The Impact of Nordic Hamstring Exercise and Prevention Programs on Incidence Hamstring Injury in Football Players: A Systematic Review and Meta-analysis

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Abstract. *Background*: Football has a fairly high popularity and is admired by people of various ages. Potential injury in football is rather high because, during the game, each player is required to run at high speed. One of the most common injuries is a hamstring injury. Thus, the purpose of this study is to ascertain whether a program for preventing injuries that includes nordic hamstring exercises affects the frequency of hamstring strains among football players. *Method*: The search of the articles used four electronic databases (PUBMED, SCOPUS, University of Cambridge, and PEDro) with a publication period of 2008 to 2022. Assessment of study quality used the PEDro scale and meta-analysis used Review Manager 5.4. *Results*: There were eight articles in the systematic review and seven articles in the meta-analysis. Significant results were obtained with p-value = 0.008 in reducing the hamstring injury rate by administering injury prevention program accompanied by nordic hamstring exercises. *Conclusions*: The systematic review and meta-analysis revealed that hamstring injuries can be reduced by combining injury prevention with nordic hamstring exercises.

Keywords: Preventive Program Injury · Nordic Hamstring Exercise · Hamstring Injury in Soccer

1 Introduction

One of the most popular sports in the world is football, in which 3.6 million people participate in and is favored by various age groups [1–3]. The potential injury for football players is rather high because, during a football game, the players are required to run at high speeds [4–7].

Causes of the injuries are excessive exercise, inadequate warm-up, age, gender, player position, and fatigue [8]. A person with a history of previous injury entails the main risk factor for future injury development [9]. The lower extremities, specifically the knee and ankle joints are the most prevalent injured parts in football, and musculoskeletal strains

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occur in the quadriceps and hamstring muscles [10]. According to Diemer et al. (2020), one of most common injuries in football is frequently mentioned to be a hamstring injury [11].

Based on the results of Baseline Health Research (2013), it is recorded that the incidences of sports injuries in Indonesia are 3,5% and in Central Java are 3,4% [12]. Injuries in football games, especially muscle injuries can be found in the main muscle groups of the lower extremities with a percentage of 37% in the hamstring muscles, 23% in adductor muscles, and 19% in quadriceps muscles [13]. Injuries to the hamstring have the highest percentage of injuries among other injuries, namely 15–50% [14].

When the nordic hamstring exercise is used, hamstring injuries are reduced [15]. Due to its objective of increasing the ability to lower the rate of hamstring injuries and hamstring muscle strength, the nordic hamstring is one of the exercises in the injury prevention [16, 17]. Nordic hamstring exercise helps minimize hamstring strains by 65% to 70% [18].

To discover whether offering a hamstring injury prevention program simultanously with nordic hamstring exercises will lower the frequency of hamstring strains in football players, meta-analysis and systematic reviews should be conducted.

2 Method

According to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), this work used systematic review and meta-analysis techniques [19].

2.1 Search Strategy

The articles were searched using computerized databases. The electronic databases used in this study are Medline Publications (PUBMED), SCOPUS, University of Cambridge, and Physiotherapy Evidence Database (PEDro) with a publication period of 2008–2022. The keywords in the search for articles in the database are “preventive program injury” “nordic hamstring exercise” and “hamstring injury in soccer”.

2.2 Eligibility Criteria

The subsequent criteria for publications to be included in this study are: (1) RCT and Cohort; (2) the population was football players; (3) used an injury prevention program intervention accompanied by nordic hamstring exercises; (4) reported the hamstring injuries rate. While the exclusion criteria in this study are as follows: (1) studies that used case studies or did not use group comparisons; (2) the article was not available in English. The purpose of this study was to compare the frequency of hamstring injuries.

2.3 Study Selection

After the overall collection of titles and abstracts, the articles underwent an eligibility check. The inclusion criteria were applied to find all pertinent articles. The article selection process can be seen in Fig. 1.

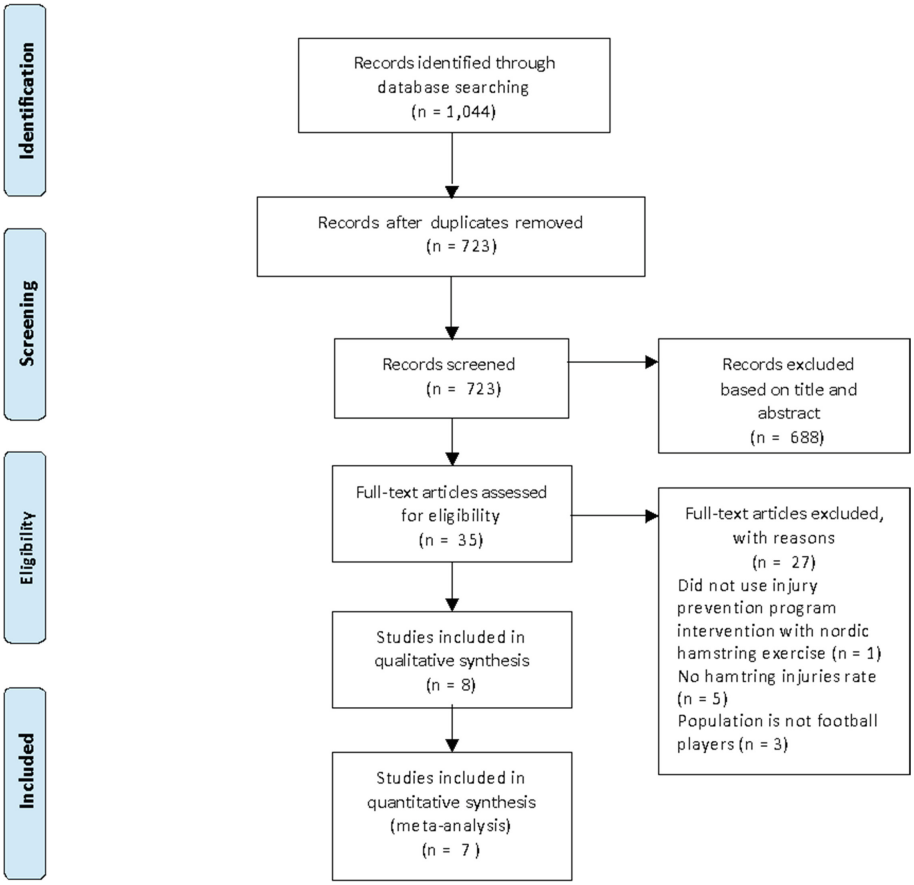

Fig. 1. PRISMA Flowchart

2.4 Data Extraction

Each article's data were extracted, namely author, year, study design, sample size, population, intervention, outcome, and results.

2.5 Assessment of Study Quality

In this study, the study quality assessment used the PEDro scale. A methodical evaluation of the quality of studies included in systematic reviews across physiotherapy, health, and medical research was conducted using the PEDro scale [20, 21]. The PEDro scale included eleven points; one point was external validity, eight points were internal validity, and two points were statistical comparisons. Interpretations of the total score are < 4 (poor); 4–5 (fair); 6–8 (good); 9–10 (excellent) [22].

2.6 Meta-analysis

Data from the meta-analysis were analyzed with Review Manager 5.4. The Review Manager in this study was employed to calculate the value of differences in each group using the 95% Confidence Interval (CI) and *P value* < 0.05 The *P value* < 0.05 showed a noticeable difference and the *P value* > 0.05 indicated that there was no significant difference.

3 Result

3.1 Search Results

The search in the electronic database found 1,044 articles, then duplicates were remoned for for titles and abstracts and selected 723 articles. Subsequently, the articles would be selected based on the inclusion criteria, and 35 articles were further selected. Of 27 articles were removed because they did not fit the requirements for inclusion, including the following: (1) 19 articles did not use injury prevention interventions with nordic hamstring exercises; (2) 5 articles did not list the hamstring strains; (3) 3 articles' population was not football players. As a result, Fig. 1 shows that the meta-analysis included 7 articles and 8 articles were analyzed in the systematic review.

3.2 Characteristic of Study Results

There were eight articles included in the paper, ranging from 2008 to 2019. One article with a cohort study design and seven articles with a randomized control trials study design, totaling 5.097 samples. The population in the article was football players aged 13–39 years. The intervention used was an injury prevention program with ordic hamstring exercises. Four articles calculated hamstring strains, and three articles calculated the injuries to the lower extremities (leg, ankle, knee, lower limbs, upper limbs, hip), and one article calculating the injury rate to all parts of the body (head, upper limbs, knee, foot, hands, torso, elbow, wrist, chest, neck, forearm, spine, arm, shoulder, wrist, elbow) in Table 1.

3.3 Quality Assessment Results

Every article was rated "yes" or "no" (1 or 0) on the criteria listed on the PEDro scale. The total score on the PEDro scale from criteria 2–11, the overall score was 0–11, and criterion no. 1 was removed because it was more closely related to the external validity [31–33]. There were two articles with "fair" interpretations and five articles with "good" interpretations in Table 2.

3.4 Meta-analysis Results

Seven articles examined hamstring injury data by comparing two groups. The result showed the statistical significance of reducing hamstring injury by giving an injury prevention program accompanied by nordic hamstring training with *p-value* $= 0.008$ in Fig. 2.

Table 1. Characteristics of Studies

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
1	Engebretsen et al. (2008) [23]	RCT	N: 508	Football	Target EXC	10 weeks	Control group (Target EXC)	**Injury rate (ankle, knee, hamstring, groin)**	ankle: IG = 13; CG = 20
					NHE				knee: IG = 7; CG = 8
									hamstring: IG = 23; CG = 17
									groin: IG = 11; CG = 16
2	Soligard et al. (2009) [24]	Cluster-RCT	N: 1892	13–17 years	Warm Up	32 weeks	Control group (Warm Up)	**Injury rate (knee, ankle, leg, anterior thigh, hamstring, hip)**	knee: IG = 35; CG = 58
				Female	NHE				ankle: IG = 51; CG = 52
				Football					leg: IG = 14; CG = 22
									anterior thigh
									hamstring: IG = 5; CG = 8

(*continued*)

Table 1. (*continued*)

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
									hip: IG = 10; CG = 9
3	Petersen et al. (2011) [25]	RCT	N: 942	Male	Reguler Training	10 weeks	Control group (Reguler Training)	**Hamstring injury rate**	IG = 15; CG = 52
				Football	NHE				
4	Grooms et al. (2013) [26]	Cohort study	N: 34	18–25 years	F-MARC 11 +	6 weeks	Control group	**Injury rate (foot, ankle, lower leg, knee, thigh, hip)**	hip flexor: IG = 0; CG = 1
							(Warm Up)		
				Male	NHE				hamstring: IG = 1; CG = 5
				Football					quadriceps: IG = 0; CG = 3
									groin: IG = 0; CG = 1
									knee MCL: IG = 1; CG = 0
									knee meniscus: IG = 0; CG = 1
									lower leg: IG = 1; CG = 1
									ankle: IG = 0; CG = 0

(*continued*)

Table 1. (*continued*)

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
									midfoot: IG = 0; CG = 1
									First metatarsophalangeal joint sprain (turf toe): IG = 1; CG = 0
5	Sebelien et al. (2014) [27]	RCT	N: 119	18–39 years	Warm Up	5 weeks	Control group (Warm Up)	**Hamstring injury rate**	IG = 0; CG = 6
				Male	NHE				
				Football					
6	Del Ama Espinosa et al. (2015) [28]	RCT	N: 43	Female	Training Program	21 weeks	Control group (Training Program)	**Hamstring injury rate**	IG = 1; CG = 5
				Football	NHE				

(*continued*)

Table 1. (*continued*)

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
7	Silvers-Granelli et al. (2015) [29]	Cluster-RCT	N: 1.525	18–25 years	FIFA 11+	32 weeks	Control group (Warm Up)	**Injury rate (knee, ankle, hamstring, head, foot, groin, hip, shoulder, quadriceps, leg, hand, spine, torso, elbow, neck, wrist, chest, arm, forearm)**	knee: IG = 34; CG = 102
				Male	NHE				ankle: IG = 59; CG = 115
				Football					hamstring: IG = 16; CG = 55
									head: IG = 31; CG = 61
									foot: IG = 22; CG = 49
									groin: IG = 23; CG = 48

(*continued*)

Table 1. (*continued*)

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
									hip: IG = 16; CG = 45
									shoulder: IG = 6; CG = 30
									quadriceps: IG = 25; CG = 44
									leg: IG = 25; CG = 39
									hand: IG = 6; CG = 10
									spine: IG = 8; CG = 30
									torso: IG = 9; CG = 10
									elbow: IG = 2; CG = 9
									wrist: IG = 0; CG = 7
									neck: IG = 1; CG = 6
									chest: IG = 0; CG = 3
									arm: IG = 1; CG = 1

(*continued*)

Table 1. (*continued*)

No.	Authors	Study Design	Sample	Population	Intervention	Duration	Comparison	Outcome	Hasil
									forearm: IG = 0; CG = 1
8	Elerian, El-Sayyad, and Dorgham (2019) [30]	RCT	N: 34	21–35 years	Warm Up	12 weeks	Control Group (Dose difference)	**Hamstring injury rate**	IG = 1; CG = 4
				Male	NHE				
				Football					

RCT = Randomized Controlled Trial; EXC = Exercise; NHE = Nordic Hamstring Exercise; MCL = Medial Collateral Ligament; IG = Intervention Group; CG = Control Group

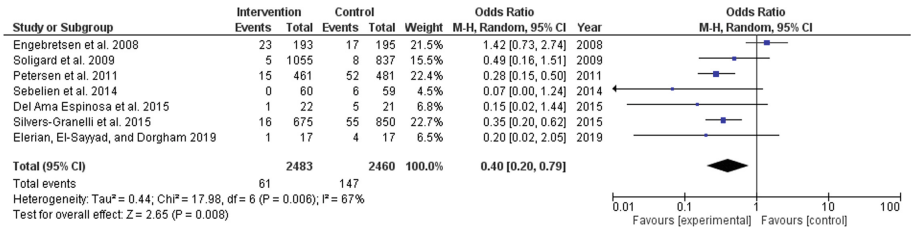

Fig. 2. Forest Plot: Nordic Hamstring Exercise and Prevention Program Injury on Incidence Hamstring Injury

Table 2. Assessment of Study Quality PEDro Scale

Study	Criteria											Total
	1	2	3	4	5	6	7	8	9	10	11	
Engebretsen et al. (2008)	0	1	0	1	0	0	0	1	0	1	0	4
Soligard et al. (2009)	1	1	1	1	0	0	0	1	1	1	1	7
Petersen et al. (2011)	0	1	0	1	1	1	1	1	0	1	1	8
Sebelien et al. (2014)	1	1	0	1	1	0	0	1	0	1	1	6
Del Ama Espinosa et al. (2015)	0	1	0	1	1	0	1	1	0	1	0	6
Silvers-Granelli et al. (2015)	1	1	0	1	0	0	0	1	0	1	1	5
Elerian, El-Sayyad, and Dorgham (2019)	1	1	1	1	0	0	0	1	0	1	1	6

"1" = "yes"; "0" = "no"; Criteria: **1** Requirements for eligibility were stated (not used for scoring); **2** Randomly selected groups were assigned to subjects; **3** The allocation was concealed; **4** At the beginning, the groups perspectives on the most crucial prognostic factors were identical; **5** The subjects were all blinded; **6** All therapists who delivered the therapy were blinded; **7** Every assessor who took at least one measurement major outcome was blinded; **8** More than 85% of the participants, who were initially divided into groups had measurements of at least one important outcome; **9** The treatment or control condition was administered to all subjects for whom outcome measurements were available, or in the event that this was not possible, data for at least one significant outcome was evaluated using the "intention-to-treat" method; **10** At least one critical outcome was in the between-group statistical comparison data given; **11** For at least one important result, the study gave both point measurements and variability measures.

4 Discussion

The meta-analysis and systemic review purpose were to determine the impact of giving a program for injury prevention together with nordic hamstring exercises on the frequency of hamstring strains. FIFA 11+ is one of the prevention programs, in which the program is an alternative warm-up to treat injuries in the lower extremities in football. Injury prevention programs can be carried out before and after exercise [34]. The goal of the nordic hamstring exercise is to improve the hamstring's eccentric strength to prevent hamstring injuries [24].

Giving an injury prevention program accompanied by nordic hamstring exercises may cause architectural changes in the muscles, especially in the biceps femoris muscle, when the condition of the fascicle biceps femoris can be lengthened after being treated with an injury prevention program accompanied by nordic hamstring exercises. The benefit of fascicle biceps femoris lengthening is it could increase muscle extensibility, which can affect the risk of injury. Thus, an improving hamstring eccentric strength and the possibility of hamstring strains can be reduced by extending the biceps femoris fascicle, resulting in a reduction in hamstring injuries' frequency [35, 36].

The meta-analysis studying seven articles with a randomized controlled trial showed significant results in providing an injury prevention program accompanied by nordic hamstring exercises to improve the hamstring strains rate in football players. These results correspond to previous studies, according to Del Ama Espinosa et al. (2015), compared two groups, namely the intervention group and the control group. Eccentric training program of nordic hamstring exercises were given to the intervention group for 23 weeks. The exercise program for the control group incorporated multiple jumping (MJ) and side leg swings (SLS). The results of the occurrence of hamstring strains in the control group were 23.8% and the intervention group was 4.5%. Due to the small number of samples (n: 43), the study's primary found there was no significant difference between groups in the statistical part, but the intervention program implemented could reduce hamstring strains by 81% [28].

In Soligard et al. (2009) study, with a total sample of 1.892, two groups were created from the sample, namely the control group with intervention of a warm-up that was commonly used and the intervention group which was given injury prevention program accompanied by nordic hamstring exercises. According to this study, severe injuries could be decreased by half and the risk of injury could be cut by up to a third, however the main results of lower extremities did not reach significance. Nevertheless, there was a considerable decline in several factors, and hamstring injury is one of them. It obtained 3.1% in the intervention group and 3.7% in the control group. The main result did not reach significance due to the low level of compliance in the program implementation since players who followed the guidelines often had a lesser risk of injury [24].

The study conducted by Soligard et al. (2009) was relevant with Silvers-Granelli et al. (2015) that used FIFA 11+ intervention accompanied by nordic hamstring and compared two groups. Intervention given to this study statistically reduced injury rate in male football players significantly with the intervention group (n:675), having a 5.6% hamstring injury percentage and in the control group (n: 850) 8.3%. The compliance level in football players greatly affected the injury rate because the higher the level of the player's compliance, the lower the level of reported injuries, and when the training program was being implemented, ensuring the players were not fatigued was essential [29].

Based on the study conducted by Elerian, El-Sayyad, and Dorgham (2019), the interventions used were warmup and nordic hamstring exercises. Additionally, it was also divided into three groups, namely: (1) the first intervention group was given the nordic hamstring before and after the exercise; (2) the second intervention group was only administered with the nordic hamstring before the exercise; and (3) nordic hamstring exercise was not treated to the control group. The training program was given for

12 weeks. There were significant differences in the hamstring injury rates in each group, namely (1) the first intervention group was 5.9%; (2) the second intervention group was 23.5%; and (3) control group was 62.5%. The level of compliance in each group was rather high (>95%), and injury risk decreased as more players complied [30].

According to Whalan et al.'s (2019) research, there were distinct major variations between the two groups, each of which showed a different reduction in injury rates, namely the FIFA 11+ standard group was 38% and the P2 post group was 35%. The hamstring injury rate in FIFA11+ standard group was 51 and the P2 group post was 45. In the P2 group post, modifications to FIFA11+ were made, namely rescheduling FIFA11+ by doing sessions 1 and 3 at the beginning of the exercise and part 2 (nordic hamstring) after the end of the workout, which was the cool-down period. Rescheduling can increase compliance and program effectiveness [34].

5 Conclusion

Based on the findings of systematic review and meta-analysis to determine the impact of injury prevention programs and nordic hamstring exercises on the frequency of hamstring strains in football players, it is revealed that there was a declining trend in the hamstring strains rate. Further research should consider the sample's compliance with the given program because of its importance to the study's findings, as well as reconsidering the number of samples that will be used in the study.

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