



## **Comparing the maximum strength of the static and eccentric pectoral muscles of the quadriceps as an indicator of injury in professional football players**

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### **Abstract**

The aim of this study was to predict the risk of hamstring (posterior quadriceps) muscle injury associated with weakness in eccentric muscle strength. The Prone ISO and Nordic tests were performed using the NordBord system from VALD to compare isometric and eccentric contractions of the same muscle group, namely the hamstring muscles, in professional soccer players competing in the Iraqi Stars League. The mean value of the Prone ISO test, which represents maximal isometric contraction, was 353.8 N, whereas the mean value of the Nordic test, which represents maximal eccentric contraction, was 288.6 N. This difference indicates a potential risk factor related to insufficient eccentric contraction capacity of the hamstring muscles. The findings demonstrated weakness in the eccentric contraction phase of the hamstring muscles. This weakness may be explained by several factors, including insufficient eccentric training of these muscles using specific exercises such as the Nordic exercise, Romanian deadlift (RDL), or other exercises designed to develop eccentric contraction capacity. If the players already perform these exercises, it is possible that they do not perform them with maximal effort against body-weight

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resistance, or that they require additional external loads to increase eccentric contraction capacity. The researcher recommends the use of modern testing methods, including those used in the present study, to identify optimal muscular performance and contraction capacity. Emphasis should also be placed on exercises that develop eccentric contraction of the hamstring muscles to protect them from potential injury during high-speed running and to improve their functional performance.

Keyword: Hamstring, Concentric contraction, Eccentric contraction, ISO Pron Test, Nordic Test



## Introduction

The study of injury risk factors has developed markedly in recent years owing to scientific and technological advances that have improved methods of testing, measurement, training, and monitoring. These advances aim to preserve player availability, reduce injury risk, and manage injuries as effectively as possible. The collection, analysis, and application of data have revolutionized the design of sports-performance programs over the past decade and have become fundamental to training-program development. Consequently, coaches no longer prescribe a single program or exercise that fits all players; instead, training is designed according to each player's strengths, weaknesses, and individual needs. This approach helps reduce injury risk, improve athletic performance, and achieve peak performance more effectively than before. Sports clubs and training centers differ in their use of advanced devices and tools for identifying injury risk according to their financial capacity and human resources. This variability may lead to a lack of effective tests, measures, and data for identifying the risk factors that affect individual players. Sports injuries in soccer are diverse.

Studies have indicated that muscle injuries are among the most common injuries in soccer. In a squad of 25 players, approximately 15 to 18 muscle injuries may be expected during a season; among these, approximately three occur in the quadriceps, five to six in the groin/adductor region, two to three in the calf muscles, and seven in the hamstring muscles. In addition, 96% of hamstring (posterior quadriceps) injuries occur without contact, meaning that they are indirect injuries (Ekstrand et al., 2011). Although other injuries have decreased substantially, hamstring injuries have increased in recent years and now account for 24% of all injuries in professional UEFA leagues (Ekstrand et al., 2022).

Multiple factors contribute to hamstring injury. Some are non-modifiable, including age, previous injury, and genetic factors, whereas modifiable external factors include physical capacities and the player's skill level. Muscle strength is one of the most important physical qualities that, together with other factors, helps protect players from indirect injuries and contributes to the development of technical and tactical performance (Timothy., 2016). Muscles produce and express force through different forms of muscle action: isometric, concentric, and eccentric. Force production is regulated by several principles, including the length-tension relationship and the force-velocity relationship. These relationships explain how muscles generate and express force, enabling coaches and specialists to select appropriate tests and exercises to develop muscle contractions optimally. The importance of the present study lies in identifying and comparing isometric and eccentric contraction capacities of the hamstring muscles to predict the possibility of injury during high-speed running. Most hamstring injuries occur during high-speed running, particularly at the end of the swing phase, when the hamstring muscles are contracting eccentrically.



## Function of the hamstring muscles during high-speed running and risk of injury

The relationship between sprinting and the hamstring muscles can be described as a love-hate relationship: sprinting may either damage the hamstrings or make them stronger. The high muscular force and mechanical stress generated by eccentric hamstring contraction during sprinting create a suitable environment for hamstring injury. However, proper development of eccentric contraction can substantially reduce injury risk and improve strength and performance. Eccentric training strengthens the hamstring muscles while they are actively lengthening, which is particularly important during high-speed running. During sprinting, the hamstrings act primarily as brakes; they contract eccentrically to decelerate forward leg swing. As running speed increases, the terminal swing phase becomes shorter, increasing angular velocity at both the hip and knee (Agre, 1985). This requires the hamstrings to generate greater torque.

Greater eccentric hamstring strength can improve sprinting performance by increasing both stride rate and stride length (Bourne et al., 2020). Conversely, as running speed increases, weak hamstrings may have difficulty generating sufficient torque at longer muscle lengths during eccentric contraction, which may increase injury risk.

### **Mechanism of hamstring injury during high-speed running**

Several mechanisms have been proposed for hamstring injury, including bending to collect the ball at high speed, landing from a jump with the knee hyperextended, kicking movements, high-speed technical movements, and high-speed running during acceleration, deceleration, and sudden changes of direction (cutting). All of these movements may contribute to injury in soccer (Al-Sulaiman, 2018, pp. 73-81). During running, in the second part of the swing phase (mid-swing), the hamstrings begin to contract eccentrically to absorb energy from the swinging limb before the foot contacts the ground. When these muscles contract eccentrically, a large change in muscle length is required (Askling et al., 2002; Brooks et al., 2006; Ekstrand & Gillquist, 1983; Verrall et al., 2005; Woods et al., 2004). This may cause muscle damage and tears according to the concept of mechanical strain (Bramah et al., 2024). Several analytical studies have also confirmed that injury occurs during the terminal swing phase, when the hamstring muscles are contracting eccentrically (Heiderscheit et al., 2009; Schache et al., 2012; Thelen, 2005).

### **Materials and methods**

#### **Participants**

Forty-seven soccer players occupying defensive, midfield, and attacking positions from 18 clubs in the Iraqi professional league participated in the study during the 2024-2026 seasons. The players were selected purposively according to the classification proposed by McKay et al. (2021). The participants were classified as Level 3 (highly trained/national level) and Level 4



(elite/international level). The sample selection criteria were as follows: (1) the player had a history of hamstring injury, including recurrent tears, strains, or discomfort during training or competition in the 2024-2026 seasons, confirmed by medical examination; (2) the player had completed the preparation periods for the 2024-2026 seasons and had not undergone any surgery involving the musculoskeletal system; and (3) the player was healthy and had not sustained an injury before data collection during the 2024-2026 season.

## Experimental procedure

The Prone ISO test (Figure 2) and the Nordic test (Figure 3) were performed to compare isometric and eccentric hamstring contractions according to the following procedures:

The same testing devices were used for all players.

All players were tested before the training session to reduce the effect of fatigue.

Testing was conducted after confirming that the player was at the lowest possible level of neuromuscular fatigue.

All players performed a warm-up before the tests.

After the warm-up, all players performed a familiarization trial on the device to simulate the actual testing method and ensure that they understood how to use the device correctly.

After completing the warm-up and familiarization, each player performed three repetitions of the Prone ISO test and three repetitions of the Nordic test.

To ensure full readiness and reduce the influence of fatigue and stress from the first test (Prone ISO), the Nordic test was performed after a 5-minute rest interval following the first test.

## Materials

The NordBord system from VALD Performance (Figure 1) was used. The device is widely used for the assessment, monitoring, and training of the hamstring muscles. It includes six test types: three isometric tests at multiple knee-joint angles (0 degrees, 30 degrees, and 60 degrees), two eccentric tests including the Nordic and Razor tests, and a custom test that can be used according to the design and needs of the player and coach.

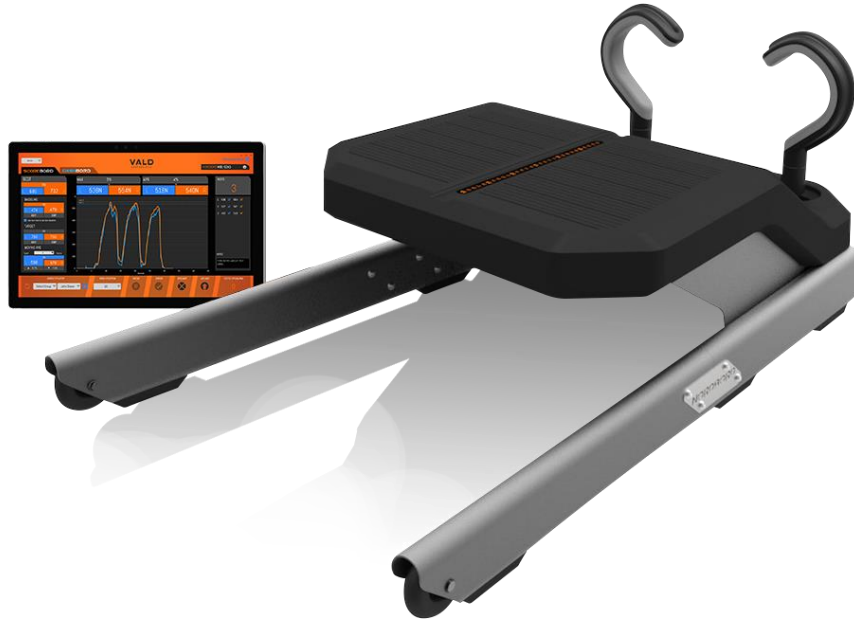


Figure 1. NordBord device

## Research tests

The following tests were used:

### Prone ISO test

**Purpose of the test:** to measure maximal isometric hamstring strength at a knee-joint angle of 0 degrees.

**Equipment and tools:** NordBord device, iPad, and a 30-cm-high box.

Testing procedure:

1. The player lies prone on the NordBord device in an extended position, as shown in **Figure 2**.
2. The player places both legs inside the hooks and pulls upward with maximal effort for three repetitions.
3. The rest interval between repetitions is 30 seconds.
4. Maximal force is calculated from the highest value recorded across the three repetitions



Figure 2. Prone ISO test

### Nordic test

**Purpose of the test:** to measure maximal eccentric hamstring strength.

**Equipment and tools:** NordBord device, iPad, and 5-cm-thick foam.

**Performance procedure:**

1. The player places both legs inside the hooks and positions both knees at an equal distance on the device platform.

The player places the hands on the chest at the beginning of knee extension and descent toward the floor.

The player attempts to resist the downward movement toward the floor as much as possible before extending the hands to receive the body on the floor.

The rest interval between repetitions is 1 minute.

Maximal force is calculated from the highest value recorded across the three repetitions.



**Figure 3. Nordic test**

## Results

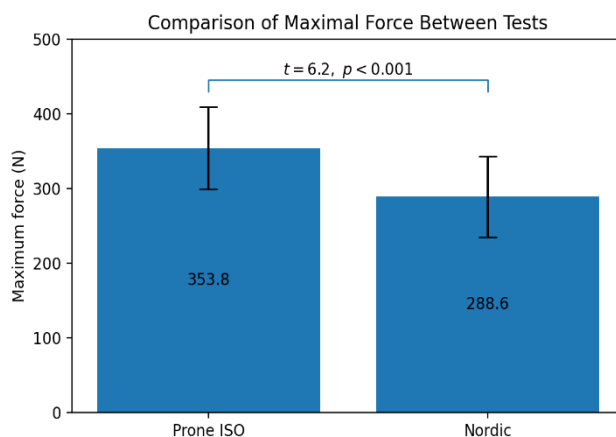
The maximal force values of the isometric and eccentric contractions were compared (Tables 1 and 2, Figure 4).

**Table 1. Descriptive statistical analysis for the Prone ISO and Nordic tests**

Variable	n	Mean (N)	SD	Min	Max
Prone ISO	47	353.8	54.9	214.5	455.25
Nordic	47	288.6	54.2	180.75	404

**Table 2. Difference test (independent t-test)**

Comparison	t-value	p-value	Result
Prone ISO vs Nordic	6.2	<0.001	Highly significant difference



**Figure 4. Results and statistical differences between the Prone ISO and Nordic tests**



## Discussion

Tables 1 and 2 and Figure 4 show differences between isometric and eccentric hamstring contractions. After testing, maximal eccentric force in the Nordic test was lower than maximal isometric force in the Prone ISO test (Table 1). This finding contradicts the principles of force production and previous studies indicating that force production is typically greater during eccentric contraction because of the contribution of non-contractile connective tissues (Chapman et al., 2014; Herbert & Hoang, 2007; Kolmerer & Labeit, 1995; McGinnis, 2013; Neumann, 2017; Nishikawa, 2012, 2021). The present results indicate that the study sample showed a pattern similar to that reported in prospective studies in groups identified as being at increased risk of hamstring injury (Opar et al., 2021; Timmins et al., 2015). Reduced maximal eccentric force compared with isometric force may indicate an imbalance in muscle contraction capacity that requires preventive intervention. However, confirmation of a causal relationship requires prospective follow-up studies. Preventive intervention should focus on developing eccentric strength in these muscles. Eccentric training is highly effective for preventing hamstring injuries. Randomized trials have shown that training using the Nordic exercise reduced hamstring injury risk by 70% (Goode et al., 2015). In addition, a meta-analysis including 8,459 athletes found that injury-prevention programs incorporating the Nordic exercise reduced hamstring injury risk by approximately half (van Dyk et al., 2019). Several possible mechanisms may explain how eccentric training reduces hamstring injury risk. Eccentric training shifts the force-length relationship to the right, allowing the hamstrings to generate greater torque and absorb greater negative eccentric energy at long muscle lengths (Brockett et al., 2001). This adaptation strongly supports the terminal swing phase during high-speed running. Eccentric training also increases fascicle length in the long head of the biceps femoris, making the muscle less susceptible to damage during high-force eccentric contractions (Andrews et al., 2025; Bourne et al., 2017). Furthermore, short-term training produces rapid improvements in eccentric hamstring strength. Although the evidence is mixed, higher levels of eccentric hamstring strength may reduce injury risk, particularly among older players and players with a previous injury history, which corresponds to the target group of the present study (Opar et al., 2021; Timmins et al., 2015). Strong eccentric hamstrings may also help balance stress distribution between active and passive force-generating structures, thereby reducing the risk of injury caused by excessive stretching during the final phase of leg swing in high-speed running.



## Conclusions

1. There were differences in maximal force values between isometric and eccentric muscle contractions.
2. Maximal eccentric force in the Nordic test was lower than maximal isometric force in the Prone ISO test.
3. Players may be exposed to injury risk because of weakness in eccentric contraction, which is related to one of the mechanisms of hamstring injury during the terminal swing phase of high-speed running.
4. It was not possible to determine the specific threshold targeting eccentric contraction accurately because of limited availability of advanced devices, such as the NordBord, that can identify such thresholds.
5. Insufficient eccentric training was used to improve eccentric contraction efficiency.
6. If body-weight eccentric exercises are used, players may already have reached maximal adaptation to body-weight loading; therefore, additional external loads may be required to push adaptation further.
7. Sports clubs lack the data needed to detect injury risk in players and to compare obtained values with normative values according to sport, playing position, and age category.

## Recommendations

1. It is necessary to identify the target threshold for the relevant tissue and for each type of muscle contraction (concentric, isometric, and eccentric). Training load should not be controlled only by repetitions, sets, or the apparent quality of exercise performance, such as the level of control displayed by the athlete. This approach would save time and accelerate tissue development toward improved muscle strength and tissue efficiency.
2. Modern devices should be provided to prescribe training doses according to the player's threshold level. The player may then be loaded approximately 2% to 10% above that threshold using the NordBord device and according to competition demands, to avoid overuse injuries related to excessive competitive intensity and training load during performance development.
3. Advanced technological devices should be used to detect injury risk by identifying differences in maximal force among the main types of muscle action: concentric, isometric, and eccentric. When maximal eccentric force is lower than maximal isometric force, this should be considered a risk factor according to muscle-contraction principles and the relevant scientific literature.



## References

- Agre, J. C. (1985). Hamstring injuries: Proposed aetiological factors, prevention, and treatment. *Sports Medicine*, 2(1), 21–33. <https://doi.org/10.2165/00007256-198502010-00003>
- Al-Sulaiman, M. S. (2018). Hamstring muscle injury (1st ed.). King Fahd National University Press.
- Andrews, M. H., Pai, A., Gurchiek, R. D., Pincheira, P. A., Chaudhari, A. S., Hodges, P. W., Lichtwark, G. A., & Delp, S. L. (2025). Multiscale hamstring muscle adaptations following 9 weeks of eccentric training. *Journal of Sport and Health Science*, 14, 100996. <https://doi.org/10.1016/j.jshs.2024.100996>
- Askling, C., Lund, H., Saartok, T., & Thorstensson, A. (2002). Self-reported hamstring injuries in student dancers. *Scandinavian Journal of Medicine & Science in Sports*, 12(4), 230–235.
- Bourne, M., Schuermans, J., Witvrouw, E., Aagaard, P., & Shield, A. (2020). Neuromuscular factors related to hamstring muscle function, performance and injury. In K. Thorborg, D. Opar, & A. Shield (Eds.), *Prevention and rehabilitation of hamstring injuries*. Springer. [https://doi.org/10.1007/978-3-030-31638-9\\_5](https://doi.org/10.1007/978-3-030-31638-9_5)
- Bourne, M. N., Duhig, S. J., Timmins, R. G., Williams, M. D., Opar, D. A., Al Najjar, A., Graham, K. K., & Shield, A. J. (2017). Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: Implications for injury prevention. *British Journal of Sports Medicine*, 51(5), 469–477. <https://doi.org/10.1136/bjsports-2016-096130>
- Bramah, C. (2024). Exploring the role of sprint biomechanics in hamstring strain injuries: A current opinion on existing concepts and evidence. *Sports Medicine*, 54, 783–793.
- Brockett, C. L., Morgan, D. L., & Proske, U. (2001). Human hamstring muscles adapt to eccentric exercise by changing optimum length. *Medicine & Science in Sports & Exercise*, 33(5), 783–790. <https://doi.org/10.1097/00005768-200105000-00017>
- Brooks, J. H., Fuller, C. W., Kemp, S. P., & Reddin, D. B. (2006). Incidence, risk, and prevention of hamstring muscle injuries in professional rugby union. *American Journal of Sports Medicine*, 34(8), 1297–1306.
- Chapman, N., et al. (2021). Poststretch isometric contractions of the hamstrings: Just a brief stretch to achieve supramaximal isometric force. *Journal of Applied Biomechanics*, 37(4), 320–326.
- Ekstrand, J., & Gillquist, J. (1983). Soccer injuries and their mechanisms: A prospective study. *Medicine & Science in Sports & Exercise*, 15, 267–270.
- Ekstrand, J., Hägglund, M., & Waldén, M. (2011). Epidemiology of muscle injuries in professional football (soccer). *American Journal of Sports Medicine*, 39(6), 1226–1232.



- Ekstrand, J., Häggglund, M., & Waldén, M. (2022). Hamstring injury rates have increased during recent seasons and now constitute 24% of all injuries in men's professional football: The UEFA Elite Club Injury Study from 2001/02 to 2021/22. *British Journal of Sports Medicine*. <https://doi.org/10.1136/bjsports-2021-105407>
- Hoang, P. D., Herbert, R. D., Todd, G., et al. (2007). Passive mechanical properties of human gastrocnemius muscle tendon units, muscle fascicles and tendons in vivo. *Journal of Experimental Biology*, 210, 4159–4168.
- Labeit, S., & Kolmerer, B. (1995). Titins: Giant proteins in charge of muscle ultrastructure and elasticity. *Science*, 270, 293–296.
- Lauersen, J. B., Bertelsen, D. M., & Andersen, L. B. (2013). The effectiveness of exercise interventions to prevent sports injuries: A systematic review and meta-analysis of randomized controlled trials. *British Journal of Sports Medicine*, 48, 871–877. <https://doi.org/10.1136/bjsports-2013-092538>
- McGinnis, P. M. (2013). *Biomechanics of sport and exercise* (3rd ed.). Human Kinetics.
- McKay, A. K. A., Stellingwerff, T., Smith, E. S., et al. (2022). Defining training and performance caliber: A participant classification framework. *International Journal of Sports Physiology and Performance*, 17(2), 317–331. <https://doi.org/10.1123/ijsp.2021-0451>
- Neumann, D. A. (2017). *Kinesiology of the musculoskeletal system: Foundations for rehabilitation* (3rd ed.). Elsevier.
- Nishikawa, K. C., et al. (2012). Is titin a “winding filament”? A new twist on muscle contraction. *Proceedings of the Royal Society B: Biological Sciences*, 279(1730), 981–990.
- Schache, A. G., Dorn, T. W., Blanch, P. D., Brown, N. A. T., & Pandy, M. G. (2012). Mechanics of the human hamstring muscles during sprinting. *Medicine & Science in Sports & Exercise*, 44(4), 647–658.
- Thelen, D. G., Chumanov, E. S., Hoerth, D. M., Best, T. M., Swanson, S. C., Li, L., Young, M., & Heiderscheit, B. C. (2005). Hamstring muscle kinematics during treadmill sprinting. *Medicine & Science in Sports & Exercise*, 37, 108–114.
- Timmins, R. G., Bourne, M. N., Shield, A. J., Williams, M. D., Lorenzen, C., & Opar, D. A. (2015). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): A prospective cohort study. *British Journal of Sports Medicine*.
- Timothy, J., et al. (2016). The importance of muscular strength in athletic performance. *Journal of Sports Medicine*.
- Verrall, G., Slavotinek, J., Barnes, P., et al. (2003). Diagnostic and prognostic value of clinical findings in athletes with posterior thigh injury. *American Journal of Sports Medicine*, 31, 969–973.



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Woods, C., Hawkins, R. D., Maltby, S., Hulse, M., Thomas, A., & Hodson, A. (2004). The Football Association Medical Research Programme: An audit of injuries in professional football—Analysis of hamstring injuries. *British Journal of Sports Medicine*, 38, 36–41.