# Changes in Hamstring Muscle Thickness and Pennation Angle Following Nordic Exercise in a Post-Surgical ACL Patient: A Case Study

Aaliyah Moore[1], Petey Mumford PhD[1]

[1] *Exercise and Performance Nutrition Laboratory, College of Science, Technology, and Health, Lindenwood University, St. Charles, MO*

## Abstract

**Background:** The hamstrings are a commonly injured muscle group that results from muscle imbalances, poor gait mechanics, and overall decreased coactivation. Many athletes present with stronger quadricep to hamstring muscle ratios, which can be a risk factor knee injuries, since the hamstrings act as a knee stabilizer. Increasing the hamstring to quadricep ratio can potentially decrease the risk of injuries. An effective hamstring exercise is Nordics. The effects of Nordic hamstring exercise on hamstrings are still being explored. Using ultrasound imaging, it is possible to observe changes in muscle thickness and pennation angle of the hamstrings in response to Nordic hamstring exercise.

**Purpose:** This study aims to utilize ultrasound imaging to investigate the effects of Nordic hamstring exercise on a post-surgical ACL rugby patient who had a hamstring tear in the contralateral leg of his ACL tear. The study will also examine any changes in the patient's ACL leg hamstring compared to the torn hamstring leg. The patient's Biodex test results will also be incorporated to determine if there is a correlation between muscle thickness and pennation angle changes.

**Methods:** The athlete began ACL rehabilitation in November 2022, followed by a Nordic hamstring exercise program (Nordics) in December 2022. Between December 2022 and January 20th 2023 the athlete performed 3 sets of 5 repetitions of Nordics on Monday Wednesday, and Friday. From January 23rd to Feb 17th, the athlete increased the sets to 5 for 5 repetitions. From Feb 20th to March 27th the athlete performed 5 sets of 5 repetitions of Nordics while holding 10kg weight. To maintain consistent results, the patient was instructed not to perform any eccentric hamstring exercises during team lifts. Ultrasound scans were taken 2 months, 4 months and will be taken again at 6 months post-surgery, following Biodex assessments.

**Results:** At 4 months post-surgery, the Biodex test revealed that the ACL hamstring was stronger than the contralateral hamstring that had been previously injured. Ultrasound images have also shown an increase in muscle thickness and potential pennation angle changes in the ACL hamstring. While 6-month scans are still pending, the patient has demonstrated an increase in hamstring strength. However, the quadriceps muscles still dominate the ham-to-quad ratio. As the athlete approaches the return-to-sport stage, they intend to continue performing Nordics due to their effectiveness in improving hamstring strength.

## Patient Demographic

Subject is 19-year-old collegiate rugby player who torn his right ACL and underwent surgical reconstruction in September 2022. Subject also tore his left biceps femoris muscle in April of 2022. Patient underwent conservative treatment for his hamstring tear.

## Nordic Hamstring Exercise Protocol

Weeks 1-4: 4 sets of 5 reps on Mondays, Wednesdays, and Fridays. The patient lowered himself to the ground and then used his hands to propel himself back up.

Weeks 5-8: 5 sets of 5 reps on Mondays, Wednesdays, and Fridays. Patient was able to lower himself down and completely pull himself back up without the help of his hands.

Weeks 8-10: 5 sets of 5 reps while holding a 10-kg plate.

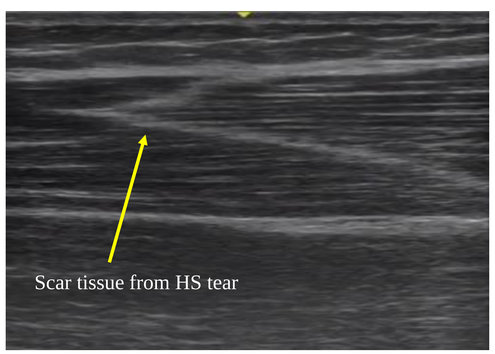
The patient was instructed to perform his Nordics after his daily rehabilitations and team lifts. Patient was instructed to not perform any eccentric hamstring exercises during his lifts or outside of research in order to keep results consistent.

## Results

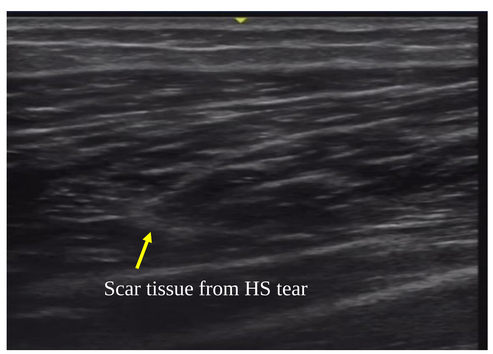
| Measurement | Leg | 2 Months | 4 Months | 5 Months | Percent Improvement |
|---|---|---|---|---|---|
| Biceps Femoris Thickness (cm) | Right | 3.81 | 3.88 * | 4.28 * | 10.98% |
| | Left | 2.86 | 3.22 | 3.82 | 25.13 % |
| Biceps Femoris PA (cm) | Right | 12.94 | 13.08 * | 13.41 * | 3.50 % |
| | Left | 6.49 | 12.29 | 13.52 | 52.00 % |
| Biodex Peak Torque Flexion (cm) (N-M) | Right | N/A | 135.9 | 160.0 | N/A |
| | Left | N/A | 173.5 | 178.7 | N/A |

*Due to a loss in data collection, the hamstring ultrasound data represents data from 3 months instead of 4 and 4 months instead of 5.

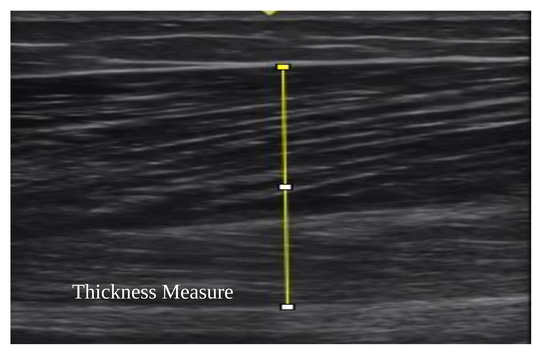
**Representative Left Hamstring - 2 Months**




**Representative Left Hamstring - 5 Months**




**Representative Right Hamstring - 4 Months**




## Conclusion

Over the course of the months there were was increase in both muscle thickness and PA. Additionally there was an increase in peak torque production with a decrease in the deficit between the hamstrings.