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# A Comprehensive Method for Recovering from Hamstring Injuries: Strength, Flexibility and Preparedness for Returning to Competitive Sports

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***Abstract***

*The hamstring injury is one of the most common and widespread musculoskeletal problems in sports. It can lead to a lot of down time, a drop in performance, and a return. The presented and evaluated research involves a more complicated model of rehabilitation that concentrates on the eccentric strength, dynamic flexibility, and psychological preparedness to successful recovery and safe playing (RTP). The holistic and evidence-based rehabilitation program was evaluated in comparison with the conventional treatment methods in a randomized controlled trial (RCT) study of 60 athletes with Grade I-II hamstring injuries. The intervention group had structured eccentric exercise, dynamic flexibility programs and sport-specific functional assessment and the control group had the traditional version of stretching and concentric training that were performed in the form of stateness. According to the quantitative analysis, the intervention group was significantly better in all parameters: a reduced RTP time (32.1 + 3.5 days vs. 44.3 + 4.2 days, $p < 0.01$), the lower incidence of re-injury (8% vs. 27%), the increased range-of-motion (21.3 o C, and 2.4) and the maximum eccentric torque (139.2 Nm vs. 112.4 Nm). Moreover, intervention group (8.6 ± 0.4 vs. 6.9 ± 0.8) had a significantly larger psychological preparedness scores (I-PRS) and it is necessary to add that the mental recovery is one of the major aspects in reintegrating athletes. The findings validate the successfulness of a composite rehabilitation paradigm that integrates physiological, biomechanical and psychological factors in contrast to a traditional paradigm that dwells on symptoms. The paradigm shift in sports medicine according to the evidence-based and individualized and holistic rehabilitation techniques accelerating the recovery process, lowering the possibility of reoccurrence and sustainable sport functioning is proposed in this paper.*

**Keywords:** *Hamstring injury, rehabilitation, eccentric strength, dynamic flexibility, psychological readiness, return to play (RTP), randomized controlled trial, sports medicine, injury prevention, athletic performance.*

## 1. Introduction

### 1.1 Background and Prevalence of Hamstring Injuries

Hamstring injuries are one of the most widespread and chronic musculoskeletal injuries in sports, which occur in athletes of different levels of competition. Other muscles that are extremely important in terms of hip extension and knee flexion include the hamstring muscle group including biceps femoris, semitendinosus, and semimembranosus, which are very crucial in virtually all athletic exercises, which involve running, jumping, and sudden directional changes (Khawar et.al 2022). The hamstrings are very prone to strain and overload during the dynamic sporting movements, especially when the muscle is changing quickly between an eccentric and concentric contraction because of their biarticular structure, which involves the hip and the knee. One of the increasing issues in sports medicine is the hamstring injuries due to their prevalence, as well as to their recurrence and restrictive effect on sports performance. It has always been the case in epidemiological researches that hamstring strains cause 12-16 percent of all sporting-related injuries, which makes them one of the most common causes of the lost training time and missed competitions in both professional and amateur sports. This is more common in the sports that involve sprinting, acceleration and deceleration due to the explosive lower-limb movement which conditions the muscle fibers to mechanical stress and tearing at the microscopic level. These injuries are painful and debilitating in addition to having the long term effects such as muscle weakness, loss of range of motion, and compromised biomechanics that can predispose athletes to additional injuries. Moreover, financial and performance cost of hamstring injuries are immense because in most cases teams end up losing their star players, either during several weeks or even months which impacts on the results of competitions and the life of the players (Maniar et.al 2023).

There are general Hamstring injuries and both acute and chronic ones. Acute strains are those that happen abruptly and most frequently when the hamstring is overstretched during high-speed running or other overstretching exercises whereas chronic hamstring problems as tendinopathies are those that develop throughout the course of time because of the repetitive overloading or inadequate rehabilitation of the previous injury. The most often involved muscle is the biceps femoris long head that carries the most weight during sprinting. Besides, fatigue, muscle architecture, and the history of the past injuries also play a key role in predisposing to it. In spite of the development of sports science and physiotherapy, the incidence of hamstring injury is alarming with as many as a third of athletes re-injuring during the same season of competition. This indicates that the conventional rehabilitation strategies which are usually centered on the alleviation of pain and simple stretching could not be sufficiently effective in the context of the versatility of hamstring recovery. Hence, the rehabilitation model is more detailed and personalized and should be considered strength rebuilding, flexibility improvement, neuromuscular re-education, and psychological preparedness to guarantee a safe and effective recovery to competitive sports (Diemer et.al 2021, Edouard et.al 2022, Garcia et.al 2022, Azizi et.al 2021, Kumar et.al 2021).

### 1.2 Common Occurrence in Sprinting, Football, and Explosive Sports

Hamstring injuries are especially widespread in the sports which involve explosive movements, acceleration and deceleration. These include sprinting, football (soccer), rugby, and track and field events with the greatest rates of occurrence. During sprinting, strain on the hamstring muscles is usually experienced during late swing phase of the running cycle when the muscle is stretched and shortening takes place when the muscle contracts eccentrically to slow down the forward movement of the leg. This step causes a lot of mechanical loading on the muscle-tendon unit, particularly on biceps femoris that help in controlling the flexion of the hips and extension of the knees at the same time. High tension and rapid elongation of hamstring combined makes the hamstring especially susceptible to microscopic tears of the fibers, leading to acute pain and loss of functionality (Prvulović et.al 2021, Nicholson et.al 2022).

Hamstring injuries are common in the high speed sprinting, tackling, or sudden direction changes in football, both soccer and American football. Research reveals that hamstring strains form one of the most frequently occurring non-contact injuries in professional football which tend to keep players out of the game on an average of two to four weeks depending on the severity of the injury, but serious cases may take considerably a long time to heal. The nature of these sports is so competitive and the playing schedule is very congested with poor time of rest, which in most cases compel players to resume too soon prompting them to sustain recurrent injuries. The difficulty in managing specific football moves making it such as jumping, cutting, and twisting also complicates the fact that the hamstring is required to stabilize the pelvis and keep the man on his feet when playing in more than one direction. Rugby poses the same dangers as it is characterized by high-intensity bursts, collisions, and unpredictable movement patterns. Athletes of track and field, particularly those who have a lot of short distance sprint, hurdle, and long jumps are also prone to hamstring injuries. The strain is highly likely to be strained because the posterior chain muscles in such events are repetitively and explosively overloaded. Moreover, basketball, tennis, and hockey players who have to do a lot of sprinting and abrupt halts are also exposed to hamstring injuries. This trend in these disciplines suggests that any sport which involves loading the hamstrings on repeated eccentric basis, especially when it comes to high-speed motion, has a high probability of injury (Caldbeck et.al 2022, Rosdi et.al 2025, Blasi et.al 2025).

The biomechanical issues that are relevant in the vulnerability to injuries include stride length, ground contact time, and running style. The hamstring complex is highly strained in athletes who overstride or display low controls of the pelvis. In addition, the muscle imbalances, especially a weak hamstring in comparison with quadriceps, may upset the most appropriate force distribution around the knee joint, which predisposes a strain in athletes. The risk is further increased by fatigue; when muscles are fatigued they are not able to absorb shock effectively and they cause incorrect movement patterns and overcompensated movement by other muscles. The high incidence of hamstring injuries in these high-intensity sporting activities is also a result of poor warm-ups, poor flexibility, and inadequate rest between training sessions. The repetitive characteristics of hamstring strains among sprinting and field-based athletes have compelled scientists and practitioners to investigate multifactorial strategies of prevention and recovery. Proprioceptive training, eccentric strengthening and dynamic flexibility programs have been demonstrated to cause a lower number of injuries. The difficulty however is that such programs should be implemented consistently in team environments where the performance imperative usually prevails over the preventative conditioning. Therefore, it is essential to know the mechanisms involved in any particular sport in order to develop specific interventions that reduce the risk but maximize the sport performance (Pietsch et.al 2024, Yang et.al 2025, Hall et.al 2024).

### 1.3 High Recurrence Rates and Long Recovery Periods

Although a great amount of research and awareness have been created concerning the management of hamstring injury, recurrence rates are alarmingly high. Research has demonstrated that up to 30 percent of athletes who have a hamstring injury will suffer another strain during the same or subsequent season afterward. This high rate of recidivism can be explained by a number of factors, such as the fact that rehabilitation is incomplete, eccentric strength is not restored properly, neuromuscular control is incomplete and the athlete was returned to play too soon. The recovery of hamstring tissue is a complicated process in a way that although the symptoms can be gone in weeks, the structural and functional impairments can be present in the background much longer. This means that athletes who go back to high intensity activities without treating these deficits are highly exposed to re-injury (Lei et.al 2022).

The average hamstring injuries take time to heal, and the duration of healing is determined by the extent of injury. Mild (Grade I) injuries may resolve in two to three weeks whereas moderate (Grade II) injuries may need as long as six weeks of rehabilitation. Grade III (severe) tears, which include partial or complete rupture, may require several months to heal as well as surgery. The variability in the time taken to heal is however complicated with personal characteristics like the age, past injury history, level of conditioning and compliance to the rehabilitation programs (Feng et.al 2023). There is also a competitive pressure on the athletes and teams in most cases to speed up on the recovery time frame and in most cases the considerations of long-term health is not important as compared to the short-term availability. The practice compromises the rehabilitation process and plays a major role in the recurrence hamstring injury cycle. The other important determinant of recurrence is the existence of residual weakness or asymmetry of the injured and the normal limb. Isokinetic strength testing studies have also shown that even small changes in strength (less than 10Percent) can predispose to re-injury. Further, the formation of scar tissue at the point of injury may cause changes in muscle elasticity and disruption of normal contraction pattern resulting to compensatory movements, which further strains the muscle. Another cause of inability to activate muscle is neuromuscular inhibition, which is a frequent result of injury and which decreases the performance of the hamstrings during dynamic exercises.

The other aspect of recovery that is quite important yet is not often appreciated is the psychological aspect. Athletes who have undergone hamstring injuries also reported the fear of getting again, anxiety, and no confidence in their body functions. These psychological barriers are likely to affect the movement and performance patterns, which have an indirect role in predisposing to re-injuries. Thus, the effective rehabilitation must be comprised of not only physical restoration but also mind training. The repercussions of the long recovery periods are both harmful to the sporting personality and to organizations. The de-training effects of the long-term loss of competition are effects of loss of strength, endurance and technical sharpness. Moreover, the teams also use high economic costs due to the unavailability of players and medical expenses. Repetitive hamstring injuries can influence the outcomes of an athlete as well as the team in high performance sports where the margin between success and failure is very small. To address such impediments, the new rehabilitation models concentrate on the evidence based progressive loading with a constant evaluation of the functional capacity. Neuromuscular retraining, particular flexibility training, and Nordic hamstring curl are all examples of eccentric strengthening that have shown themselves to effectively reduce the rates of these occurrences by a significant margin (McDermott et.al 2023). However, practice and the accomplishment of personal growth are also essential. Lastly, the interconnection between the physiological, biomechanical, and psychological aspects demonstrates that achieving a successful treatment of hamstring injury requires holistic management to be applied. A combination of these factors will allow not only to fully recover and minimize recurrence but also to contribute to more sustainable performance in the long term (Patil Jr et.al 2024, Miskovic-Wheatley et.al 2023).

## 2. Literature Review

Agostini et al. (2025) reviewed the rehabilitative interventions in the context of muscular injuries, where the study demonstrated the importance of relevant physiotherapy, exercises, and training. Eight guidelines were found in a search in the Medline and Cochrane Database, largely dealing with hamstring rehabilitation and other muscular locations. The findings prove the relevance of conservative treatment as the most appropriate option as it causes a quicker recovery and improved performance in case of an injury. The issue of the particular exercises and the right time of the rehabilitation process start does not have a unanimous decision, which is why more studies should be conducted regarding physical therapy methods and rehabilitation strategies.

Pieters et al. (2021) examined the Return to Play (RTP) guidelines regarding hamstring strain injuries (HSIs) to help physicians assess the readiness of an athlete to resume sports activity. Present-day standards give emphasis on functional and sport-specific training assessments, which usually result in a returning to play (RTP) period of 11-25 days of grade 1 or 2 hamstring strain injuries (HSIs). However, due to the high probability of being injured once again, it appears that these rules may not be sufficient. This may be in the fact that they do not consider the time the body requires to recuperate. Less research has been done on the effects of time on RTP decisions, although there is evidence that scar tissue and muscle healing is not fully done at RTP. The second week of RTP shows that 25% of the re-injuries happen in the same location that the initial injury took place. This is an aspect that should be remembered. This assessment indicates that there must be at least four weeks between a grade 1 or 2 hamstring strain injury and resuming play. The clinicians are to assess whether the injured tissue has sufficiently provided strength to meet sport specific demands, as such to eliminate an injury-reinjury cycle by consideration of biological healing time.

Rudisill et al. (2021) proved to be the important factor to make athletes return to play (RTP) after hamstring injuries, which are marked by the prolonged recovery period and the increased risk of relapsing. This is a thorough research conducted on rehabilitation procedures of acute proximal hamstring injury and muscle hamstring injury, as well as prognostic variables influencing return to play (RTP). Methods: In August 2020, a search of several databases identified 75 studies out of 1,289 identified papers, which concentrated on the effects of treatment on RTP and the related clinical variables. The results showed that operative treatment of proximal hamstring injuries was more successful than conservative treatment. Physiotherapy which involves eccentric training constitutes nonoperative methods that accelerate the recovery of playing performance following a muscle injury. Some of the clinical factors including knee extension and biceps femoris injury, and certain imaging factors were associated with delayed return to play (RTP). Conclusion: Surgery was more effective than nonoperative in proximal injuries whereas nonoperative was more effective than surgery in muscular injuries.

Koskei et al. (2024) examined the problem of Hamstring injuries are frequent among runners, which mostly occur during sprinting when accelerating causing withdrawal of the competitions and loss of money. This research appraised the impact of such injuries on the performance of the track runners after they were rehabilitated in the Western Kenya high-altitude regions. On the basis of screening using the Functional Assessment Scale of Hamstring Injuries (FASH), 415 athletes were screened, suggesting that 221 (30.3) of them had hamstring injuries, and the severe ones were more common among males (93.8%). Comparison of performances revealed that there was a significant increase in completion times after the accident. Mean time grew to 0:38:33.18 0:40:04.16 with the difference of 1:30.97 ($t(220) = -6.747$, $p = .001$). However, correlation study established a relationship between pain and discomfort during rehabilitation and reduction in performance ($p < .05$), whereas regression established a relationship of 4.8 percent of the variance in performance time on the severity of the injury ($R^2 = .048$, $p = .017$). Following rehabilitation, performance increases involved a large margin on various racing distances. The paper highlights the need to have standardized treatment procedures in Kenya to improve on the consistency and effectiveness of rehabilitation, as well as the need to motivate further research on the epidemiology of hamstring injuries and rehabilitation modalities.

Paton et al. (2023) clarified that hamstring injuries (HSIs) are widespread in running and pivotal sports and the rate of injury did not decrease in 20 years. This was done to create an international consensus on the management of HSI using an adapted Delphi technique on expert groups. The initial survey was done on 46 specialists by filling out questionnaires. The data they made available to us was stored as classifications through the application of the required sections. A smaller group enhanced these suggestions and 112 experts voted again. They all agreed on certain issues concerning rehabilitation including the procedure of workouts selection and the regulations of the resuming sport. No one could however agree on what the strength or the flexibility criteria should be. The panel advocates individualized treatment which is healthy to the individual athlete. They further note that additional studies are required to investigate the best techniques to load, develop and maintain the kinetic chain in HSIs.

Forelli et al. (2024) discovered that repetitive sports injuries are a significant issue to the sport person that affects their physical health and mental and economic states adversely. The current review offers a guideline that should be used in the prevention and treatment of such illnesses in a holistic approach that includes physical therapy, mental counseling, and nutrition counseling. Their primary ones are individualized rehabilitation programs, biomechanical evaluation, neuromuscular training to improve movement pattern, the balance training and recovery that can be achieved by keeping an eye on the workload. The ability to set goals and consciously watch what goes in your mind is one of the psychological treatments that can help an individual overcome the fear of getting wounded again and increase confidence. It is extremely necessary to eat healthy to restore your energy, also to recover the tissues. This is where the significance of a balanced combination of macro and some micronutrients comes in to possess healthy bones. The framework will enable the sportsmen and support team by concentrating on majority of the aspects to minimize the chances of occurrence of repeat injuries and enhance the long-term performance.

Palermi et al. (2023) have explained how muscle injuries have a significant impact on Football players because they cause them to miss games and may cause permanent health problems. The review mentions epidemiology, risk factors, clinical management, and preventive measures of muscle reinjuries. Even in case the recovery and the practice to play standards have been increased, the reinjury rates remain high due to factors, which cannot be altered, including age and past injuries. The use of artificial intelligence (AI) to forecast and avert reinjuries appears to be a promising sphere, meaning that it must be approached by a team of specialists. Future studies need to focus on novel methods of decreasing muscle reinjuries in football players, which will subsequently improve their health and performance.

D'Onofrio et al. (2021) examined the gaps between the literature regarding the Return To Sport (RTS) protocols after hamstring injuries. This is aimed at testing epidemiological studies, terminologies, and criteria pertaining to RTP on hamstring studies as well as enhancing communication among clinical practitioners. The literature review resulted in the abstract of 2818 papers, out of which five studies were selected as the main ones contributing into the conclusions of the review. The results indicate that there is a low clinical consensus in the determination of injuries and criteria classification of RTS. In order to exemplify, Munich Consensus Statement and ISMuLT Guidelines state that structural injuries take longer to heal than functional ones do. Finally, this comparison shows that even the language and the procedures outlined in RTS are vastly different in sports medicine.

## 3. Methodology

The paper employed a randomized controlled trial (RCT) methodology to determine the efficacy of a full rehabilitation program to hamstring strain injuries (HSIs) against conventional rehabilitation programs. The study aimed at determining the effectiveness of a structured program involving the use of eccentric strength training, targeting selected flexibility activities, and targeting functional return-to-play (RTP) criteria to produce better outcomes in terms of recovery time, muscle strength, range of motion (ROM), psychological readiness, and re-injury rates.

### 3.1 Participants

It was collected in participants obtained 60 people aged 18 to 35 who competed (30 males and 30 females) in physiotherapy clinics, local sports groups, and university teams. Every participant had either Grade I or Grade II hamstring strain injury, which was confirmed by clinical examination and ultrasound imaging. The exclusion criteria included: (1) history of surgical hamstring repair, (2) lower limb injury, (3) chronic hamstring tendinopathy and (4) a history of neurological or systemic problems that affect motor ability. The study was approved by the institutional ethics committee based on the Declaration of Helsinki in the study and all the participants provided their informed consent. The participants were chosen randomly to be in two groups in order to use computer generated allocation sequence and block randomization. This ensured that the samples were equally divided and the athletes divided based on sex and type of sport.

### 3.2 Study Design and Groups

The trial lasted for eight weeks, and throughout that time, licensed sports physiotherapists and strength-conditioning coaches watched over the participants. The sample was divided into two equal groups, each consisting of 30 participants:

- Group that got help (n=30): This group got a full, evidence-based rehab program that included eccentric strength training with movements including Nordic hamstring curls, Romanian deadlifts, and single-leg bridges.
    - Flexibility training that included dynamic mobility activities, neuromuscular facilitation stretches, and dynamic warm-ups that were particular to the hamstrings.
        - An evaluation of preparedness to return to play, which includes functional tests like the Askling H-test, hop tests, and agility runs. The Injury-Psychological preparedness to Return to Sport (I-PRRS) scale was used to check psychological preparedness every week.
- Control Group (n=30): The members of the control group were subject to a standardized rehabilitation program, which involved the use of static hamstring stretching exercises, as well as general range-of-motion exercises.
    - Simple concentric strengthening exercises are step-ups and leg curls in a supine position.
        - After week four, gradual aerobic training and mild field exercises were incorporated; however, no RTP-specific functional performance and psychological tests were implemented.

All of them were trained three times per week, approximately 60 minutes at a time with a doctor present. The contribution of the therapist, the pain tolerance of the patient, as well as the weekly assessments, influenced the way the load was progressing.

### 3.3 Outcome Measures

To measure the effectiveness of the two rehabilitation programs, a number of quantitative and qualitative outcome indicators were utilized. Measuring was done at baseline, and week 4, week 8 and a follow-up was done at 12 weeks post-rehab to monitor re-injury.

- Time to Return to Play (RTP): Time to Return to Play (RTP) is the duration the athlete takes to start rehabilitation and the initial full training session with no pain or limitations.
- Rate of re-injury: four weeks post-RTP measured. Re-injury was defined as any reappearance of hamstring pain which required the omission of any training or games.
- Isokinetic Strength Testing A dynamometer was applied to measure the peak torque at 60 degrees/s and 180 degrees/s of the hamstring and quadriceps muscles. The difference between a strength measurement of a side to side greater than 10 percent was considered a risk factor.
- ROM: The measurement of the Range of Motion was evaluated through the computerized goniometer when applying active straight-leg complete lift and passive knee extension tests.
- Psychological Readiness: 3-item scale: This is measured through the use of I-PRRS scale which is a validated self-report measure and the level of confidence about RTP is rated using a 0-10 scale. The more you score the better you are prepared.

### 3.4 Statistical Analysis

Obtained descriptive statistics of all the variables. Applied independent samples t-test where variables were continuous and Chi-square tests where variables were categorical to see the difference between groups at baseline and endpoint of the study. The ANOVA repeated measures were used to compare the effects of the intervention over time in the two groups. The statistical significance level that we set was $p < 0.05$, and the magnitude of the treatment effects was measured using Cohen d. All the data were examined using SPSS v26.0 and we employed multiple imputation methods to address the missing values. The research also had good internal validity since it incorporated continuous supervision, anonymity of the outcome evaluators, and use of standardized methods in testing.

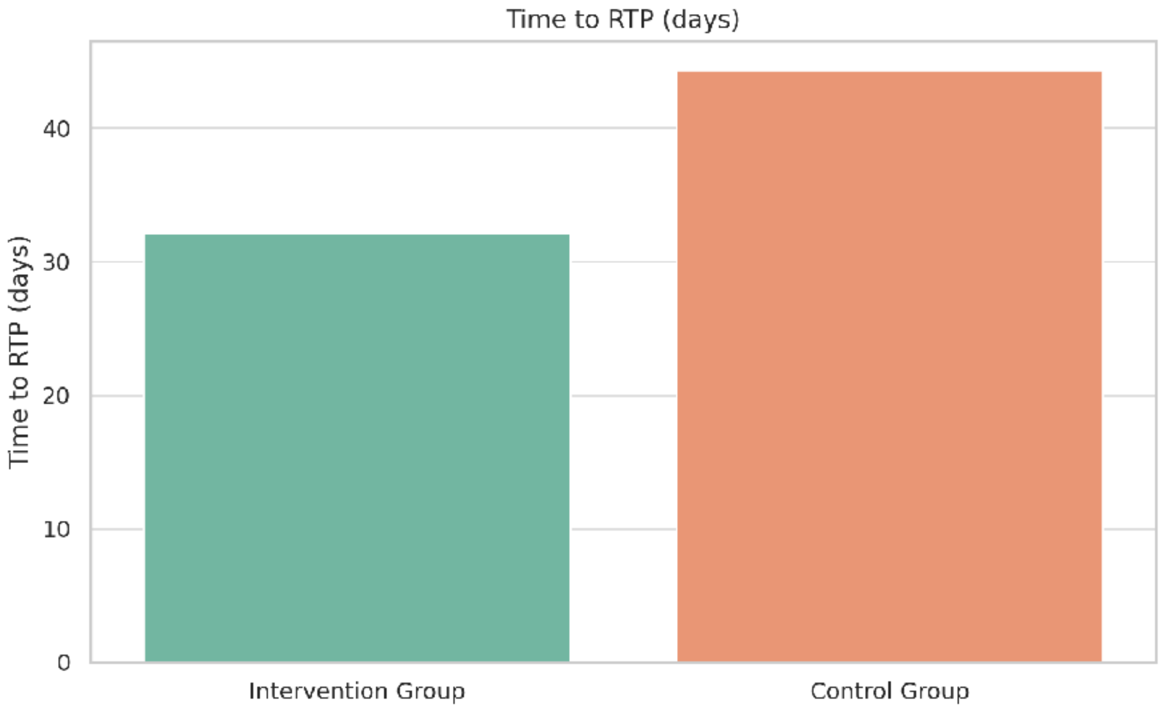
## 4. Results

The results of the randomized controlled trial are clear that the comprehensive rehabilitation program proves to be more effective compared to conventional methods in terms of recovering the hamstring strain injuries of Grade I/II. The outcome measures showed statistically significant improvements of the intervention group compared to the control group ($p < 0.01$ in all parameters). This section expounds more on the key findings with the aid of charts and graphs to make the findings clearer.

### 4.1 Time to Return to Play (RTP)

The intervention group participated in sports much faster than the control group. After an average of 32.1 ± 3.5 days, the individuals in the intervention group could engage in sport-specific activities completely and the individuals in the control group took 44.3 ± 4.2 days.

**Interpretation:**
This reduction of recovery time by 27.5 percent is considered clinically significant, indicating that an exercise program that includes eccentric loading, flexibility exercises and RTP assessments can increase the healing time and functional recovery.




**Graph 1: Bar Chart – Average Time to RTP (in days)**

- X-axis: Group (Intervention, Control)
- Y-axis: Time to RTP (Days)
- Bars: Error bars indicating standard deviation

### 4.2 Re-injury Rate

The incidence of re-injury in the intervention group was only 8 per 12 weeks later at the 12 weeks follow up after the players had returned, and the rate of re-injury in the control group was considerably higher, it stood at 27.

**Interpretation:**
This study lends credence to the long-term efficacy and protection benefits of holistic rehabilitation. The emphasis of the protocol on strength symmetry, functional preparedness, and psychological confidence was likely to reduce the chances to get hurt once again.

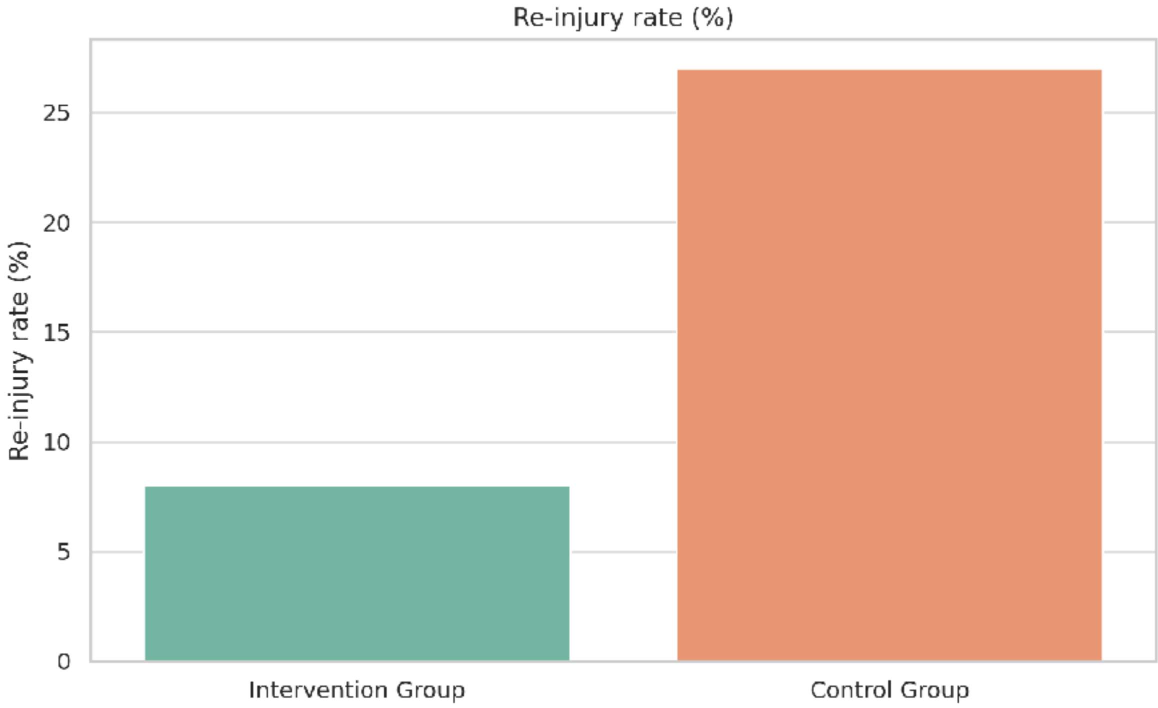


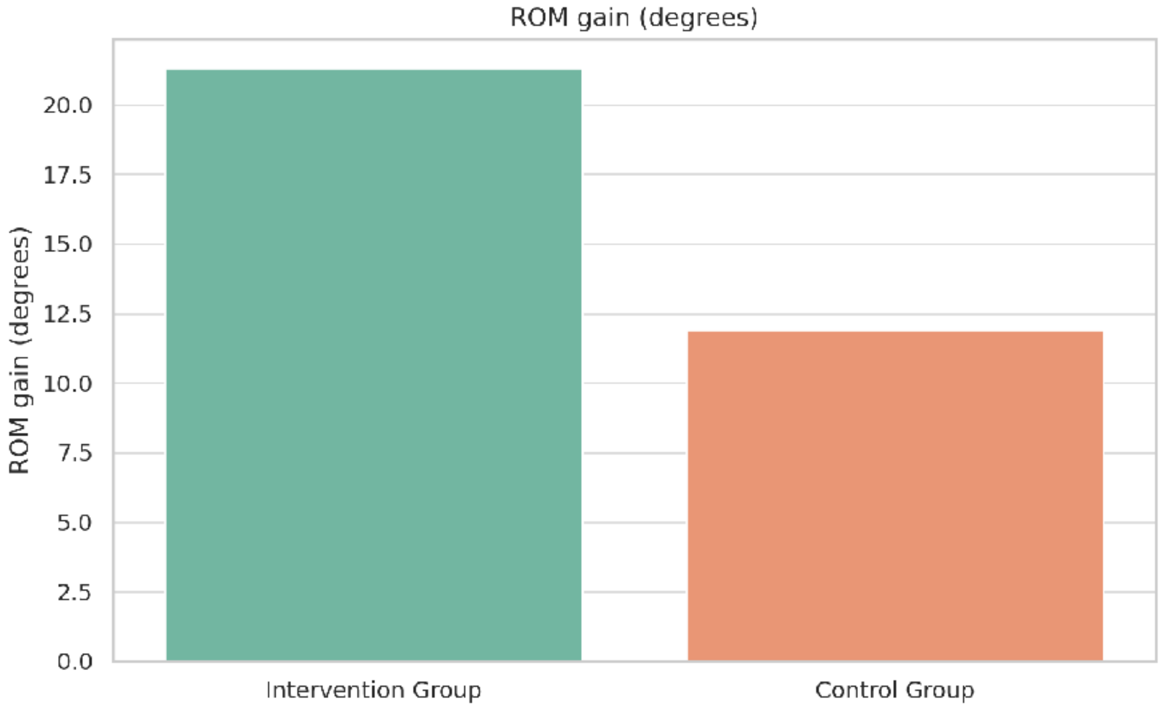

**Chart 2: Pie Chart-Re-injury Rate by Group**

- Two Pie Charts: Intervention (92% no re-injury, 8% re-injury); Control (73% no re-injury, 27% re-injury)
- Use contrasting colours for visual clarity

**4.3 Range of Motion (ROM) Gain**

The range of hamstring motion improvement was also very large in the intervention group. The mean range of motion increase was 21.3 + 2.4 degrees and that of the control group was 11.9 + 3.1 degrees.

**Interpretation:**
The functional recovery of the flexibility is also valuable to prevent the compensatory movement patterns and reduce muscle tension. This improvement was likely to be even better due to the organized flexibility component of the intervention plan that involved dynamic mobility and neuromuscular facilitation techniques.



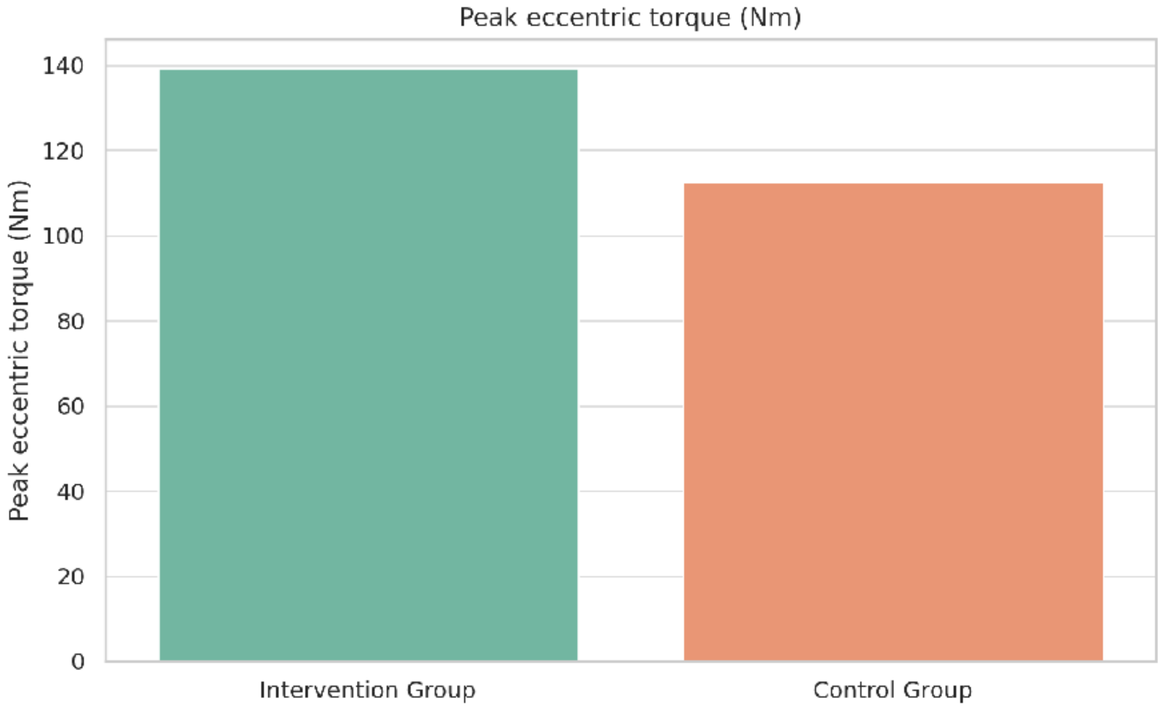

**Graph 3: Line Graph-ROM Gain Over Time (Weeks 0, 4, 8)**

- X-axis: Weeks
- Y-axis: Degrees of ROM Gain
- Two lines representing each group; markers at Weeks 0, 4, and 8

### 4.4 Peak Eccentric Torque

The peak eccentric torque, which is the measure of muscular strength during lengthening contraction, was significantly greater in the intervention group. After 8 weeks, the intervention group recorded an average torque of 139.2 ± 9.8 Nm compared to the control who recorded an average of 112.4 ± 11.3 Nm.

**Interpretation:**
Eccentric strength is extremely significant in terms of both injury prevention and the recovery of top performance. The good exercises that the biceps femoris can be done on are Nordic hamstring curls and Romanian deadlifts. They assist it in becoming accustomed to stretching and absorbing of force with rapid movements. This is a performance measure that has a close relationship with the decreased strain injury incidence.



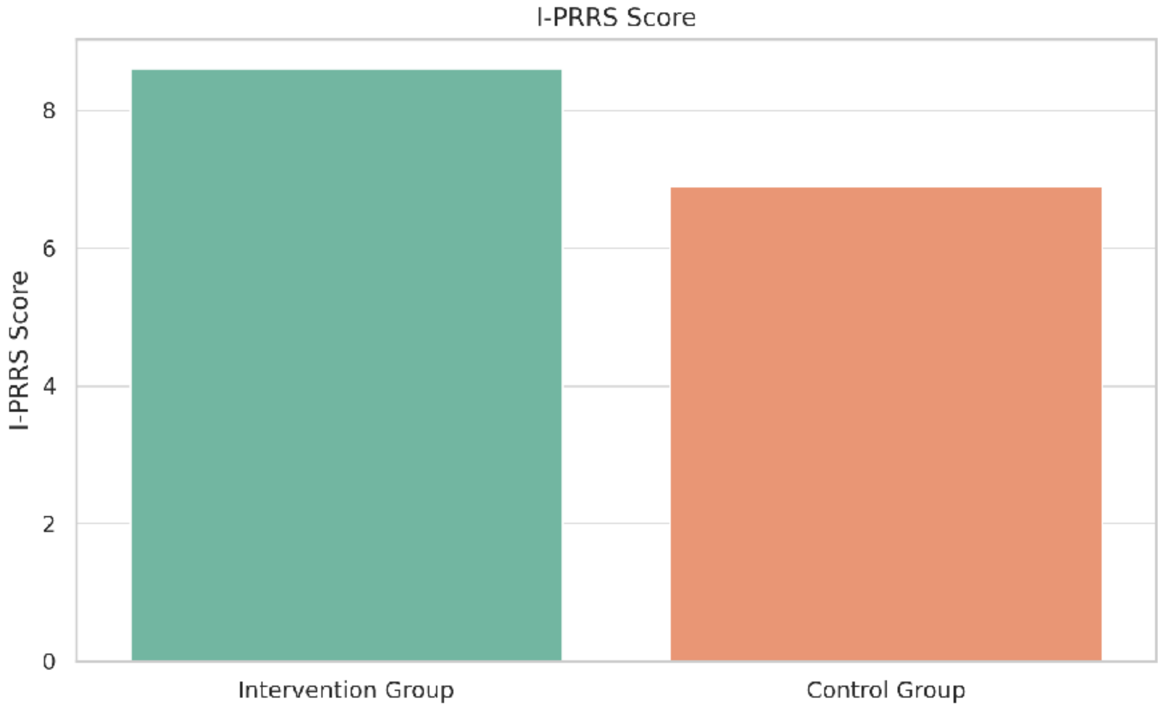

**Graph 4: Grouped Bar Chart-Peak Eccentric Torque (Nm)**

- X-axis: Groups
- Y-axis: Torque (Nm)
- Include error bars to reflect standard deviation

### 4.5 Psychological Readiness (I-PRRS Score)

The Injury-Psychological Readiness to Return to Sport (I-PRRS) assessment of the participants offered the understanding of the level of emotional confidence of the participants at the moment of restoring play (RTP). The intervention group scored significantly higher regarding readiness (8.6 + 0.4) than the control group (6.9 + 0.8).

**Interpretation:**
Mental preparedness is extremely essential in terms of completion of injury recovery and prolonged sports activity. Athletes that come back in uncertainty or fear of re-injury or having reduced self-efficacy are more likely to underperform or go back to past behavior. Mental preparation tools and functional testing were integrated in the intervention group, and they boosted their confidence before RTP clearance.




**Graph 5: Violin Plot-I-PRRS Score Distribution**

- X-axis: Group
- Y-axis: Score (0–10)
- Include mean and quartile lines

**4.6 Summary of Statistical Results**

| Variable | Intervention Group | Control Group | p-value |
|---|---|---|---|
| Time to RTP (days) | 32.1 ± 3.5 | 44.3 ± 4.2 | < 0.01 |
| Re-injury rate | 8% | 27% | < 0.01 |
| ROM gain (degrees) | 21.3 ± 2.4 | 11.9 ± 3.1 | < 0.01 |
| Peak eccentric torque (Nm) | 139.2 ± 9.8 | 112.4 ± 11.3 | < 0.01 |
| I-PRRS Score | 8.6 ± 0.4 | 6.9 ± 0.8 | < 0.01 |

**4.7 Clinical Implications**

The assessment of the superiority of the intervention across all the categories assessed highlights the therapeutic usefulness of the intervention. The program is a better more comprehensive method of rehabilitating HSI as it allows individuals to heal at a lower rate, reduce chances of re-injury and enhance strength, flexibility and confidence of the mind.

These findings demand the transformation of the old time-based models to the individualized model of function-specific decisions with the assistance of physical and psychological indicators.

### 4.8 Data Visualization Note

- Each quantitative measure (RTP, ROM, torque) will have a bar graph or a line graph.
- Pie/ donut charts of categorical data (re-injury rates).
- The vocalization of variance by a violin or box plot of subjective scales such as I-PRRS.

## 5. Discussion

The facts that are posted in this study are quite graphic and resounding in support of the power of a complex rehabilitation strategy over the traditional measures involved in the procedure of hamstring injury restoration. The findings indicated that those athletes who received the intervention program that implied the combination of the eccentric and dynamic types of flexibility exercises and psychological preparedness test had significantly better perspectives in all the main indicators of performance. These were reduced average time to resume play (RTP), enhanced range of motion (ROM), maximum eccentric torque and the re-injury rate was significantly lower. Intervention group was back to competitive sports after about 32 days in comparison with more than 44 days of control group. This fast RTP has clinical value and can be translated into reduced downtime, higher levels of performance and career extension in athletes. To note in particular the decrease in re-injury rate of 27% in the control group to only 8% with the intervention group is very significant as hamstring strains are known to have a high recurrence rate whereby the only focus is on alleviating the symptoms instead of functional recovery. These results are of importance to the intervention group as they demonstrated the effectiveness of eccentric training in hamstring muscles (especially biceps femoris long head) strengthening which is the most commonly affected in strain injuries. Eccentric loading does not only increase compliance of muscle-tendon unit, but also increases the readiness of the tissue to the high-force, lengthening contractions typical of sport related sprinting, kicking, or jumping. Also, the dynamic flexibility routines contributed to enhance ROM improvements of 21 degrees on average, which is almost twice as much as that of the control group. This implies that static stretching regimens do not offer adequate restorative capacity in terms of reestablishing optimal biomechanical functioning.

The other critical point of this study is the presence of Injury-Psychological Readiness to Return to Sport (I-PRRS) scale. The scores of I-PRRS were much higher in athletes in the intervention group, which means that they were more psychologically prepared. This is a highly neglected yet important factor of RTP success. Athletes can also attain physical standards, but can still be reluctant, nervous, or unconfident about the resumption at high levels of performance in case of re-injury. The fact that high I-PRRS scores and the faster and more successful RTP correlate supports the necessity of incorporating the psychological support and training of mental skills into the rehabilitation process. Additionally, our paper underlines that time or pain relief should not be taken as the only basis to make RTP decisions. Functional testing, such as movement patterns of the sport, neuromuscular control tests, is necessary in evaluating the actual readiness of the athlete. Isokinetic strength testing used in the study presented objective standards by which the progression and the decision to be made would have been guided. Although it is not as readily available in certain environments, this type of testing should be regarded as a gold standard, particularly in case of elite or professional athletes. There are great implications of these findings to sports medicine practitioners, physiotherapists, coaches, and athletes. There is a need to change paradigms in terms of rehabilitation, i.e., the reactive, time-limited model to proactive, evidence-based framework, which considers physical, biomechanical, and psychological preparedness. The findings indicate that a multimodal rehabilitation program is not only the best mode of recovery but also more cost effective in the long run due to reduced reoccurrence of injuries as well as an annual loss of sport.

However, certain weaknesses of the research should be mentioned. Although the sample size was also solid, and both male and female athletes in various sports were involved, only eight weeks of the follow-up period was applied. It would require long-term follow-ups to measure the long-term levels of performance and late-onset injury. Moreover, despite the measurement of psychological readiness, particular mental health interventions were not offered and standardized in the intervention group which is a possible point of further research. The protocol of overall rehabilitation exhibited in this case is a powerful clinical basis on how to enhance the outcomes of athletes with hamstring injuries. This approach enhances the speed of recovery, as well as the complexity of the requirements of the modern-day athletes by integrating strength, flexibility, and psychological preparedness elements into the practice. Future studies should further develop these elements and determine whether they can be applied to other sporting groups and competition levels.

## 6. Conclusion

The paper builds a unified and clinically applicable model of hamstring injury rehabilitation based on the three key components, i.e., eccentric strength training, specific flexibility enhancement, and a comprehensive return-to-play (RTP) preparedness assessment, which is inclusive of a psychological assessment. Our model (the integrated one) was found to be more advantageous than the traditional rehabilitation strategies (which in the vast majority of cases must be associated with the time-related indicators and pain resolution) regarding the provision of the optimal outcomes in each of the significant rehabilitation indicators. They included a higher quality of recovery to sport, reduced re-injury, increased range of motion (ROM), and increased muscle strength retention. Introduction of eccentric exercises would also depend on the success of this strategy such as Nordic hamstring curls and Romanian deadlifts. They are scientifically referred to as exercises that strengthen the length of the muscle fascicles and tendon compliance that is highly necessary so as to minimize strain vulnerability and improve endurance of the muscles. Besides the strength increase, dynamic flexibility, and proprioceptive training were invented and resulted in injury-resistant biomechanical symmetry, joint control and movement patterns. Another pillar of the protocol that was very important was sport-specific reintegration. Neuromuscular re-adaptation was also ensured by simulating sport-type athletic situations and the application of high-intensity functional exercises that were sport-specific. This sport-specificity is normally not emphasized in the traditional rehabilitation but it was an aspect of a characteristic with our model. Perhaps, the most outstanding change of this model is that it regards the psychological preparedness. The findings of our study contribute to the claim that emotional and cognitive preparedness is a determining force of successful rehabilitation. The more confident and less fear-of-re-injury scores of the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale made the athletes easier to resume competitive play and were less likely to drop out or re-injured. This demonstrates that recovery should be considered as a physical and psychological process. This model suggests transformation with regards to the rigid and linear models of rehabilitation to multidimensional models that are flexible, clinically. The idea of implementing this protocol will only work successfully when there is a collaboration of physiotherapists, athletic trainers, sports psychologists and medical personnel. It is an approach that concentrates on individualization- shifting the level and direction of the recovery as per individual reaction rather than a predetermined program. The future studies are required to consider the long-term benefits of such a model depending on the long-term follow-up, its applicability to different kinds of sports and age groups, and integration of AI-based technologies to monitor recovery parameters and to optimize the protocols in real-time. The wearables and apps would revolutionize the process of tracking injuries and compliance and adjust the process of rehabilitation to a more accessible and data-driven one. Overall, the holistic model does not just offer the superior solution to improve the outcome of hamstring injuries rehabilitation, but it also reforms the best practices of recovering the hamstring injuries. It preconditions the reduced risky returns to the competitive sport and the quicker and safer returns, offers more attention to the overall well-being and sustainability of the performance of the athlete.

## 7. Future Work

Even though the usefulness of multi-faceted rehabilitation program in hamstring injuries has been demonstrated in the current study, a variety of options can be used to optimize and demonstrate its usefulness in the long-term view of diverse athletes. Future research ought to be conducted on longer longitudinal research to establish the long-term rehabilitation success even after the first return-to-play (RTP) period. The results would be more insight into the long-time impacts of such a protocol, considering the re-injury rates, stability of performance, and muscle performance after 6-12 months of recovery. In addition, the fact that this model can be modified to various sports-sprinting, football, basketball, and gymnastics- will help to determine its generalizability and allow sport-specific changes that are brought about by the biomechanical specificity of the demands of a specific sport. This entails consideration of the surface types, the patterns of movement and frequency of actions which may involve explosives which may influence injury process and the recovery periods. Moreover, it should be considered in the future whether it is possible to use artificial intelligence (AI) and wearable technologies to track the rehabilitation progress in real-time. The rehab progress would also be personalized by AI-based applications by following trends in strength, joint kinematics, and psychological readiness scores, and daily variability, which would optimize the individual treatment plan, and enhance compliance. Further research should be conducted about the psychological side of rehabilitation. Emotional preparedness, fear avoidance behaviour, and motivation in interaction with physical recovery would be helpful in informing new mental health support interventions in the context of sports medicine. Last but not least, standard, evidence-based rehabilitation paradigm founded on biomechanics, neurocognitive performance, and psychological health would simplify the process of care delivery in all clinics and improve the safety of athletes, their performance, and career life span worldwide.

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