season were related to each injury. We also discussed injury protocols with team doctors and physiotherapists. All year, we were in close touch with the health and fitness teams of the players. We recorded all incidences of injury based on the team’s medical report. Injury grades were established based on ultrasound or MRI diagnoses. The players had similar training programs during the study period. Players had 6 training sessions plus 1 game per week and 1 gym session. All players had a prior familiarization with the isokinetic measurement and also had testing experience with isokinetic testing. The players trained on either natural grass or artificial grass while preferring natural grass. The average time of injury incidence was 2.3 months after preseason assessment, and most injuries happened in the second half of the season. The study design was explained to all participants before commencing the study. Informed consent was signed and collected from participants and parents of participants who were not over 18 years old in accordance with the Ethical Committee of the Faculty of Physical Education and Sport at Charles University in Prague, Czech Republic (Nr. 238/2019) under the conditions of the ethical standards in sport and exercise science research [27].

2.2. Study Sample

The 134 male professional soccer players from 7 teams in the highest Czech soccer league were monitored for 2 seasons. We then selected (retrospectively) 10 players with ACL injuries and 10 players with hamstring injuries (HAM) (minimum grade: 3) and a random selection of 20 healthy players for comparison (n = 40, age = 20.7 ± 1.6 years). The inclusion criteria were that all players were healthy, non-injured, and had no performance limitations in the preseason, when the measurements were performed.

Players were divided according to the type of injury into the following groups: ACL rupture (ACL, n = 10), grade-3 hamstring strain (HAM, n = 10) [28], and a control group, which consisted of non-injured players who were selected randomly (CON, n = 20).

2.3. Monitoring

Isokinetic strength evaluation with 90° knee flexion and extension of the knee extensors (KE) and flexors (KF) during concentric muscle contraction at a 60°·s⁻¹ angular velocity [24,25] was performed using a Cybex Humac Norm dynamometer (Cybex NORM®, Humac, CA, USA). Limb dominance was defined by determining which leg each participant preferred to kick with (i.e., the kicking leg) [29]. Musculoskeletal abnormality of the knee muscles was defined as a bilateral strength imbalance of more than 10% which contributed to a knee risk factor [30]. The following strength variables were evaluated: peak muscle torque of the knee extensors (PTE) and flexors (PTF) in the dominant and non-dominant lower limb, ipsilateral strength ratio of the hamstring to the quadriceps (H:Q), and bilateral strength ratios of the quadriceps to quadriceps (Q:Q) and hamstring to hamstring (H:H). The bilateral ratios between limbs were calculated according to the following formula [31]:

\[
\text{Deficit} = \frac{\text{Dominant limb score} - \text{Non-dominant limb score}}{\text{Dominant limb score}} \times 100(\%)
\]
The ipsilateral strength ratio was expressed as the percentage proportion of peak torque of the agonist and antagonist muscle on the same limb according to the following formula:

\[ \frac{H}{Q} = \frac{\text{Peak torque of hamstring}}{\text{Peak torque of quadriceps}} \times 100(\%) \]

Before testing, all players completed a short warm-up including 12 min of indoor cycling at 80–90 W and 80–90 revolutions per minute (rpm) on an ergometer (Excalibur; Lode®, Groningen, the Netherlands), 2 sets of half squats with 10 repetitions, and 2 sets of forward lunges with 10 repetitions. During the testing set-up, torque was gravity-corrected using a standardized device procedure, and dynamometer calibration was performed in accordance with the manufacturer’s instructions. Following five sub-maximal warm-up repetitions, the subjects performed two repetitions at maximal effort. There was a 30-s rest interval between the trials and testing attempts. Visual feedback and verbal stimulation were provided during the test. To achieve a rational comparison of isokinetic strengths between players, we expressed strength in relative values (normalized to body mass).

2.4. Statistical Analyses

Descriptive statistics were calculated for all dependent variables (mean, standard deviation, skewness, and kurtosis). A Shapiro–Wilk test was used to evaluate the normality of the data distribution. The effects of the main factors (comparison between groups with different types of injury (GROUP) and comparison between injured (IL) and non-injured (NL) legs) were investigated using analysis of two-way factorial variance (ANOVA). The effect size in the ANOVA model was assessed using the partial eta-squared coefficient (\(\eta_p^2\)), where \(\eta_p^2 < 0.010\) was considered to reflect a small effect size, \(0.011–0.059\) a small-to-medium effect size, \(0.060–0.138\) a medium-to-large effect size, and \(>0.139\) a large effect size [32]. For all analyses, the statistical significance level to reject the null hypothesis was set at \(p = 0.05\). Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, USA, 2012).

3. Results
3.1. Strength of Knee Extensors

The PTE of the injured legs in the ACL group was 3.04 ± 0.45 N·m·kg\(^{-1}\), and it was 3.08 ± 0.22 N·m·kg\(^{-1}\) in the non-injured group. This difference of 1.5% was not significant \((p = 0.806)\). The HAM group reached a strength of 3.12 ± 0.29 N·m·kg\(^{-1}\) and 3.03 ± 0.30 N·m·kg\(^{-1}\). This 3% difference was also insignificant \((p = 0.510)\) (Figure 1). The statistical comparison between groups (Table 1) showed a non-significant effect by the injury type (GROUP) on the PTE performance level \((F_{2,80} = 1.587, p = 0.211)\) but with a small-to-medium effect size (\(\eta_p^2 = 0.041\)). There was also an insignificant difference between the injured and non-injured legs (LEG) \((F_{1,80} = 0.403, p = 0.782)\) and between the interaction of the main factors (GROUP × LEG) \((F_{1,80} = 0.403, p = 0.528)\).

| Scheme                  | Type III Sum of Squares | df | Mean Square | F   | Sig.  | Partial Eta-Squared |
|-------------------------|-------------------------|-----|-------------|-----|-------|---------------------|
| GROUP (Types of Injuries) | 0.32                    | 2   | 0.16        | 1.587 | 0.211 | 0.041               |
| LEG (Injured Leg, Yes or No) | 0.01                   | 1   | 0.01        | 0.077 | 0.782 | 0.001               |
| GROUP × LEG             | 0.04                    | 1   | 0.04        | 0.403 | 0.528 | 0.005               |
| Error                   | 7.64                    | 75  | 0.10        |      |       |                     |
| Total                   | 717.15                  | 80  |             |      |       |                     |

Legend: Y = yes, N = no.
3.2. Strength of Knee Flexors

The PTE of the injured leg in the ACL group was 1.85 ± 0.43 N·m·kg⁻¹ and 1.90 ± 0.54 N·m·kg⁻¹ in the non-injured legs. The difference of 2.6% revealed no statistical significance (p = 0.098). The HAM group had a PTF of 1.78 ± 0.23 N·m·kg⁻¹ in the injured legs and 1.85 ± 0.23 N·m·kg⁻¹ in the non-injured legs (Figure 2) with insignificant differences (p = 0.093). Neither of the investigated factors had a significant effect (Table 2) on the size of the PTF (GROUP: F[2,80] = 2.77, p = 0.069; LEG: F[1,80] = 0.405, p = 0.526; GROUP × LEG: F[1,80] = 0.007, p = 0.932), but a medium-to-large effect size (η_p² = 0.069) was found in the injury type groups (ACL, HAM, and CON).

| Source                  | Type III Sum of Squares | df | Mean Square | F      | Sig.  | Partial Eta-Squared |
|-------------------------|-------------------------|----|-------------|--------|-------|---------------------|
| GROUP (Types of Injuries) | 0.47                    | 2  | 0.24        | 2.768  | 0.069 | 0.069               |
| LEG (Injured Leg, Yes or No) | 0.03                    | 1  | 0.03        | 0.405  | 0.526 | 0.005               |
| GROUP × LEG             | 0.00                    | 1  | 0.00        | 0.007  | 0.932 | 0.000               |
| Error                   | 6.42                    | 75 | 0.09        |        |       |                     |
| Total                   | 255.28                  | 80 |             |        |       |                     |

Legend: Y = yes, N = no.
3.3. Bilateral Ratio

The preseason bilateral ratio showed insignificant differences between all groups (GROUP: $F_{2,80} = 0.305, p = 0.738$; Q:Q and H:H: $F_{2,80} = 0.181, p = 0.672$; GROUP × BR: $F_{2,80} = 1.581, p = 0.213$) (Figure 3, Table 3) and a small-to-medium effect size ($\eta_p^2 = 0.041$) between the interaction of the main factors (GROUP × BR).

![Figure 2](image)

**Figure 2.** Comparison of knee flexor’s peak torques between observed groups. Note: ACL = anterior cruciate ligament group, HAM = hamstring group, and CON = control group.

![Figure 3](image)

**Figure 3.** Comparison of bilateral differences between observed groups. Note: ACL = anterior cruciate ligament group, HAM = hamstring group, and CONTROL = control group.
### Table 3. Effect of observed factors on the bilateral strength ratio.

| Source                      | Type III Sum of Squares | df | Mean Square | F    | Sig. | Partial Eta-Squared |
|-----------------------------|-------------------------|----|-------------|------|------|---------------------|
| GROUP (Types of Injuries)   | 18.47                   | 2  | 9.23        | 0.305| 0.738| 0.008               |
| BR (Q:Q, H:H)               | 5.47                    | 1  | 5.47        | 0.181| 0.672| 0.002               |
| GROUP × BR                  | 95.73                   | 2  | 47.87       | 1.581| 0.213| 0.041               |
| Error                       | 2240.55                 | 74 | 30.28       |      |      |                     |
| Total                       | 8136.00                 | 80 |             |      |      |                     |

Legend: BR = bilateral ratio; Q:Q = quadriceps-to-quadriceps ratio; H:H = hamstring-to-hamstring ratio.

### 3.4. Unilateral Strength Ratio

The analysis did not show a significant effect by the investigated main factors on the size of the unilateral ratio in the groups (GROUP: F<sub>2,80</sub> = 0.552, p = 0.578; LEG: F<sub>1,80</sub> = 0.162, p = 0.688; GROUP × LEG: F<sub>1,80</sub> = 0.086, p = 0.771) (Figure 4, Table 4).

![Figure 4. Comparison of ipsilateral strength ratios between observed groups. Note: ACL = anterior cruciate ligament group, HAM = hamstring group, and CONTROL = control group.](image)

### Table 4. The effect of observed factors on the level of the unilateral strength ratio.

| Source                      | Type III Sum of Squares | df | Mean Square | F    | Sig. | Partial Eta-Squared |
|-----------------------------|-------------------------|----|-------------|------|------|---------------------|
| GROUP (Types of Injuries)   | 95.50                   | 2  | 47.75       | 0.552| 0.578| 0.015               |
| LEG (Injured Leg, Yes or No)| 14.02                   | 1  | 14.02       | 0.162| 0.688| 0.002               |
| GROUP × LEG                 | 7.39                    | 1  | 7.39        | 0.086| 0.771| 0.001               |
| Error                       | 6484.14                 | 75 | 86.46       |      |      |                     |
| Total                       | 293,150.00              | 80 |             |      |      |                     |

Legend: Y = yes. N = no.
The results of our study showed that low-angular velocity preseason testing did not result in a player’s HSI or ACL injury during the season. The comparison showed low evidence for significant differences.

4. Discussion

The aim of this study was to find a possible connection between the preseason low angular velocity isokinetic strength parameters of the lower limbs and hamstring and ACL injuries during the professional soccer season. The key finding of this study was that players who were injured or not injured during the season (groups of ACL and HAM) did not differ in any comparison within the preseason isokinetic testing. Medium-to-large effect sizes between the injured and non-injured groups were found in the PTE and PTF and in the bilateral ratios among the interaction of the main factors (GROUP × BR).

4.1. Strength of Knee Extensors and Flexors

Our study revealed no significant difference between the groups and the strength levels of the knee extensors (ACL to CON: 1.5%, $p = 0.806$; HAM to CON: 3%, $p = 0.510$) and knee flexors (ACL and CON: 2.6%, $p = 0.098$; HAM to CON: 3%, $p = 0.098$). Our results here confirm the findings of Van Dyk et al. [33] and Zvijac and Kiebzak [34], who also did not find a significant relationship between the isokinetic strength peak torque and hamstring injuries in soccer players. Van Dyk et al. [33] did not support that identification of hamstring strain injury risk factors by isokinetic concentric and eccentric strength deficits is a suitable predictor and found small absolute strength differences among 190 injured and 424 non-injured soccer players over 4 seasons. They reported that isokinetic strength measurements as a predictor of hamstring damage are inconsistent [28,35–38]. On the other hand, some authors have proven that a strength deficit has been considered as a risk factor for both primary [39] and recurrent [40] hamstring injuries. One reason for the different findings may be that the strong leg compensated for the weak leg’s muscle deficit by lateral body movement to distribute the load in proportion to the muscular strength of each leg [41]. Soccer players usually perform specific movements at higher speeds (e.g., kicking, jumping, and sprinting) and also in eccentric mode (e.g., braking phase when changing direction). The hamstring’s contribution to horizontal strength production during the support phase is determined to generate a high level of eccentric strength and be activated at the end of the swing phase [42,43]. This muscle group plays a central role in any sprint demands, mostly between the middle swing phase and a blow or early stance [44]. Picerno et al. [45] presented a discussion evaluating the mechanism leading to HSI in high-speed running. The conclusions suggest that the scientific community is inclined to argue that hamstrings are more prone to tearing during the late phase of the swing [46] than in the early stance [47]. Liu et al. [28] provided evidence of an increased incidence of HSI related to the subsequent digging phase, which supports the thesis of Chumanov et al. [46] because these maneuvers are much more biomechanically similar to a late swing than an early stance. Activated muscle complexes are able to absorb greater eccentric forces on impact, and high-intensity sprinting involves intricate neuromuscular coordination in the hamstrings [48]. In this context, it is clear that protection against excessive muscle load is provided not only by strong muscles but also by the appropriate timing and size of the nerve control.

4.2. Bilateral Ratio

Our results identified a non-significant relationship between the bilateral strength ratio (Q:Q and H:H) at a low angular velocity and the incidence of ACL and hamstring injuries in soccer players. Contrary to our conclusions is the study of Liporaci et al. [22], where they demonstrated a significant increase in the risk of knee injury if asymmetry between the extensors and knee flexors reached up to 10% at a low angular velocity ($60^\circ \cdot \text{s}^{-1}$) in soccer players. It should be added that we lack the mean values and standard deviations of the isokinetic peak torque in the study, and therefore we cannot determine
with certainty whether the difference between the injured and uninjured players achieved these criteria. The research observed greater bilateral asymmetries in the knee flexors than in the extensors in soccer players of varying ages and levels of performance [29,49,50]. Another of our studies detected higher bilateral differences in the knee flexors than in the extensors (H:H = 7.94 ± 11.47%, Q:Q = 7.97 ± 9.29%,) in 70 young elite soccer players, which may be a potential risk for hamstring injuries [29]. Preseason screening of strength asymmetries consisting only of isokinetic strength tests seems to be insufficient. For testing, we should include more methods that can provide a better picture of the current state of the player [45,46]. Furthermore, low lateral strength asymmetry in the quadriceps (up to 10%) is necessary for a safe return after injury [51,52]. Van Dyk et al. [53] found similar pre-injury isokinetic strength and isokinetic strength values after hamstring injuries in soccer players, but they found side-to-side asymmetry in pre- and post-injury testing. In contrast, Lee et al. [21] identified a lower eccentric hamstring peak torque below 2.4 N·m·kg⁻¹ and a lower concentric hamstring-to-quadriceps ratio below 50.5% as being related to an increased risk of hamstring injury during the season. Strength asymmetry between the knee flexors is the most important feature in the prevention of hamstring injuries [54]. Carvalho et al. [55] proposed that the pre-season period should be used to increase muscle strength and reduce strength bilateral asymmetries between the flexors and extensors of the knee, especially by using unilateral and eccentric strength training.

4.3. Unilateral Strength Ratio

The results of our analysis did not reveal a significant effect of the observed main factors on the unilateral ratio in the target groups. In the ACL group, the H:Q ratios in the injured and non-injured legs were almost the same (IL: 61.55 ± 16.17%; NL: 61.89 ± 13.68%). However, in the HAM group, the difference was more than 3.5%. An H:Q ratio of 55–64% is considered a healthy limit in soccer players [22]. The H:Q ratio is a commonly used test for detecting injury risk. However, it appears to be an insufficient predictor without a combination of other injury predictors [56]. The authors of [56] found the biggest problem with this method to be that it is used in a fatigue-free state, but most hamstring injuries and anterior cruciate ligament (ACL) injuries occur in a state of fatigue. Football-specific fatigue disrupts the mechanics of neuromuscular feedback, and the time between the onset of the response to a stimulus of muscle activity and the onset of strength is prolonged [10]. Furthermore, fatigue causes a temporary decrease in muscle strength and negatively affects the movement pattern of the lower limbs [57]. This leads to a deterioration of the dynamic stability of the knee joint from a neuromuscular point of view, which may increase the risk of ACL injury [10]. On the other hand, the conventional H:Q ratio can be a good predictor of recurrent ACL injuries in combination with other methods [58]. In disagreement with our study results, Freckleton and Pizzari [37] conducted several meta-analysis prospective studies in which they analyzed the isokinetic strength of the knee muscles as a risk factor for hamstring injury, showing that the high strength of the quadriceps relative to the hamstring was a significant risk factor for lower limb injuries (SDM = 0.43, 95% CI: 0.05–0.81, p = 0.03). Lee et al. [21] found a statistically significant relationship between an H:Q ratio below 50.5% and the risk of acute posterior thigh muscle injury in professional soccer players (OR = 3.14; 95% CI: 1.37–2.22), based on concentric mode testing at angular speeds of 60°·s⁻¹ and 240°·s⁻¹.

In spite of the existence of the abundant literature dedicated to the relationship between strength asymmetry and injury, it remains controversial. Studies on the etymology of sports injuries must take into account the multifactorial nature of sports injuries by including as many relevant risk factors as possible and using a multidimensional statistical approach [39].

4.4. Study Limitations

Primarily, we consider the low number of injured players as a bearing limit of this study. Secondly, low-velocity isokinetic strength testing performed under the fatigue
protocol may reveal the level of fatigue resistance profile of players and thus better detect potential hidden flaws. Categorization of contact and non-contact injury incidence may also help in further research.

5. Conclusions

An angular velocity of 60°·s⁻¹ within concentric muscle contraction alone was not linked to subsequent injury of the hamstring nor the anterior cruciate ligament and acted as an insufficient factor of injury risk in adult professional soccer players. Other potential risk of injury factors like isokinetic diagnostics at higher angular velocities, eccentric muscle contraction, and various fatigue protocols need to be included if the early detection of higher risk of injuries is desired. These factors must also be supplemented by factors such as neuromuscular characteristics, hip imbalance, degree of knee valgus, or lack of flexibility. Determining the complex level of isokinetic muscle strength within conventional and functional ratios is highly recommended for uninjured or already injured players and as a suitable diagnostic tool for a possible return to soccer matches. We recommend implementation of a wider variance of testing isokinetic velocities like 180°·s⁻¹ and 300°·s⁻¹ under concentric and also eccentric hamstring contractions. Evaluating the individual’s functional range of motion or flexibility in the lower limb and hip area is also considered an important factor for lower limb injury risk prediction and should be maintained during all preseason diagnostics. More frequent monitoring of abilities in terms of relative strength and strength endurance, as well as fatigue protocols, can help indicate athletes who are more prone to injury in the coming period.

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