Evaluation of isometric and isokinetic knee muscle strength in professional, amateur and juniors German soccer players

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Abstract

Hamstring strain is one of the most prevalent injuries in soccer. Lower extremity muscle asymmetry and strength deficiency have been introduced as risk factors for predicting a Hamstring strain. The aim of this study was to analyze the relationship between the lower extremity asymmetry and strength deficiency on Hamstring strain in soccer players. Hamstring and Quadriceps isokinetic and isometric strengths were obtained and Hamstring to Quadriceps conventional and functional ratio were calculated between the injured and uninjured leg. The results indicate that the Hamstring's isokinetic concentric strength at both 60°.s-1 and 180°.s-1,and isokinetic eccentric strength at 60°.s-1 were significantly different between the injured and uninjured leg. The Quadriceps isokinetic concentric strength at 60°.s-1 was significantly different between the injured and uninjured leg. Similar differences were observed between the maximum isometric strength and eccentric leg press strength between the injured and uninjured leg. However, these differences in strength did not predict Hamstring strain.

Keywords: strength imbalance, torque, injury

Introduction

Muscular injuries in soccer represent a major problem accounting for 31% of total injuries sustained. Hamstring strains comprise 37% of the muscle injuries (Ekstrand, Hägglund, & Waldén, 2011) and with a high reoccurrence rate (Brukner, Nealon, Morgan, Burgess, & Dunn, 2013; Hägglund, Waldén, & Ekstrand, 2005). A variety of risk factors has been introduced as causes(Opar, Williams, & Shield, 2012), composing the Hamstring strain such as, but not limited to age (Opar et al., 2012), previous injury (Hägglund, Waldén, & Ekstrand, 2006), inflexibility (Bradley & Portas, 2007; Witvrouw, Danneels, Asselman, D'Have, & Cambier, 2003) and strength imbalance (Heiser, Weber, Sullivan, Clare, & Jacobs, 1984).

Muscular strength imbalance, between the lower extremities or agonist-antagonist muscle groups, have been reported in sports with asymmetric motor pattern movements, such as soccer (Rahnama, Lees, & Bambaecichi, 2005). It has been proposed that in soccer muscular strength asymmetries are associated with lower extremity injury provocation (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008; van Dyk et al., 2016); therefore symmetrical muscular strength is crucial from a performance and injury prevention perspective.

A decrease in Hamstring peak torque output (van Dyk et al., 2016) or a decrease in either conventional and functional Hamstring to Quadriceps (H:Q) have been suggested to have an association with Hamstring strain occurrence (Croisier, Forthomme, Namurois, Vanderthommen, & Crielaard, 2002; Croisier et al., 2008). The use of isokinetic dynamometers to predict Hamstring strains have remained controversial (Marc Dauty, Menu, & Fouasson-Chailloux, 2017). The aim of this study was:

- To evaluate isometric and isokinetic strength variables via isokinetic dynamometer
- To determine whether an improvement of muscular strength and the agonist-antagonist ratio of the imbalanced player in the preseason, could significantly reduce the rate of hamstring injuries.

Methods

55 professional male soccer athletes from the first division of German football league were chosen. Subjects signed an informed consent form, which implied the procedures and purposes of the study. All measurements were taken, during the 2014-2015 preseason. Isometric and eccentric maximal strength and isokinetic peak torque of Hamstring and Quadriceps for both, DL and ND were measured, using the Isomed2000 dynamometer (D&R Ferstl GmbH, Germany) (Dirnberger, Kösters, & Müller, 2012)

A standardized 10-minute warm up, using an ergometer bicycle with low resistance (75 to 100 Watts), preceded the main measurement. Prior to the test, dynamic stretching of the selected muscle groups (Quadriceps and Hamstrings) was performed, in a single set of 15 seconds.

The testing protocols involved: a) maximum isometric strength test, b) maximum eccentric strength test, c) isokinetic concentric-concentric (Con-Con) torque test at 60°.s-1 and 180°.s-1 velocities and d) isokinetic eccentric-eccentric (Ecc-Ecc) torque test (60°.s-1). Each participant was verbally encouraged during the test and did not receive any visual feedback. The players were seated as, recommended by the dynamometer manufacture’s guidelines (hip flexion angle = 110◦). Straps were applied to stabilize the shoulders, trunk, waist, and thigh of the tested leg, onto the chair. The sagittal rotational axis of the knee was determined by the dynamometer's laser pointer, at the center of the lateral femoral epicondyles. The resistance pad, at the lower end of the lever arm, was placed two centimeters proximal to the lateral malleolus. After the warm-up, the subjects performed a familiarization set on the dynamometer. Similar velocities were used in both familiarization and main test sets, to reduce the learning effects and ensure the reproducibility of the collected data. The tests included:

a) Maximum isometric leg press test: The main measurement commenced after a warm-up set of three submaximal isometric contractions. The subjects were seated, with their knees maintaining a 90° angle. Afterward, the subjects were informed to maintain a five-second maximum isometric contraction. This process was repeated two times, followed by a 3-minute rest between each set (2x1repetitions, separated by a 3-minute rest) (Fousekis, Tsepis, & Vagenas, 2010).

b) Maximum eccentric leg press test: Subjects performed an eccentric maximal strength test with the knee starting angle position ranging from 88°- 93°. This process was repeated two times, followed by a 1-minute rest between each set (2x3repetitions, separated by 1-minute rest) (Fousekis, Tsepis, & Vagenas, 2010).

c) Isokinetic test: The subjects performed a maximum concentric Hamstring and Quadriceps strength test, after a warm-up set of three submaximal trials. The range of motion was determined between 10° to 90° (80°); where the knee angle was flexed at a 10° and 90° position respectively, at 60°.s-1 and 180°.s-1 velocities. This process was repeated two times, followed by a 2-minute rest between each set (2x3repetitions, separated by 2-minute rest).

e) Conventional Ratio (Hamstring Concentric (Hcon): Quadriceps Concentric (Qcon)): This ratio was introduced by Wyatt (Wyatt & Edwards, 1981) which involves the maximum Hamstring concentric strength to maximum Quadriceps concentric strength. The test was performed at 60°.s-1 and 180°.s-1 velocities (2x3repetitions, all sets of isokinetic testing were separated by a 1-minute rest).

d) Functional ratio test (Hamstring Eccentric (Hecc)): Quadriceps Concentric (Qcon)): The functional ratio (Hecc: Qcon) was presented as a better alternative to describe the lower extremity muscular function during a gait. This functional ratio depicts a similar representation of the gait activity specifically during the swing phase(Aagaard, Simonsen, Trolle, Bangsbo, & Klausen, 1995). This test was carried out as a maximum Hecc:Qcon ratio at 60°.s-1 and a mixed ratio of Hecc at 60°.s-1 to Qcon at 180°.s-1 velocities (2x3repetitions, all sets of isokinetic testing were separated by a 1-minute rest).

e) Injury report: All Hamstring strains were recorded by the team’s physician during the season. Hamstring strain was defined, as an acute pain occurring during a match or training in the posterior region of the thigh which resulted in the termination of play and inability to train at the next session (Ekstrand, Gillquist, Möller, Oberg, & Liljedahl, 1983; Fuller et al., 2006). Athletes with previous Hamstring injuries were excluded from this study.

Statistical Analysis:

Descriptive analysis was used to showcase the mean and standard deviation (SD) of the measured parameters. The normality of data distribution was tested and confirmed. Univariate analysis (Independent t-test) was used to analyze muscle strength difference of the DL and ND between the injured and non-injured group. Binary logistics was used to calculate the risk of injury associated with muscular strength. Results were considered significant at the 5% critical level ($p < 0.05$). Excel (Microsoft Office 2010) and SPSS Statistics (IBM) were used to analyze data.

Results

Initially, 55 athletes were chosen to participate in this study. After accounting for previous Hamstring injuries as exclusion criteria, 19 (34.54%) participants didn't have consent to participate, hence a total number of 35 (63.63%) participants remained in the study.

A total number of 7 (20%) Hamstring strains were recorded throughout, the season. No significant difference was observed, for the anthropometric data (Table 1) between the injured and non-injured group.

Injury		Mean ± Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Age (years)	Non-injured	21.07 ± 4.50	0.85	0.91
	Injured	21.28 ± 5.73	2.16	
Weight (kg)	Uninjured	76.23 ± 6.38	1.20	0.90
	Injured	76.62 ± 13.01	4.91	
Height (cm)	Uninjured	181.52 ± 6.63	1.25	0.70
	Injured	180.40 ± 8.83	3.34	
Fat %	Uninjured	10.63 ± 2.46	0.46	0.92
	Injured	10.54 ± 1.75	0.66	
BMI	Uninjured	23.12 ± 1.33	0.25	0.66
	Injured	23.38 ± 1.79	0.67	

Table 1 Anthropometric data between Two Groups

Isometric and Isokinetic Strength Tests: Significant differences were observed, between the DL and ND maximum isometric ($p = 0.001$) and maximum eccentric leg press ($p = 0.000$) strength (Table 2). Isokinetic strength at different speeds had shown significant difference between the DL and ND, except for the Quadriceps concentric strength at 60°.s-1 ($p = 0.384$) and 180 °.s-1 ($p = 0.094$) (Table 3).

Variables		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Maximum Isometric Strength of the Injured and Uninjured	89.88	138.37	23.38	42.35	137.41	3.84	34	0.01*
Pair 2	Maximum Eccentric Leg Press Strength of the Injured and Uninjured	109.45	161.71	27.33	53.91	165.01	4.01	34	0.01*

Table 2 Maximum Isometric and Eccentric Leg Press Strength between Injured and Uninjured

Variables		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Hamstring Concentric Strength at 60°.s^{-1} between the Injured and Uninjured	12.85	20.64	3.48	5.76	19.94	3.68	34	0.01*
Pair 2	Hamstring Concentric Strength at 180°.s^{-1} between the Injured and Uninjured	9.88	19.02	3.21	3.34	16.41	3.07	34	0.01*
Pair 3	Hamstring Eccentric Strength at 60°.s^{-1} between the Injured and Uninjured	21.34	28.48	4.81	11.55	31.12	4.43	34	0.01*
Pair 4	Quadriceps Concentric Strength at 60°.s^{-1} between the Injured and Uninjured	5.60	37.54	6.34	-7.29	18.49	0.88	34	0.38
Pair 5	Quadriceps Concentric Strength at 180°.s^{-1} between the Injured and Uninjured	6.45	22.16	3.74	-1.15	14.07	1.72	34	0.09
Pair 6	Quadriceps Eccentric Strength at 60°.s^{-1} between the Injured and Uninjured	17.65	44.55	7.53	2.35	32.96	2.34	34	0.02*

Table 3 Maximum Isokinetic Strength at 60°.s-1 and 180°.s-1 velocities between DL and ND

No significant differences were observed, between the isometric and isokinetic strength values of the DL and ND between the injured and non-injured group ($p > 0.05$). Similarly, none of the isometric or isokinetic strength parameters for the DL and ND showed any significant associated with Hamstring strain ($p > 0.05$).

Conventional Hcon: Qcon and Functional Hecc:Qcon ratio test: The functional ratio between the DL and ND were significantly different at 60°.s-1 ($p = 0.0026$). In addition the Hamstring at 60°.s-1 with the Quadriceps at 180°.s-1 presented a significant difference between the DL and ND ($p = 0.017$) (Table 4). The differences between the conventional and functional ratio between the injured and non-injured group for the DL and ND were not significant ($p > 0.05$).

Variables		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	H:Q Conventional Ratio at 60°.s^{-1} between the Injured and Uninjured	0.04	0.15	0.02	-0.01	0.09	1.69	34	0.10
Pair 2	H:Q Functional Ratio at 60°.s^{-1} between the Injured and Uninjured	0.08	0.22	0.03	0.01	0.16	2.32	34	0.02*
Pair 3	H:Q Conventional Ratio at 180°.s^{-1} between the Injured and Uninjured	0.02	0.11	0.02	-0.01	0.06	1.09	34	0.28
Pair 4	H at 60°.s^{-1} :Q at 180°.s^{-1} Functional Ratio between the Injured and Uninjured	0.08	0.19	0.03	0.01	0.15	2.51	34	0.01*

Table 4 The difference of H:Q Conventional and Functional Ratios between the DL and ND

The differences between the conventional and functional ratio between the injured and non-injured group for the DL and ND were not significant ($p > 0.05$). Likewise, these ratios did not indicate any association with Hamstring injury for the DL and ND ($p > 0.05$).

Discussion

The results of this study show most of the strength parameters are different among three Professional, U23 and U19 groups. However, only the eccentric strength of the non-dominant leg on the leg press managed to show a significant relationship with the hamstring injury. Other strength parameters such as H: Q conventional and functional ratio did not predict the possibility of a Hamstrings injury.

Our results show that there are some differences between the DL and ND. Rahnama et al. report similar findings. His study showed that knee extensors' isokinetic strength of soccer athletes between the DL and ND were not significantly different. Similarly, he mentioned that knee flexors' strength of soccer athletes between the DL and ND were different (Rahnama et al., 2005). The reason behind these findings, He argued, is that the ND acts as a stabilizer during a ball kick. This stabilization requires forceful contraction and strength to support the joints while performing the kicking task. He mentions that this is the reason why no difference was found, between the DL and ND. Conversely, Magalhaes et al. results show that the Quadriceps isokinetic concentric strength at 90°.s-1 and 360°.s-1was different between the DL and ND which is in contrast with our findings. He also indicated that Hamstring concentric isokinetic strength was not different between the DL and ND at similar speeds, which is again in disagreement with our results (Magalhaes, Oliveira, Ascensao, & Soares, 2004). One factor that may explain the discrepancy of the results is the velocity at which the tests are conducted. Aagaard et al. reported a difference in strength output as the velocity of the dynamometer was altered (Aagaard et al., 1995). It is important when comparing the results of the strength analysis, to take the velocity difference into account.

In a similar study, Opar showed the effectiveness of weak Hamstring strength on Hamstring strength. He reported that eccentric Hamstring strength under 256N at the preseason with pose a serious risk to sustain a Hamstring strain (Opar et al., 2014). One issue with Opar finding was that he used the Nordic field test device which in comparison to an isokinetic dynamometer has less reliability and is more questionable. In this test, freedom of joint movement is apparent which could eventually influence the results thus it is incomparable with a standard isokinetic dynamometer.

The Hamstring and Quadriceps isokinetic strength at two different velocities did not differ between the injured and uninjured players. A study by Bennell et al. reached identical results showing that isokinetic Quadriceps and Hamstring, concentric and eccentric strength in Australian Rule Football athletes at 60°.s-1 and 180°.s-1 velocity did not differ (Bennell et al., 1998). A noteworthy factor he deemed to be of importance was the exclusion of athletes with a previous Hamstring strain which is known to be an indicator of the Hamstring strain. (Gabbe, Bennell, Finch, Wajswelner, & Orchard, 2006). However, Dyk et al. detected a difference in the concentric and eccentric strength of the Quadriceps and Hamstrings between players who did and didn't suffer Hamstring strain. Although the number of subjects was relatively high (n = 614), but the effect size was rather small (d < 0.2) which signifies that the overall difference, although significant, is not that much substantial. (van Dyk et al., 2016).

Many studies have suggested that with a decrease in H: Q ratio there is chance of increased risk of Hamstrings injuries (Croisier et al., 2002; Croisier et al., 2008; Heiser et al., 1984; Orchard, Marsden, Lord, & Garlick, 1997). Different cutoff values have been introduced for predicting athletes with a high risk for Hamstring strain. For conventional Hcon:Qcon ratio, values below 0.47(Heiser et al., 1984) and 0.60 (Croisier et al., 2002) ,and for functional Hecc:Qcon ratio, values below 0.6 (M Dauty, Potiron-Josse, & Rochcongar, 2003), 0.8 (Croisier et al., 2002) and 1(Fousekis, Tsepis, Poulmedis, Athanasopoulos, & Vagenas, 2010) were introduced as a risk factor for Hamstring strain indication. Croisier et al. mentioned players with preseason muscular imbalance are more prone to Hamstring strain compared to athletes who fall above these cutoff values (Croisier et al., 2002) and players below these values were found to be 4 to 5 times more likely to sustain an Hamstring strain (Croisier et al., 2008).

Dauty et al. found no association between the cutoffs suggested and Hamstrings strain. In his study, 194 professional soccer athletes participated in which 18.5% suffered Hamstring strain. He stated that the cutoffs proposed in the recent studies did show any association with the occurrence of a Hamstring strain (Marc Dauty et al., 2017). In a similar manner, Dyk stated that isokinetic testing are weak risk factors for predicting a Hamstring injury (van Dyk et al., 2016). He showed that the Receiver Operating Characteristics curve (ROC), which indicates the specificity and sensitivity of a cutoff point were very low. The low score represents a weak cutoff point in which it functions as a random guessing threshold rather than a good classifier thus being a weak cutoff point for predicting and injury (Hajian-Tilaki, 2013). Another reason that can suggestively alter the results is the exclusion of previously strained Hamstrings. Croisier et al. did not state this exclusion which is likely to affect the outcome.

In other identical sports such as the NFL and Australian Rule Football, the isokinetic H:Q strength ratio was not proven to be an indicator of Hamstring strain (Bennell et al., 1998; Zvijac, Toriscelli, Merrick, & Kiebzak, 2013).

Conclusion:

The results of this study show that the Quadriceps and Hamstring isokinetic, isometric and ratio are not good indicators of a Hamstring strain. Thus we believe that low H:Q conventional and functional ratio, low Hamstring and Quadriceps concentric and eccentric strength, and low isometric and eccentric leg press are not good risk factors for identifying soccer related Hamstring strain.

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