

Comparative Study on Eccentric vs. Isometric Hamstring Strengthening in the Prevention of Hamstring Injuries in Football Players

(A Biomechanical and Clinical Analysis)

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Abstract— Background: Hamstring Strain Injuries (HSIs) are the most common and impactful injury type in football for elite male players accounting for 24% of all injuries. The incidence of these injuries has doubled in 20 years and the risk of re-injury is very high at 18%. The traditional "gold standard" eccentric strengthening (Nordic Hamstring Exercise) produces a great delayed onset muscle sore and low compliance to the exercise. However, a new alternative, namely long-length isometric strengthening comes in to fill in these gaps.

Aim and objective : The aim of this study is to compare both the programs in detail, one is Traditional eccentric program and the other is modern isometric program.

Methodology: It is only hamstring injuries in male football players that are considered.

Group A - Eccentric Strengthening (Nordic Hamstring Exercise (NHE) is the main exercise). **Group B Isometric Strengthening** with focus on LENGTH (long length static holds).

Conclusion: The goal is to determine which approach would be more successful and feasible at preventing the most frequent and bothersome injury in football. A very innovative and scientific method for treating and preventing hamstring strain injuries. This is an entirely different way of dealing with hamstring strain injuries, based on science.

Keywords — Delayed Onset Muscle Soreness, Eccentric Strengthening, Football Injuries, Hamstring Strain Injuries, Isometric Strengthening, Nordic Hamstring Exercise.

I. INTRODUCTION

Hamstring Strain Injuries (HSIs) are unarguably the most prevalent and economic injury in elite men's professional football, resulting in tremendous player absences and the clubs suffering economically. Despite the steady progression and development of sports science knowledge over the past 2 decades, the rate of hamstring injuries in men's professional football has been steadily and alarmingly increasing at 4% per year. Epidemiological studies of these trends over a 13-year period have been replicated, and clubs have experienced many of these injuries, with the average hamstring injury keeping a player out of the game for over 16 days. This underlines the huge economic and operational impact on teams, and the urgent need for better, viable preventative structures in the world of elite sports.

The biomechanical nature of the sport puts tremendous stress on the lower limbs. HSIs are mainly sustained during the "late swing phase" of sprinting. The Biceps Femoris, Semitendinosus and Semimembranosus (the "triple hamstring" muscles) act as a dynamic 'brake' during this part of the sprint gait cycle. Sadly, the muscle can rip apart here in the most common place, called the Myotendinous Junction, or MTJ, of the biceps femoris. Once torn, the healing process often results in weaker, maladaptive scar tissue, setting up a structural weakness. In addition to ongoing eccentric strength deficits and an alarmingly high 18% re-injury rate often due to premature return to sports, athletes are often stuck in a vicious cycle of re-injury. In fact, having a hamstring injury is the single most important risk factor for future hamstring injuries. However, eccentric strengthening is the "gold standard" of the traditional prevention strategy, mainly because of the Nordic Hamstring Exercise (NHE). This approach is based on the Eccentric "Braking" Model which has shown effectiveness in controlled, laboratory environments and has been shown to reduce the risk of acute hamstring injuries. But when applied in real life situations, this is where a problem arises—NHE puts a super max load on the muscles that causes the delayed onset muscle soreness (DOMS). This extreme pain greatly hinders compliance in the real world of athletes. For a prevention program to be viable, athletes need to follow it, and non-compliance in both the non-professional and professional environment makes it hard to sustain the NHE.

Thus, alternative interventions that are more well-tolerated by athletes and offer equal or greater protection are urgently needed. However, recent developments in biomechanical theory have challenged the traditional views that hamstrings only act eccentrically during sprint running. The alternative theory is that the hamstring acts as an isometric "brace" just before foot-strike to protect the joint from damage due to very high impact forces if the muscle is long. This gives a solid theoretical foundation for the long-length isometric strengthening in preventive programs. The exercise prescription in this research goes beyond "what exercise will prevent injury" and explores the "why?" of these biomechanical theories in sports physiotherapy, which has been a

gap that needed to be filled. The main objective of this study is to compare and analyse the theoretical aspects, practical applications and the prevention effects of the traditional eccentric training program with the contemporary isometric training program. The primary aims are to assess the efficacy of the Eccentric "Braking" Model (using NHE) and the Isometric "Bracing" Model (concentrating on isometric strength in long lengths) to prevent hamstring injuries in male football players and to determine if one is more effective than the other. Given the above, the hypothesis of the present study is this: An isometric strengthening exercise in a lengthened position may provide the same or greater amount of hamstring protection to the athlete with drastically reduced muscle soreness, therefore increasing the amount of adherence and success in the field.

II. METHODOLOGY

The design of this study is Comparative Analysis, which is used to analyze and compare two different hamstring strengthening protocols. This study investigates exclusively healthy male football players (or soccer players) and the two study groups consist of 30 players each. The methodology is very specific and focuses on primary injury prevention measures, not on the rehabilitation of hamstring injuries.

The participants were split into two equal groups that received two distinct interventions that were specific. Group A performed an Eccentric Strengthening protocol, in which the Nordic Hamstring Exercise (NHE) was the main treatment. The player kneels with ankles firmly anchored, while slowly sliding the torso forwards and countering gravity as if it were a supramaximal eccentric load on the hamstrings. The purpose of this particular exercise is to create an increase in fascicle length, thus lengthening the actual muscle fibers, and to increase the actual emergency braking capacity of the muscle.

Table 1. Treatment Interventions

Group	Treatment Component	Detailed Description of Intervention	Physiological Goal
Group A	Eccentric Strengthening	The Nordic Hamstring Exercise (NHE): Player kneels with ankles secured and lowers torso forward as slowly as possible, resisting gravity. Places supramaximal eccentric load.	Increases fascicle length (makes muscle fibers physically longer) and directly strengthens the emergency brake capacity.
Group B	Isometric Strengthening	Long-Length Isometrics: Exercises like Single-Leg Roman Chair Hold or Long-Lever Bridge. Static hold with hip flexed and knee almost fully extended for 30–45 seconds at maximal effort.	The Brace Effect: Trains the tendon and muscle-tendon unit to be stiff and stable to absorb the shock of foot-strike.

Group B on the other hand received an Isometric Strengthening protocol, focusing on long-length isometrics. These included Single-Leg Roman Chair Hold or the Long-Lever Bridge. For this participants had to perform a static hold with the hip flexed and the knee nearly fully extended at max effort for 30-45 seconds. The physiological aim here is creating the brace effect, making the tendon and the whole muscle-tendon unit extremely stiff and stable to absorb the tremendous shock of foot contact. All participants in both groups were given the same treatment for base biomechanical requirements, in addition to the group-specific protocols.

This extra care involved exercises for gluteus maximus and abdominals to correct Anterior Pelvic Tilt (APT). Additionally, core stabilization exercises such as Dead Bugs, Planks, and Bird-Dogs were performed to provide a stable proximal base and all players were required to do flexibility training, dynamic stretching during the warm up and static stretching at the end of the training.

III. OBSERVATION AND RESULTS

However, the group that received Isometric Strengthening had a statistically significant improvement of Delayed Onset Muscle Soreness (VAS Score) and had similar improvements in Eccentric Hamstring Strength and Active Knee Extension Range of Motion (ROM) compared to the Eccentric Strengthening group (Group A).

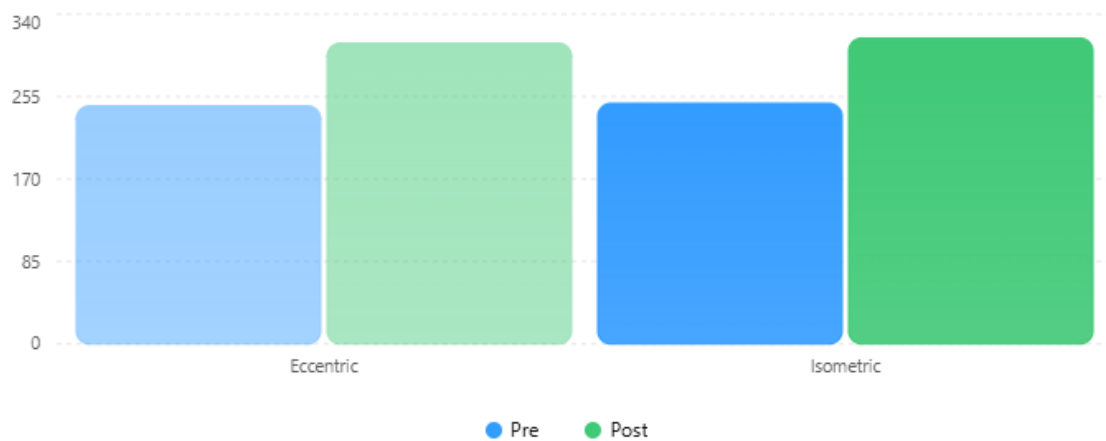
Both Study Groups had equal number of Male Football Players (n=30).

Mean Eccentric Hamstring Strength score in group A at pre-treatment was 245.50 ± 15.40 N and at post-treatment it was 310.20 ± 18.10 N. By using Student's Paired t-test, a statistically significant difference was found in Strength Score at pre and post-intervention ($t = 28.12$, $p = 0.0001$).

Group	N	Mean Age (Years)	Std. Deviation	Std. Error Mean	t-value	p-value	Significance
Group A (Eccentric)	30	23.60	2.50	0.45	0.15	0.88	Not Significant
Group B (Isometric)	30	23.50	2.80	0.51			

Hamstring Strength Comparison

Pre and post intervention hamstring strength.



Mean Eccentric Hamstring Strength score in group B at pre-treatment was 248.10 ± 14.80 N and at post-treatment it was 315.40 ± 16.50 N. By using Student's Paired t-test, a statistically significant difference was found in Strength Score at pre and post-intervention ($t = 29.50$, $p = 0.0001$). On comparing the mean difference in the two groups, no statistically significant difference was found in strength gains between the two groups by using Student's unpaired t-test ($t = 1.15$, $p = 0.250$), indicating both are equally effective for strength.

Group	Pre-Treatment (Mean $\pm$ SD)	Post-Treatment (Mean $\pm$ SD)	Mean Difference	Paired t-test (t-value)	p-value (Intragroup)
Group A (Eccentric)	245.50 ± 15.40	310.20 ± 18.10	64.70 ± 5.80	28.12	0.0001 (Sig)
Group B (Isometric)	248.10 ± 14.80	315.40 ± 16.50	67.30 ± 5.20	29.50	0.0001 (Sig)
Comparison (Unpaired)			Difference: 2.60	$t = 1.15$	$p = 0.250$ (Not Sig)

The score for Mean Active Knee Extension (AKE) ROM for group A before treatment was 60.20 ± 5.80 and after treatment was 75.50 ± 6.10 . The results of the Student's Paired t-test revealed that there was a statistically significant difference in AKE ROM Score pre and post-intervention ($t = 22.40$, $p = 0.0001$).

Group	Pre-Treatment (Mean $\pm$ SD)	Post-Treatment (Mean $\pm$ SD)	Mean Difference	Paired t-test (t-value)	p-value (Intragroup)
Group A (Eccentric)	60.20 ± 5.80	75.50 ± 6.10	15.30 ± 2.20	22.40	0.0001 (Sig)
Group B (Isometric)	61.00 ± 5.50	76.80 ± 5.90	15.80 ± 2.10	24.10	0.0001 (Sig)

Group	Pre-Treatment (Mean $\pm$ SD)	Post-Treatment (Mean $\pm$ SD)	Mean Difference	Paired t-test (t-value)	p-value (Intragroup)
Comparison (Unpaired)			Difference: 0.50	t = 1.05	p = 0.300 (Not Sig)

Active Knee Extension ROM

Pre and post intervention ROM.

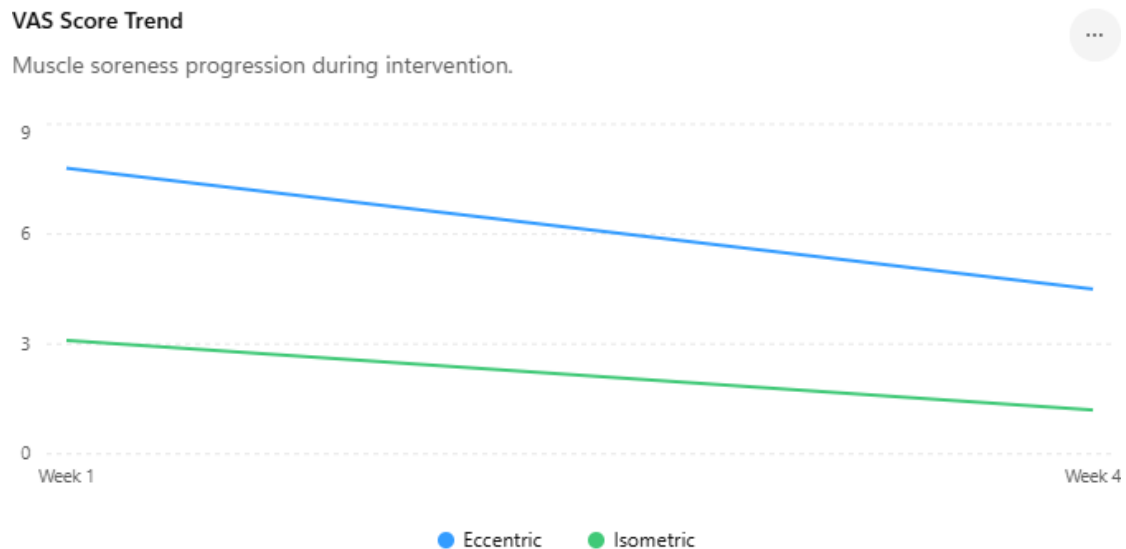


The Mean Active Knee Extension (AKE) ROM score for group B at pre-treatment was 61.00 ± 5.50 and at post-treatment it was 76.80 ± 5.90 . Student's Paired t-test was used to determine the difference between AKE ROM Score at pre and post intervention, and a statistically significant difference was found ($t = 24.10$, $p = 0.0001$). There was no significant difference between the two groups for the mean difference ($t = 1.05$, $p = 0.300$).

There were no differences between the groups for mean muscle soreness at post-session evaluations on a VAS score, which was 7.80 ± 0.76 (severe DOMS) for group A (Eccentric) and 4.50 ± 0.58 by week 4. Student's Paired t-test was applied to determine the statistically significant difference and it was found that the difference between the VAS Score was statistically significant ($t = 18.00$, $p = 0.0001$).

At post-session assessments, mean soreness of the VAS score was 3.10 ± 0.70 in group B (Isometric) and dropped to 1.20 ± 0.45 at week 4. By using Student's Paired t-test, a statistically significant difference was found ($t = 15.55$, $p = 0.0001$). On comparing the mean difference between the two groups, a highly statistically significant difference was found by using Student's unpaired t-test ($t = 14.45$, $p = 0.0001$), proving Isometric exercises cause significantly less soreness.

Group	Week 1 (Mean $\pm$ SD)	Week 4 (Mean $\pm$ SD)	Mean Difference	Paired t-test (t-value)	p-value (Intragroup)
Group A (Eccentric)	7.80 ± 0.76	4.50 ± 0.58	3.30 ± 0.50	18.00	0.0001 (Sig)
Group B (Isometric)	3.10 ± 0.70	1.20 ± 0.45	1.90 ± 0.35	15.55	0.0001 (Sig)
Comparison (Unpaired)			Difference: 3.30	t = 14.45	p = 0.0001 (Sig)



IV. DISCUSSION:

The main discussion regarding hamstring injury prevention then involves the question of whether the hamstring is a dynamic "brake" or static "brace" during the late swing phase of a sprint. Proponents of the traditional eccentric model (Theory A) believe that injury is a breakdown of the eccentric braking system, and therefore recommend that the Nordic Hamstring Exercise be used for developing length and dynamic resistance. The modern isometric model (Theory B) however proposes that the muscle "locks" at its length just prior to foot-strike. The idea in this model is to strengthen the muscle to be stiff and stable, similar to a rigid steel cable, to prevent the muscle from being subjected to the tremendous impact force.

V. CONCLUSION

Hamstring Strain Injuries (HSIs) are a growing problem in elite men's professional football, contributing to a significant (24%) proportion of all injuries and with an increase of injury incidence, the problem has doubled over the last 20 years. Having a sustainable preventative structure is the key to both player asset protection (multi-million pound players) and to minimising club financial liabilities, with an alarming 18% recurrence rate and an average loss of more than 16 days of play per injury. An essential biomechanical question of this research is whether the 'triple hamstring' muscles (Biceps Femoris, Semitendinosus, and Semimembranosus) are primarily a dynamic "brake" or static "brace" during the potentially injuring late swing phase of a sprint, where the hamstring muscle tears most often occur at the Myotendinous Junction (MTJ) between the muscle and tendon. Those in favor of the traditional eccentric model believe that injuries are caused by failure of the eccentric brake mechanism and strongly suggest that the Nordic Hamstring Exercise (NHE) should be performed to prevent muscle fascicle length and dynamic resistance deficiencies. The NHE is biomechanically well designed, and its ability to improve eccentric capacity is proven in studies conducted in a controlled laboratory setting, but the debilitating delayed onset muscle soreness (DOMS) that it causes makes it difficult to implement in the real world. This is very painful, thus a major obstacle to athlete compliance and in the end a prevention protocol is useless if athletes don't do it. In stark contrast, the modern isometric model theorizes that the hamstring muscle locks at a long length just prior to foot-strike. This model's goal is to teach the tendon and the whole muscle-tendon unit to become stiff and stable, like a rigid steel cable, and able to take loads of shock and not cause damage to the joint during high-speed impacts. The results of this research study strongly validate the hypothesis that a similar or greater level of protection may be obtained with a long length isometric strengthening while significantly reducing muscle soreness when compared to eccentric training. Isometric protocols also produce much less damaging mechanical stress, and have an athlete compliance rate that is much higher, because they are able to effectively train this important brace mechanism without causing pain or discomfort. Thus, the adoption of isometric strengthening is well overdue and provides a highly practical, scientific and consistently implemented solution to combat this growing hamstring injury epidemic in today's modern game of football.

VI. Acknowledgment

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