

The Effect of 8-Week Nordic Hamstring Exercise on Hamstring Quadriceps Ratio and Hamstring Muscle Strength

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Abstract

The aim of the study is to investigate the effect of 8-week Nordic Hamstring (NH) exercise on hamstring/quadriceps ratio (H/Q) and hamstring muscle strength. 22 amateur soccer players participated in the study. Soccer players were divided into two groups: the control group (CG) (n = 11) who only practiced soccer training and the Nordic Hamstring exercise group (NHEG) (n = 11) who performed NH in addition to soccer training. The isokinetic knee muscle strength of the soccer player was measured twice at the beginning of the study and after the 8 week NH exercise. An isokinetic dynamometer was used to determine isokinetic knee strengths of soccer players. The difference between pre-test and post-test results of isokinetic knee muscle strength of soccer players was determined by Wilcoxon test. According to the results obtained, it was found that the H/Q ratio (at 180°s⁻¹ and 240°s⁻¹ angular velocities) and hamstring muscle strength (60°s⁻¹, 180°s⁻¹ and 240°s⁻¹ angular velocities) increased statistically significantly (p<0.05). As a result, it can be stated that NH exercise is a very important factor in achieving the desired level of H/Q ratio, which is an important factor in increasing sportive performance and thus decreasing the risk of injury as well as increasing hamstring muscle strength.

Keywords: Nordic hamstring, H/Q ratio, soccer

1. Introduction

Soccer is the world's most popular sport, with more than 275 million participants (FIFA, 2007). 15 million people in the world are amateurs and 100,000 play soccer professionally (FIFA, 2009). Due to the stiffness of the nature of soccer, and there are several double actions which make soccer players encounter the risk of high injuries. In particular, male amateur soccer players have a high tendency to be injured (Ekstrand, Hagglund, & Walde'n, 2011; Schmikli, de Vries, Inklaar, & Backx, 2011; van Beijsterveldt, Stubbe, Schmikli, van de Port, & Backx, 2014). It has been determined that male amateur soccer players have an injury frequency between 20.4 and 36.9 per 1000 competition hours and between 2.4 and 3.9 per 1000 training hours (Kordi, Hemmati, Heidarian, & Ziaee, 2011; van Beijsterveldt, van der Horst, van de Port, & Backx, 2013; van Beijsterveldt et al., 2014).

Hamstring injuries are the most common muscle injury related to soccer. Hamstring injuries account for 37% of all muscle injuries (Hagglund, Walde'n, & Ekstrand, 2009; van Beijsterveldt et al., 2012; Ekstrand et al., 2011), with 12 to 16% of all future injuries (Woods et al., 2004; Ekstrand et al., 2011). The greatest problem of these injuries is the high likelihood of recurrence (12% -33%) (Heiderscheit, Sherry, Silder, Chumanov, & Thelen, 2010; Hagglund et al., 2009; Woods et al., 2004) and the long-term treatment and rehabilitation process for the athlete's re-spore rotation is required (Woods et al., 2004, van Beijsterveldt et al., 2012; Ekstrand et al., 2011). In addition to factors such as age, players' position, previous hamstring injury, muscle structure, fatigue, flexibility, hamstring muscle strength has also a significant effect on hamstring injuries (Engebretsen, Myklebust, Holme, Engebretsen, & Bahr, 2010; Cloke et al., 2012; Freckleton & Pizzari, 2013; van Beijsterveldt et al., 2013).

On the other hand, a number of researchers have suggested that inadequate hamstring strength causes H/Q ratio

imbalance or bilateral strength difference (BLD) in the hamstring (Burket, 1970; Yamamoto, 1993; Orchard, Marsden, Lord, & Garlick, 1997; Croisier, Forthomme, Namurois, Vanderthommen, & Crielaard, 2002). The H/Q ratio is obtained as a result of knee flexors compared with knee extensors (Alexander, 1990; Kannus & Jarvinen, 1990). Several studies have reported that the H/Q ratio should be between 0.5 and 0.8 (Bennell et al., 1998, Clanton, & Coupe, 1998, Orchard, Marsden, Lord, & Garlick, 1997). It is stated that BLD, which is another cause of sporting performance decrease and sports injuries, should be less than 10% (Alexander, 1990, Burket, 1970).

NH exercise is a kind of movement that does not require hamstring injuries and can be performed everywhere with his own body weight to improve hamstring strength along with providing knee muscle strength balances (H/Q ratio, BLD). NH exercise has been found to be an effective tool to improve hamstring muscle strength and provide a higher increase in eccentric hamstring strength compared to normal hamstring curl exercise (Mjølunes, Arnason, Raastad, & Bahr, 2004). It also allows NH exercise to be performed exclusively on his own body weight so that people of all age groups can perform comfortably.

The purpose of this information study is to examine the effect of 8-week NH exercise on hamstring strength and H/Q ratio of young amateur soccer players.

2. Material and Method

A total of 22 amateur soccer players participated in the study between the ages of 15 and 16. Soccer players had 4 training sessions and 1 competition per week. The soccer team was divided into two groups as the soccer training group (CG = 6) and the Nordic Hamstring exercise group (NHEG), which performed the same training along with NH training as the CG soccer training. The isokinetic knee strength measurements of the soccer players in both groups were repeated twice at the beginning of the competition period and after 8 weeks from the first measurement. The contents of the NH exercises conducted for 8 weeks are given in table 1 and the percentage distributions of the soccer training contents in table 2.

2.1 Isokinetic Knee Muscle Strength Test

The lower extremity isokinetic knee muscle strengths of soccer players participating in the study were measured during rest days when they did not participate in any physical activity during the last 24 hours. This measurement was repeated twice at the beginning of the competition period and after 8 weeks from the first measurement. The isokinetic knee muscle strengths of soccer players were determined with the Cybex brand isokinetic dynamometer (Humac Norm Testing and Rehabilitation System, CSMI, USA) at Ondokuz Mayıs Yaşar Doğu Faculty of Sports Sciences. The soccer players were warmed up for a total of 10 minutes, which was the running and stretching movements for the lower extremity before the test. All players' bodies and knee zones were fixed with bands and standardized. The concentric-concentric isokinetic knee muscle strength test consisting of 15 repetitions at 180°s^{-1} and 240°s^{-1} angular speed was conducted to soccer players on both legs with 10 repetitions at 60°s^{-1} angular velocity. Before the beginning of the test, the soccer players were given 3 trials at both angular speeds. The measurements were given a resting time of 3 min between both legs and 60 sec between each angular velocity.

2.2 Nordic Hamstring Exercise

The NH exercise is a partner exercise where the subject attempts to resist a forward-falling motion using his hamstrings to maximize loading in the eccentric phase (see figure 1). The subjects were asked to keep their hips fixed in a slightly flexed position throughout the whole range of motion, and to fall as far as possible for their hamstrings, 'let go'. They were asked to use their arms and hands to fall, let the chest touch the surface, and immediately get back to the starting position by forcefully pushing with their hands to minimize loading in the concentric phase (Mjølunes et al., 2004). In this study, the effect of the force on the surface of the fingertip was investigated.



Figure 1. Nordic Hamstring Exercise

2.3 Statistical Analysis

SPSS 24 package program was used in the analysis of the obtained data. The difference between pre-test and post-test results of isokinetic knee muscle strength of soccer players was determined by Wilcoxon test. Significance level in the study was accepted as $p < 0.05$.

Table 1. Nordic Hamstring Exercise Protocole

Week	Sessions per week	Sets and repetitions	Load
1	1	2x5	Load is increased as subject can withstand the forward fall longer. When managing to withstand the whole ROM for 12 reps, increase load by adding speed to the starting phase of the motion. The partner can also increase loading further by pushing at the back of shoulders.
2	2	2x6	
3	3	3x6-8	
4	3	3x8-10	
5-8	3	3 sets, 12,10,8 reps	

ROM: range of motion (Mjøl̄snes et al., 2004)

Table 2. Percentage Content of Training That Soccer Players Performed for 8 Weeks

Training Type	Distribution of training in percenyage
Warm-up	% 16.29
Aerobic and Unaerobic Strength	% 32.43
Speed and coordination	% 11.36
Strength	% 13.14
Tecnique, tactic and game forms	% 21.19
Regeneration	% 5.59

3. Findings

Table 3. Descriptive Statistics of Control and Exercise Groups

	N	Control Group $\bar{x} \pm Sd$	N	Exercise Group $\bar{x} \pm Sd$
Age (year)	11	15.82±0.4	11	15.91±0.30
Height (m)	11	1.72±0.54	11	1.74±0.04
Weight (kg)	11	60.82±6.5	11	62.00±4.67
BMI (kg/m ²)	11	20.30±1.48	11	20.37±1.35

Table 4. Hamstring and Quadriceps Peak Torques (PT) of the Control Group Participants Difference Table between Pretest and Posttest

Variable	Pair Groups	N	$\bar{x} \pm Sd$	Z	p
D 60° s ⁻¹ PT Q	Pre-test	11	221.91±40.27	-0.801	0.42
	Post-test	11	215.82±38.57		
D 60° s ⁻¹ PT H	Pre-test	11	110.55±22.75	-0.296	0.76
	Post-test	11	110.45±22.71		
ND 60° s ⁻¹ PT Q	Pre-test	11	205.45±38.1	0.178	0.85
	Post-test	11	205. ±31.52		
ND 60° s ⁻¹ PT H	Pre-test	11	100.27±21.54	0.178	0.85
	Post-test	11	102±24.18		
D 180° s ⁻¹ PT Q	Pre-test	11	130.09±24.08	-1.783	0.07
	Post-test	11	135.45±23.56		
D 180° s ⁻¹ PT H	Pre-test	11	74.36±12.69	-1.693	0.9
	Post-test	11	79.45±15.61		
ND 180° s ⁻¹ PT Q	Pre-test	11	120.27±18.59	-2.756	0.00*
	Post-test	11	135.82±20.91		
ND 180° s ⁻¹ PT H	Pre-test	11	69.91±17.97	-2.357	0.01*
	Post-test	11	77.91±20.76		
D 240° s ⁻¹ PT Q	Pre-test	11	112.36±16.01	-2.314	0.02*
	Post-test	11	120.45±22.98		
D 240° s ⁻¹ PT H	Pre-test	11	67±11.52	-2.501	0.01*
	Post-test	11	70.91±11.71		
ND 240° s ⁻¹ PT Q	Pre-test	11	111.73±26.26	-0.919	0.35
	Post-test	11	116.64±18.05		
ND 240° s ⁻¹ PT H	Pre-test	11	62.55±18.88	-1.604	0.1
	Post-test	11	66.82±16.31		

* p<0.05

Table 4 shows that the dominant leg hamstring and quadriceps peak torques of the nondominant leg quadriceps and hamstring peak torques at 180°s⁻¹ angular velocity and 240°s⁻¹ angular velocity were statistically significant at the posttest.

Table 5. H / Q Ratio of Control Group Participants' Difference between Pre-Test and Post-Test

Variables	Pair Groups	N	$\bar{x} \pm Sd$	Z	p
D 60° s ⁻¹ H/Q	Pre-test	11	50.27±8.59	0.871	0.38
	Post-test	11	52.±10.03		
ND 60° s ⁻¹ H/Q	Pre-test	11	49.18±9.47	-0.46	0.64
	Post-test	11	49.64±7.51		
D 180° s ⁻¹ H/Q	Pre-test	11	57.91±9.57	0.411	0.68
	Post-test	11	58.55±10.63		
ND 180° s ⁻¹ H/Q	Pre-test	11	58.18±14.77	-0.51	0.95
	Post-test	11	57.73±13.09		
D 240° s ⁻¹ H/Q	Pre-test	11	59.91±9.56	-0.85	0.93
	Post-test	11	59.73±11.99		
ND 240° s ⁻¹ H/Q	Pre-test	11	56.64±16.34	0.968	0.33
	Post-test	11	58.82±14.73		

* p<0.05

Table 5 shows that there is no statistically significant difference in H/Q ratio at any angular velocity.

Table 6. Hamstring and Quadriceps Peak Torques (PT) of Participants in the Exercise Group Difference Table between Pretest and Posttest

Variables	Pair Groups	N	$\bar{x} \pm Sd$	Z	p
D 60° s ⁻¹ PT Q	Pre-test	11	185.18±15.32	-2.805	0.01*
	Post-test	11	205.91±16.22		
D 60° s ⁻¹ PT H	Pre-test	11	99.09±12.31	-1.989	0.04*
	Post-test	11	112.00±13.06		
ND 60° s ⁻¹ PT Q	Pre-test	11	189.73±15.55	-2.135	0.03*
	Post-test	11	206.55±18.64		
ND 60° s ⁻¹ PT H	Pre-test	11	88.73±14.39	-2.667	0.01*
	Post-test	11	103.55±13.22		
D 180° s ⁻¹ PT Q	Pre-test	11	118.45±14.20	-0.296	0.77
	Post-test	11	121.27±9.48		
D 180° s ⁻¹ PT H	Pre-test	11	57.36±10.64	-2.497	0.01*
	Post-test	11	73.09±11.30		
ND 180° s ⁻¹ PT Q	Pre-test	11	121.91±13.01	-1.158	0.25
	Post-test	11	118.09±10.49		
ND 180° s ⁻¹ PT H	Pre-test	11	55.82±10.35	-2.407	0.02*
	Post-test	11	66.82±8.67		
D 240° s ⁻¹ PT Q	Pre-test	11	113.09±10.43	-1.026	0.31
	Post-test	11	109.18±8.68		
D 240° s ⁻¹ PT H	Pre-test	11	48.09±11.55	-2.848	0.00*
	Post-test	11	64.09±11.23		
ND 240° s ⁻¹ PT Q	Pre-test	11	107.55±9.33	-0.765	0.44
	Post-test	11	104.64±9.12		
ND 240° s ⁻¹ PT H	Pre-test	11	47.36±8.93	-2.802	0.01*
	Post-test	11	60.09±6.12		

*p<0.05

Table 6 shows that hamstring peak torque increases statistically at both 60°s⁻¹, 180°s⁻¹ and 240°s⁻¹ angular velocities in dominant and nondominant limbs. It was also found that the quadriceps peak torque increased statistically in both dominant and nondominant limbs at 60°s⁻¹ angular velocity.

Table 7. H/Q Ratio of Exercise Group Participants Difference Table between Pretest and Posttest

Variables	Pair Groups	N	$\bar{x} \pm Sd$	Z	p
D 60° s ⁻¹ H/Q	Pre-test	11	54.00±8.80	0.000	1.00
	Post-test	11	54.45±5.91		
ND 60° s ⁻¹ H/Q	Pre-test	11	46.91±8.35	-1.602	0.11
	Post-test	11	50.55±7.67		
D 180° s ⁻¹ H/Q	Pre-test	11	48.55±7.52	-2.805	0.01*
	Post-test	11	60.45±8.49		
ND 180° s ⁻¹ H/Q	Pre-test	11	55.82±10.35	-2.407	0.02*
	Post-test	11	66.82±8.67		
D 240° s ⁻¹ H/Q	Pre-test	11	42.45±8.98	-2.937	0.00*
	Post-test	11	59.00±10.83		
ND 240° s ⁻¹ H/Q	Pre-test	11	44.27±9.49	-2.608	0.01*
	Post-test	11	58.00±8.44		

*p<0.05

When Table 7 was examined, it was determined that the dominant and nondominant leg H/Q ratio increased statistically significantly at both 180°s⁻¹ and 240°s⁻¹ angular velocity.

4. Discussion

In the current study, it was determined that the 8-week NH exercise increased the hamstring muscle strength statistically significantly at both angular speeds of D and ND legs of 60°s^{-1} , 180°s^{-1} and 240°s^{-1} . In Mjolsnes et al (2004), 21 male soccer players divided 2 groups as NH and hamstring curl exercises, and soccer players performed these exercises for 10 weeks. As a result of the study, Nordic hamstring exercise was found to have a higher strength development in the hamstring. Although a high violent hamstring curl movement has been associated with a high strength increase in the hamstring, it has been reported that there is no protective feature in hamstring injuries. Contrary to this information, NH exercise has shown that athletes develop eccentric hamstring muscle strength, thus being a preventive factor in hamstring injuries.

Askling, Karlsson, & Thorstensson (2003) and Arnason, Andersen, Holme, Engebretsen, & Bahr (2008) reported that NH exercise was the best exercise to increase hamstring muscle strength and prevent hamstring injuries; moreover, it did not require advanced equipment. In a similar study, Petersen et al (2011) divided 942 professional and amateur soccer players into two groups of NH practitioners and control groups. Soccer players who performed NH exercise stated that hamstring strength development was high and hamstring injury risk was low. As a result of this study, Petersen et al emphasized the need to focus on eccentric strengthening of hamstring muscles to prevent hamstring injury. It is also noted that NH exercise should be applied as a general exercise in most soccer training programs, considering that NH exercise is easy to practice, which does not take a great deal of time without any additional equipment (Petersen et al., 2011).

In another study, 579 amateur soccer players were divided into two groups as a CG and as an NH group. It was determined that NH exercise applied for 13 weeks decreased the risk of hamstring injury but did not decrease the severity of injury. As a result, it has been reported that NH is an important protectant for hamstring injuries (van der Horst, Smits, Petersen, Goedhart, & Backx, 2015). The results of the above-mentioned studies support the results of the current study and it was determined that NH exercises increased hamstring strength. It is known that hamstring muscle strength is one of the important factors in preventing hamstring injuries. Studies have shown that although concentric hamstring curl exercises increase muscle strength, they do not have an effective role in hamstring injuries; on the contrary, eccentric NH exercise is an effective exercise to prevent hamstring injuries. Considering this situation, it can be said that to include the NH exercises in the soccer training is both an important factor in improving sportive performance and hamstring injuries by increasing muscle strength.

In the study conducted, it was determined that the H/Q ratio of both D and ND legs increased at 180°s^{-1} and 240°s^{-1} angular velocities statistically. Soccer is an aggressive and thematic game that increases the injuries of the lower extremities. It is evident that low H/Q ratio is among the most important causes of these injuries.

It is known that the H/Q ratio imbalance is related to the hamstring muscle being weak (Yamamoto, 1993). Since this ratio can not be stabilized by reducing quadriceps muscle strength, it is necessary to conduct studies to increase hamstring muscle strength. These are the studies related to the field (Eniseler, Sahan, Vurgun, & Mavi, 2012) and the studies on the effect of combined strength training (Daneshjoo, Mokhtar, Rahnama, & Yusof, 2012; Mendiguchia et al., 2015; Cihan, Kale, Can, & Ari, 2012) as well as the studies of hamstring-based exercises (Mjolsnes et al., 2004; Holcomb, Rubley, Lee, & Guadagnoli, 2007).

NH exercise is a method used in hamstring-based studies to increase the H/Q ratio. Studies that examine changes in H/Q ratio with NH exercise are limited. Mjolsnes et al (2004) reported that the H/Q ratio of NH exercise applied to soccer players increased for 10 weeks. Mjolsnes et al.'s study supports the results of the current study.

5. Conclusion

As a result, it is shown that NH exercises can be used as an effective method to increase hamstring muscle strength and H/Q ratio of soccer players. Generally, coaches use leg curl exercises to improve hamstring strength and increase H/Q ratio. However, they observe that NH exercise has a higher effect on preventing hamstring injuries and hamstring strength increase than on leg curl exercise. For this reason, both the athletes and the coaches should be informed about the NH exercise and should be included in the content of soccer training. Moreover, it seems evident that such exercises should be included in the curriculum within the programmes of physical education and sports so that not only athletes but also coaches will be able to become more conscious in the implementation of new beneficial exercises.

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