The Impact of Nordic Hamstring Exercise on the Eccentric Strength of Hamstring and the Length Fascicle Biceps Femoris: Systematic Review and Meta-analysis

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Abstract. Background: Hamstring strain injury is a non-contact injury caused by high-speed running. Two of risk factors that of HIS is due to lack of eccentric power of the hamstring muscle and the length of the biceps femoris fascicle. This study to aobserve the effect of nordic hamstring exercise on peak torque eccentric hamstring strength & length of biceps femoris fascicle. Method: Literature search using three databases PubMed, ScienceDirect and SPORTDiscus. In this systematic review and meta-analysis uses randomized control trial (RCT) was used by dividing two groups, namely the intervention group and the control group. Assessment of study quality and risk of bias using the cochrane scale. Results: Six articles were Included in this systematic review and meta-analysis, of which four articles were observed of hamstring muscle eccentric strength and three articles were observed of biceps femoris fascicle length. The eccentric strength showed that there was a significant difference in value (P = 0.009) while for the length of the biceps femoris fascicle, there was no significant difference in value (P = 0.41). Conclusion: Nordic hamstring exercises can increase the eccentric strength of the hamstring muscles, but not the length of the biceps femoris fascicle.

Keywords: Nordic Hamstring Exercise · Eccentric Strength Hamstring Muscles · Length Fascicle Biceps Femoris

1 Introduction

Sport is a positive physical activity and is loved by all people from children, adults to the elderly [1, 2]. Sport provides health benefits or physical fitness, it is also defined as physical exercise carried out individually or in groups that have predetermined goals [3]. Sport is an activity that involves directed and measurable body movements, but does not rule out the possibility that sports will cause problems or injuries to the body movement system, for example such as soccer, basketball, athletics and others [4, 5]. Football is a sport with a high level of popularity among the public, therefore the physical readiness of every player must be improved so that competence can run smoothly and be free from injury [6].

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The rate of sports injuries among young adults is high, with 60% lower extremity injuries [2]. Hamstring strain injury (HSI) is one of the most frequent lower extremity injury with the rating of 12% of all injuries reported in 17 European football clubs and high-speed running has been reported to be a common cause of HSI and has been reported in professional football the UK reaches 60% experiencing HSI [5]. This is due to high or excessive eccentric loads in the swing phase until the foot steps on the surface when running [7]. HSI is a non-contact injury that often occurs in sports involving running, this injury occurs when the muscle is stretched eccentrically [8]. One of the risk factors for HSI is the low level of hamstring strength, strength hamstring muscle has been ratified as one aspect to reduce the risk of developing HSI and the risk of HSI increases if there is a lack of hamstring strength [5, 9]. The risk other factor of HSI are age, previous injury, imbalance of strength, fatigue and lack of flexibility in the hamstring [10].

Nordic hamstring exercise (NHE) method is the one of exercise to train the eccentric strength of the hamstring [7]. This exercise focus on eccentric contraction of hamstring muscle, eccentric strength exercise is done by kneeling on the mat with the upper body upright, while the therapist or partner hold the ankles, then the participant trying to drops the upper body onto the mat. Slowly or as slowly as possible. In this phase, the hamstring contraction will maximize the load on eccentric strength during lowering the upper body to the surface [7, 11–13].

According to study by Mjølsnes et al. (2004) nordic hamstring exercises are effective in increasing the eccentric strength of the hamstring thereby may reduce the risk of HSI [14]. While study by Alonso-Fernandez et al. (2018) nordic hamstring exercises can increase the length of the biceps femoris fascicle [12]. So that nordic hamstring exercises are proven to reduce hamstring injuries. FIFA 11+ has included or recommended nordic hamstring exercises in the warm-up that are preventive hamstring injuries in soccer athletes, but in the real world the level of adherence is low in athletes when given nordic hamstring exercise interventions [5].

The purpose of this study is to see the effect of nordic hamstring exercise on the eccentric strength of the hamstring muscle and adaptation of the length of the biceps femoris fascicle.

2 Method

This study uses a quantitative approach with systematic review and meta-analysis studies that follow the guidelines of the preferred Reporting Item for Systematic review and Meta-Analysis (PRISMA) [15].

2.1 Search Strategy

A search articles using electronic database such as PubMed, ScienceDirect and SPORTDiscus. The keywords used in the search for articles in this database were "nordic hamstring exercise" AND "eccentric strength of hamstring muscles" OR "eccentric power" AND "long biceps femoris fascicle" OR "muscle architecture Adaptations" OR "biceps femoris long head (BFlh)" from the 2004–2022 publication range.

2.2 Eligibility Criteria

In this study, it must meet the requirement criteria. The inclusion criteria in this research article are as follows: (1) someone who is still actively exercising, (2) randomized control trial, (3) minimal nordic hamstring exercise completed for 4 weeks, (4) pre and post intervention values, (5) article in english. While the exclusion criteria in this study are as follows: someone who has an injury to the lower extremity and is not available in the full text articles.

2.3 Study Selection

After the overal collection of titles and abstracts, the articles underwent an eligibility. The inclusion criteria are used to find all pertinent articles. PRISMA is carried out in four stages, namely identification, screening, eligibility, included. This review can be seen in Fig. 1.

2.4 Data Extraction

Each article's data is extracted category of author, year of publication, study, sample, population, intervention, comparison, duration, outcome and results. This extraction data can be seen in Table 1.

2.5 Assessment of Study Quality

The study quality assessment uses the cochrane scale for risk of bias in randomized trials. In Cochrane there are several categories that can be assessed including: (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) blinding of outcome assessment, (5) incomplete outcome data, (6) selective reporting, (7) selective reporting [16, 17].

2.6 Meta-analysis

This study uses review manager 5.4 to process statistical data, the review manager in this study is used to calculate the value of differences in each pre and post values in each intervention group and control group using 95% Confident Interval (CI) in each outcome measure. P value <0.05 indicates a significant difference and a P value >0.05 indicates an insignificant difference. In this study, the value of the eccentric strength was observed at the value of the eccentric peak torque while the length of the biceps femoris fascicle was observed by the value of the fascicle length.

3 Result

3.1 Search Results

Initial searches yielded 508 articles. After deletion due to duplicates it became 503 articles. The second stage is the screening of the title and abstracts of produce 35 articles based on the criteria, 29 articles are left out because they do no fit the requirements for

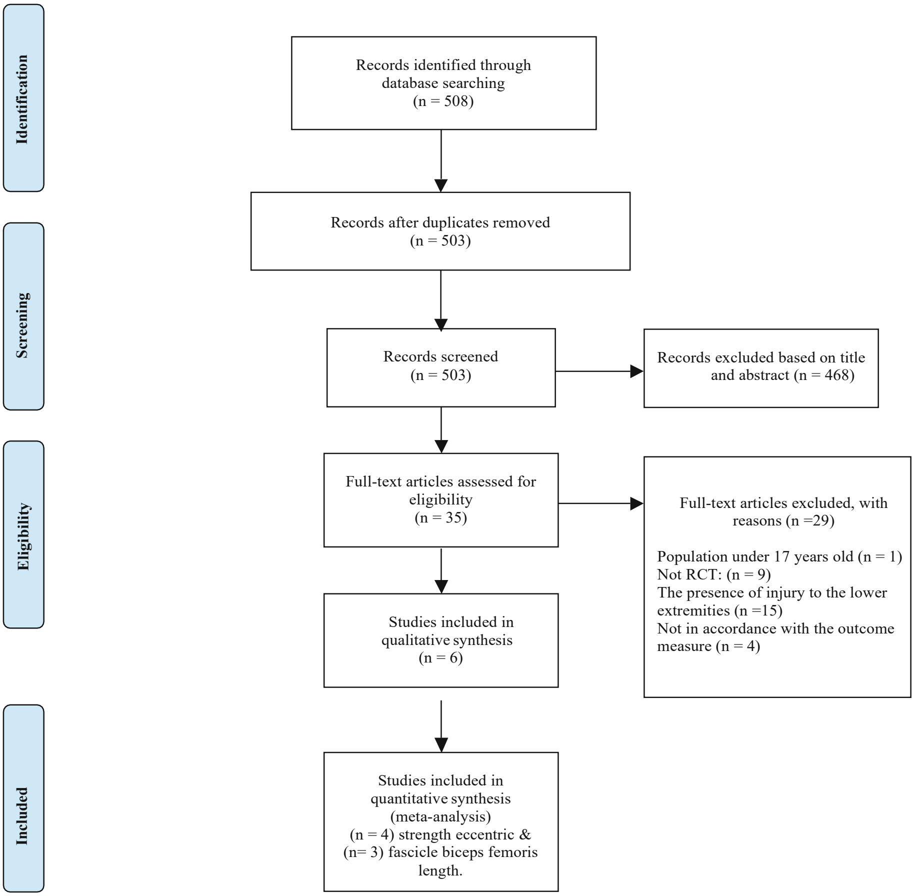

Fig 1. PRISMA Flowchart

inclusion. The final result is to use 6 articles for a systematic review and meta-analysis, where for the meta-analysis 4 articles are used for the outcome of hamstring muscle eccentric strength and 3 articles are used for the outcome of the length of the biceps femoris fascicle. PRISMA review can be seen in Fig. 1.

3.2 Characteristic of Study Results

In this study, there were 6 studies using a randomized control trial study. The participants involved were 114 participants (n: 114) with an average age of 17–35 years, who were still actively exercising. The intervention given is the nordic hamstring exercise. 4 articles were used to calculate the outcome of hamstring eccentric strength with an looking at the value of the eccentric peak torque and 3 articles were used to calculate the length of the biceps femoris fascicle by the value of the fascicle length. The study characteristics data can be seen in Table 1.

Table 1. Characteristic of Included Studies

No	Authors	Study Design	Sample	Population	Intervention	Comparison	Duration (Weeks)	Outcome	Result
1	Iga et al. (2012)	RCT	N: 18	Mean age 22,9 years NHE: n = 10 CG: n = 8	NHE	Control Grup (Dynamic warm up)	4 weeks	Dynamometer isokinetic (eccentric peak torque)	Eccentric peak torque (Nm) IG: (134 ± 42), CG: (121 ± 35)
2	Ishoi et al. (2018)	RCT	N: 35	Mean age 17-35 years NHE: n = 18 CG: n = 17	NHE	Control Grup (Warm up)	10 weeks	Eccentric peak torque	Eccentric peak torque (N) IG: (383,2 ± 68,6), CG: 372.7 ± 62.1
3	Mjolsnes et al. (2004)	RCT	N: 21	Soccer athlete NHE: n = 11 CG: n = 10	NHE	Control Grup (Hamstring curl)	10 weeks	Dynamometer isokinetic (eccentric peak torque)	Eccentric peak torque (Nm) IG: (267 ± 13), CG: (116 ±7)
4	Presland at al. (2018)	RCT	N: 20	Mean age 22,3 years NHE: n = 10 CG: n = 10	NHE	Control Grup (NHE high volume)	6 weeks	Ultrasound Imaging (fascicle length)	Fascicle length (Cm) IG: (12.56 ± 0.97), CG: (12.50 ± 0.72)
5	Ribeiro-Alvares et al. (2017)	RCT	N: 20	Mean age 18-35 years NHE: n = 10 CG: n = 10	NHE	Control Grup (Not NHE)	4 weeks	Dynamometer isokinetic (eccentric peak torque) & Ultrasound imaging (fascicle length)	Eccentric peak torque (Nm) IG: (126,9 ± 33,4), CG: (124,8 ±33.0) & Fascicle length (Cm) IG: (10,18 ± 0,75), CG: (9,59 ± 2,03)
6	Seymore at al. (2017)	RCT	N: 20	Mean age 18-25 years NHE: n = 10 CG: n = 10	NHE	Control Grup (Static stretching)	6 weeks	Ultrasound imaging (fascicle length)	Fascicle length (Cm) IG: (8.59 ± 1.5), CG: (10.19 ± 2.01)

RCT = Randomized Controlled Trial, NHE = Nordic Hamstring Exrecise, CG = Control Grup, IG = Intervention Grup

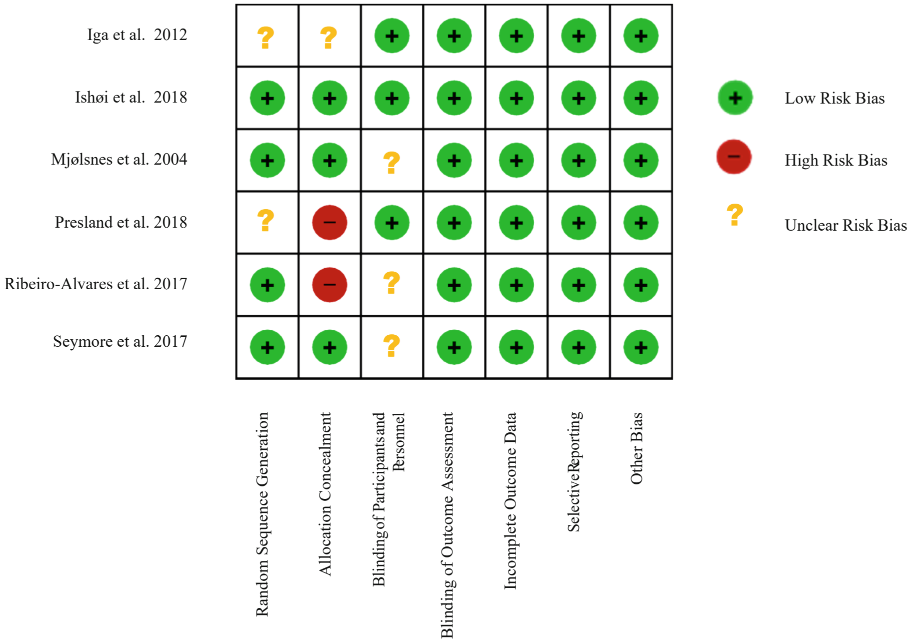

Fig. 2. Assessment of Study Quality Cochrane Scale.

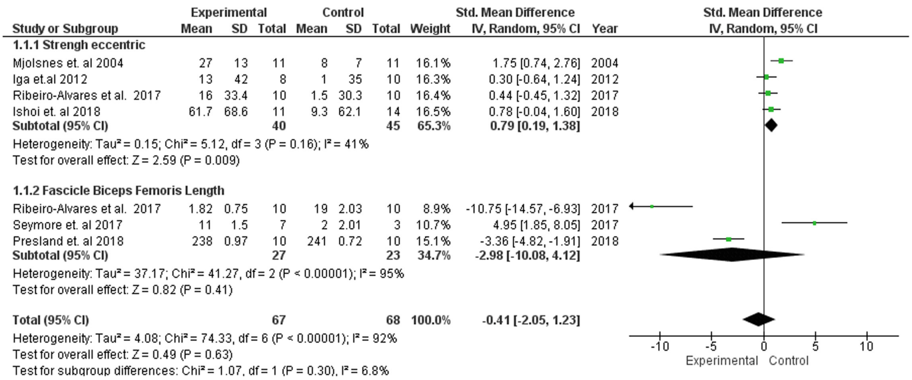

Fig. 3. Forest Plot: Strength Eccentric and Fascicle Biceps Femoris Length Score

3.3 Quality Assessment Results

Risk assessment of bias in all studies using Cochrane as described, of the results 6 studies observed the results show generally a low risk for most category, with 2 high bias in allocation concealment, 1 bias in unclear in the category allocation concealment, 2 bias in unclear in the category of random sequence generation, and 3 bias is not clear in the category of blinding of participants and personnel. This review can be seen in Fig. 2.

3.4 Meta-analysis Results

3.4.1 Eccentric Force

Four studies that conducted on the assessment of the eccentric strength of the hamstring muscles and analyzed using meta-analysis the results stated that there was a considerable a significant difference in value (P = 0,009). See in Fig 3.

3.4.2 Fascicle Biceps Femoris Length

Three studies that conducted research on length of the biceps femoris fascicle and analyzed using a meta-analysis results showed no significant difference in value (P = 0,41). See in Fig. 3.

3.5 Systematic Review Results

3.5.1 Eccentric Force

According to study conducted by Iga et al. (2012), Ishøi et al. (2018), Mjølsnes et al. (2004) and Ribeiro-Alvares et al. (2017) explained that there was a significant change or increase in eccentric strength in the hamstring muscles after being given Nordic hamstring exercises for at least 4 weeks [9, 14, 18, 19].

3.5.2 Fascicle Biceps Femoris Length

Study conducted by Ribeiro-Alvares et al. (2017) showed that there is a significant increase in length of biceps femoris fascicle after being given nordic hamstring exercises [19]. Similar to the study of Presland et al. (2018) explained that there was a significant increase in the length of the biceps femoris fascicle after being given nordic hamstring exercise, but there was no significant difference for the low and high dose groups of nordic hamstring intervention [8]. In contrast to the study conducted by Seymore et al. (2017) showed that there was no significant increase in the length of the biceps femoris fascicle [20].

4 Discussion

Meta-analysis and systematic review's purpose is determine the effect of nordic hamstring exercise on changes in the eccentric strength of the hamstring muscles and the length of the biceps femoris fascicle. The main goal of nordic hamstring exercise is to increase the strength of the hamstring muscles, where hamstring strength is an important component to prevent HSI. Thus, the power hamstring eccentric well-developed are important for injury prevention hamstring in athletes.

The results of this review found an increase in eccentric strength of hamstring muscles. Bassed on the study conducted by Mjølsnes et al. (2004) which showed the results in the nordic hamstring exercise intervention group there was an 11% increase in the eccentric peak torque of the hamstring while in the hamstring curl group it increased 7% during 10 weeks of exercise. Thus it can be concluded that the nordic hamstring exercise more effective than the hamstring curl to increase eccentric strength of the hamstring muscle [14]. The nordic hamstring exercise produces a different mechanism with the hamstring curl, where the nordic hamstring exercise causes eccentric contractions that cause muscle contractions accompanied by muscle lengthening, while the hamstring curl causes concentric contractions accompanied by active muscle shortening [5]. These results are relevan with previous study conducted by Elizabeth J et al. (1996) that eccentric exercise increases muscle strength more than concentric exercise [21].

Study conducted by Iga et al. (2012) nordic hamstring exercise for 4 weeks showed significant results in increasing the eccentric peak torque of the hamstring up to 21% [18]. Similar to the study of Ishøi et al. (2018) showed a significant increase in the eccentric peak torque of the hamstring by 19.2% after being given a nordic hamstring exercise intervention for 10 weeks [9]. In a study conducted by Ribeiro-Alvares et al. (2017) there was an increase in hamstring eccentric strength by 13% after 4 weeks of intervention [19].

Based on these results there is evidence that the eccentric strength training program using the nordic hamstring exercise method was effective in increasing the eccentric strength of the hamstring muscles in athletes [7], so FIFA 11 + recommends the nordic hamstring exercise as a preventative warm-up program for HSI risk, because in eccentric contraction exercises this elicits a greater adaptive response in muscle strength compared to concentric training [5, 14].

According to Opar et al. (2012) who explained that the length of the biceps femoris fascicle will affect the risk of injury, because a longer lenght fascicle will increase extensibility of larger muscle [10]. In the results of this review found no significant increase in the length of the biceps femoris fascicle, this study was aligned Seymore et al. (2017) that nordic hamstring exercise did not increase the length of the biceps femoris fascicle [20]. In the study of Presland et al. (2018) did not show a significant increase between the low and high doses of the nordic hamstring exercise group on the length of the biceps femoris fascicle, nordic hamstring exercise [8]. In contrast to the study conducted by Bourne et al. (2017) showed the results of a significant increase in the length of the biceps femoris fascicle after being given a nordic hamstring exercise, but the intervention given to participants with a knee range of motion was greater than the usual nordic hamstring exercise intervention, in the study of Bourne et al. (2017) this Nordic hamstring exercise intervention was modified by means of an elevated exercise surface on the knee mat only, so that when dropping the body the surface would be further away, this causes the knee range of motion to increase and results in increased muscle length which can increase the length of the biceps femoris fascicle [22]. Based on the research of Sharifnezhad et al. (2014) explained that the increase in the length of the biceps femoris fascicle depends on the length of the muscle produced at the time of the intervention [23]. In three studies observed intervention the nordic hamstring exercise was not modified with a surface that was not elevated at the time of the intervention, so that the resulting muscle length was shorter, this could affect the length of the fascicle [8, 19, 20].

Several studies have observed that compliance with the application of the nordic hamstring exercise intervention is low. Although not all studies explain the results of the level of compliance, adherence in carrying out the intervention has an effect on showing the results of the effectiveness of a study. Low adherence was reported in the study of Ishøi et al. (2018) who achieved the level of compliance in the Nordic hamstring exercise intervention group only reached 60% [9]. Similar to the study of Lovell et al. (2018) explained that the level of adherence in the low nordic hamstring exercise intervention group only reached 52.8% [24]. National Strength and Conditioning Association (NSCA) guidelines, with increasing intensity will result in the most effective increase in muscle strength ability [5], but intensity can be a problem when dosing a nordic hamstring intervention. It was seems to occur because maximal nordic hamstring exercise will produce a true eccentric mechanism, so that the hamstring muscle is overloaded beyond its capacity which causes muscle damage, causes muscle pain and causes fatigue. Thus, participants considered this exercise to be painful or to cause fatigue, thus affecting the low level of adherence to this nordic hamstring exercise intervention [5, 25]. As described in the study conducted by Presland et al. 2018) explained that the level of adherence was greater in the low-dose nordic hamstring exercise group which reached 100% while in the high-dose group it only reached 99.2% [8].

The limitations of this study was the data that has been obtained are still minimal, the requirements and the value of low-dosed and high dosed in terms of intervention distribution are not included and not all of the researches insert their adherence during exercise.

5 *C*onclusion

Based on a systematic review and meta-analysis that had been done, it shows that nordic hamstring exercise can increase eccentric hamstring strength, but does not increase the length of the biceps femoris fascicle. Observing the results of low adherence to the intervention, low-dose nordic hamstring exercise was recommended for athletes so that it can increase adherence during the intervention and can potentially reduce the risk of HSI. Need that further study to clarifying of low and high doses of nordic hamstring exercise that will affect the eccentric strength and length of the biceps femoris fascicle, and pay attention to participant compliance to reduce the risk of HSI.

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