Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2021; 37: 43–51. ISSN 2300-0767
DOI: 10.19271/IRONS-000146-2021-37

REVIEW ARTICLE

REHABILITATION PROTOCOL AFTER ACHILLES TENDON RECONSTRUCTION WITH AN AUTOLOGOUS HAMSTRING GRAFT

PROTOKÓŁ REHABILITACYJNY PO REKONSTRUKCJI ŚCIĘGNA ACHILLESA Z WYKORZYSTANIEM PRZESZCZEPU Z MIĘŚNIA PÓŁŚCIĘGNISTEGO I SMUKŁEGO

Bartosz Kiedrowski[1], Paweł Bąkowski[2], Łukasz Stołowski[3], Jakub Kaszyński[2], Gino Kerkhoffs[4], Tomasz Piontek[2]
[1]Physiotherapy Unit, Rehasport Clinic, Poland
[2]Orthopaedic Unit, Rehasport Clinic, Poland
[3]Rehabilitation Department, Rehasport Clinic, Poland
[4]Department of Orthopedic Surgery of the Academic Medical Center, Amsterdam, Netherlands

ABSTRACT

Introduction

One of the treatment options in chronic damage or unsuccessful suturing of the Achilles tendon is a surgical treatment consisting of its reconstruction using the tendon of semitendinosus and gracilis muscle. The multitude of types of reconstruction causes discrepancies in rehabilitation protocols. All of them aim to return to full functional fitness as the ultimate goal.

Aim

This study aims to present the proprietary rehabilitation protocol after Achilles tendon reconstruction using the tendon of semitendinosus and gracilis muscle.

Material and methods

The presented rehabilitation program lasts about 12 months and is divided into six stages. Stage I consists of standing up and anticoagulant exercises, and isometric exercise. Stage II, lasting up to 2 weeks after the procedure, consists of the patient's independent work in the home environment. Stage III, lasting up to 4 weeks, involves learning to walk and putting weight on the limb in a cam Walker. In the third stage, after the postoperative wounds have healed, exercises in water conditions are started. Stage IV, lasting from 4 weeks after the operation, involves loading the limb with support, increasing the range of dorsiflexion motion, and progressive muscle strengthening. Stage V, which lasts up to 8–12 months after surgery, eliminates functional deficits and prepares the patient for a functional biomechanical assessment. Stage VI is the stage of work on the compensation of deficits resulting from the analysis of the results of the functional biomechanical assessment necessary to return to the full sports activity.

Results

The rehabilitation time, in accordance with the assumptions of the above protocol, is 8–12 months. After this time, the patient should proceed to a functional biomechanical assessment.

Author responsible for correspondence:
Bartosz Kiedrowski
Rehasport Clinic
Górecka 30, 60-201 Poznań, Poland
Email: bartosz.kiedrowski@rehasport.pl
https://orcid.org/0000-0002-3301-4359

Authors reported no source of funding
Authors declared no conflict of interest

Date received: 10th August 2021
Date accepted: 1st September 2021

Discussion and conclusions
The rehabilitation protocol presented by our team describes in detail the stages of post-operative rehabilitation after Achilles tendon reconstruction with a hamstring graft. It provides the conditions necessary for the patient to meet before starting the next phase and returning to sport. Our requirements are consistent with the assumptions available in the scientific base.

Keywords: Achilles tendon reconstruction, return to sport, rehabilitation program.

STRESZCZENIE
Wstęp
Jedną z opcji leczenia w przewlekłym uszkodzeniu lub nieudanym zszyciu ścięgna Achillesa jest leczenie operacyjne polegające na jego odbudowie za pomocą ścięgna mięśnia półścięgnistego i smukłego. Mnogość rodzajów rekonstrukcji powoduje rozbieżności w protokołach rehabilitacyjnych. Wszystkie z nich dążą do powrotu do pełnej sprawności funkcjonalnej jako ostatecznego celu.

Cel
Celem pracy jest przedstawienie autorskiego protokołu rehabilitacji po rekonstrukcji ścięgna Achillesa przy użyciu ścięgna mięśnia półścięgnistego i smukłego.

Materiał i metody
Przedstawiony program rehabilitacji trwa około 12 miesięcy i jest podzielony na sześć etapów. Etap I składa się z ćwiczeń nauki chodzenia, przeciwzakrzepowych oraz ćwiczeń izometrycznych. Etap II, trwający do 2 tygodni po zabiegu, polega na samodzielnej pracy pacjenta w środowisku domowym. Etap III, trwający do 4 tygodni, polega na nauce chodzenia i obciążaniu kończyny w ortezie typu Walker. W trzecim etapie, po zagojeniu się ran pooperacyjnych, rozpoczyna się ćwiczenia w wodzie. Etap IV, trwający od 4 tygodni po operacji, polega na obciążeniu kończyny z podpiętkami, zwiększeniu zakresu ruchu zgięcia grzbietowego i stopniowym wzmacnianiu mięśni. Etap V, trwający do 8–12 miesięcy po zabiegu, niweluje deficyty czynnościowe i przygotowuje pacjenta do funkcjonalnej oceny biomechanicznej. Etap VI to etap prac nad wyrównaniem deficytów wynikających z analizy wyników biomechanicznej oceny funkcjonalnej, niezbędnej do powrotu do pełnej aktywności sportowej.

Wyniki
Czas rehabilitacji, zgodnie z założeniami powyższego protokołu, wynosi 8–12 miesięcy. Po tym czasie pacjent powinien przystąpić do biomechanicznej oceny funkcjonalnej.

Wnioski
Przedstawiony przez nasz zespół protokół rehabilitacji szczegółowo opisuje etapy rehabilitacji pooperacyjnej po rekonstrukcji ścięgna Achillesa z wykorzystaniem przeszczepu z ścięgna mięśnia półścięgnistego i smukłego. Zapewnia on pacjentowi warunki niezbędne do spełnienia przed rozpoczęciem kolejnej fazy i powrotem do sportu. Nasze wymagania są zgodne z założeniami dostępnymi w bazie naukowej.

Słowa kluczowe: rekonstrukcja ścięgna Achillesa, powrót do sportu, program rehabilitacji.

Introduction

One of the treatment options in a chronic tear or unsuccessful suturing of the Achilles tendon is a reconstruction with an autologous hamstring graft.

The minimally invasive technique of Achilles tendon reconstruction proposed by our team (described in the paper by Piontek *et al.,* 2016) creates biomechanical conditions for the quick, postoperative restoration of foot function by using muscles far from the ankle for tendon transplantation. The patient gains the possibility of normal walking very quickly, which is a definite advantage of the presented surgical treatment. Our rehabilitation protocol is based on biomechanical tests performed in a cadaver lab and described in our previous work (Bąkowski *et al.,* 2020).

The current observations of the rehabilitation results based on the protocol described below allow us to conclude that all patients return to their professional and sports activities before the injury, including athletes practicing sports at a professional level.

Aim

This paper aims to present the proprietary 12-month rehabilitation protocol after Achilles tendon reconstruction with a hamstring graft.

Material and methods

Rehabilitation after Achilles tendon reconstruction with semitendinosus and gracilis tendons takes about 12 months. This is the essential time of rehabilitation and has a decisive impact on the subsequent recovery of the full function. (Bąkowski *et al.,* 2020). After this time, the strength and endurance of the calf muscles are expected to return fully. The main goal of rehabilitation is to regain full physical activity. The physiotherapist monitors the course of rehabilitation. He is in constant contact with the operating doctor.

We divide the rehabilitation protocol into stages, depending on the time after the surgery.

First stage

After the procedure, the foot is positioned in maximum plantar flexion using the cam Walker. On the first day after the procedure, the physiotherapist shows how to use the orthosis and teaches how to walk with weight-bearing as tolerated. He teaches anti-inflammatory and isometric exercises that the patient will be doing over the following days at home.

Second stage

The patient should lead a sparing lifestyle at this stage, but it is not recommended to lie down constantly. This stage takes about 12 days. The patient should remove the orthosis several times a day to maintain the hygiene of the operated area.

Exercises performed during this period focus on breathing exercises and isometric work of the lower limbs, pelvis, and torso muscles. All exercises should be painless during and after. They should not increase the swelling in the operated area. In case of pain, recommended is ice compression and elevation. Increased swelling may occur after too long staying in the standing position. A patient is taking anticoagulants throughout this period. He walks with weight-bearing as tolerated.

Third stage

This stage begins about 10–14 days after the surgery. After a medical control, the doctor removes the stitches and refers the patient for rehabilitation. If the wound is fully healed, the cam Walker is removed, and a patient walks in normal shoes with 3 cm heel pads. A physiotherapist begins his work with an interview, manual examination, and a conversation about the patient's expectations and the purpose of rehabilitation. During the examination and therapy, the therapist cannot avoid the knee joint area, and the hamstring group from the graft was harvested. In the rehabilitation process, exercises for this muscle group will be necessary because the remaining muscles, such as the biceps and

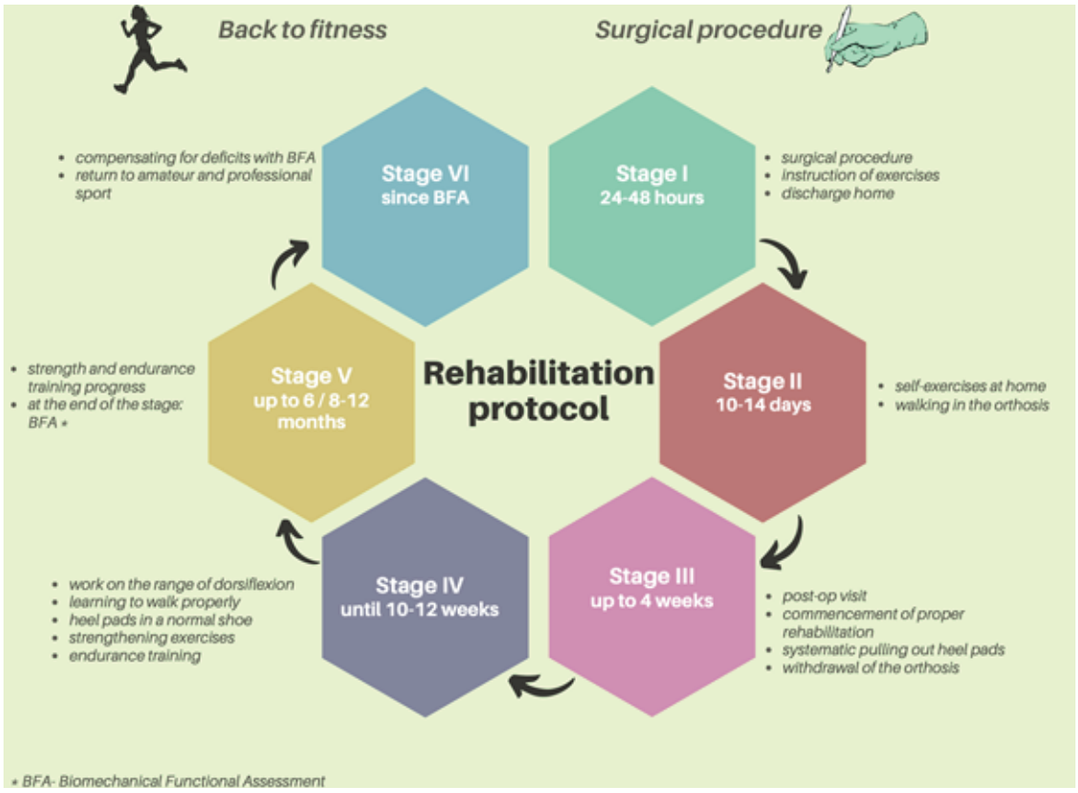

Figure 1. The main goals of the individual stages of rehabilitation.

semimembranosus, must compensate for the weakness of this area.

Manual work focuses on therapy around the operated area. The foot, upper and lower ankle joint, proximal calf, knee joint, hamstring group, and buttock. Therapy stimulating the circulatory and lymphatic systems is performed, which will help in regeneration. In the following weeks, the therapist introduces active and passive movement in the operated area. The therapy should be painless and comfortable for the patient. Increasing the range of motion is done more by gradually introducing exercises and manual therapy than by stretching. A slow and gradual increase of the range of motion makes it possible to remove the heel pads. The condition is that there is no pain when standing and moving. All of them should remove within about four weeks after the procedure.

General development exercises are also helpful in restoring proper functions. The therapist introduces exercises for the torso, axial stabilization, the gluteal muscle group, and the thigh muscles. It is also possible to work calmly on a stationary bike.

Exercises in the operated area are aimed at stimulating and improving blood supply. Isometric calf triceps tension exercises are introduced in the light plantar flexion setting. Active movement of the upper ankle is performed with a possible, painless, Theraband rubber load. Flexor hallucis is activated. In the sitting position, core foot system exercises are introduced. This term means exercises for the short muscles of the foot. These exercises are progressing through the successive stages of rehabilitation (McKeon *et al.*, 2014).

By the end of this stage, the wounds should be fully healed. The therapist starts working with the scars to make the operated area more flexible. It is possible to introduce rehabilitation in an aquatic environment. This type of activity starts with basic deep water exercises and ends with complex swimming exercises.

The timing of completion of the three stages is 4–6 weeks after surgery. However, apart from time, the most important element

for the transition to the next phase is removing the orthosis.

Stage fourth

The goals of this period are: to progressively build the range of dorsiflexion in the upper ankle joint and restore normal gait. The test to prove the range of motion is the "knee to wall test". (Powden *et al.,* 2015) The movement performed during the test is often used as an exercise. The patient can perform them freely at home. The exercises from the previous stage are progressed. Triceps calf isometry is performed in the new range of motion. Calf muscle resistance exercises can be performed in various body positions with external load or full-body load, e.g., climbing on toes in a sitting or standing position. One-leg exercises are introduced, including one-leg deadlift, Bulgarian squat, lunge, and steps on the box.

Progression of short-foot exercises comes down to proprioception exercises with the activation of the whole body. The therapist pays attention to exercises that restore gait phases. As a rule, the hell-off and toe-off phases are the most disturbed. It should be focused on by introducing gait re-education exercises from various physiotherapeutic methods.

The work of the muscle groups above the knee passes to the stage of rebuilding and increasing muscle strength. Exercises should be properly progressed with positions and external weight.

The platform with the Gamma system assessing the distribution of loads on the right and left sides of the body is helpful in this period. During exercises, e.g., a squat, the patient gets a visual response of the correct load on both sides of the body.

Endurance training on a stationary bike is continued while maintaining sitting positions.

In this stage, heel pads are used while walking in normal shoes (8 weeks after surgery, we use 1.5 cm heel pads).

Stage fifth

We continue at this stage: therapy to increase the range of motion of the upper and lower ankle joints, using three-dimensional movements of all joints in the lower limb; mobilizations and automobilizations of the forefoot; therapy increasing the range of dorsiflexion of the big toe.

Attention should be paid to the excessive activity of the toe flexors when climbing on toes in the operated limb. Further progression of the isometric calf muscles contraction using a lunge or squat position and lengthening the time and power of contraction. The exercises can be much more complex and strenuous. The patient continues to conduct general body development exercises using all movement patterns. A simple test, and at the same time an exercise, is the movement of climbing on the toes of the operated limb. The climbing on toes movement on the operated leg is necessary to restore the patient's regular physical activity (Olsson *et al.,* 2014). This stage lasts up to 8–12 months after the procedure. It is expected to regain: proper gait, full range of motion compared to the unoperated limb, painless during exercise and everyday life.

In the final two months of this stage, we introduce full calf muscle strength training and the initial stages of plyometric training. It is to prepare the patient for the stress that occurs during the functional biomechanical assessment.

Results

The rehabilitation time, according to the assumptions of the above protocol, is 8–12 months. After this time, the patient should proceed with the evaluation. It is very individual and depends on the patient's involvement in the rehabilitation process.

Biomechanical functional assessment

It is a battery of tests that allow the physiotherapist to determine the patient's condition objectively. The results show deficits, and on their basis, further rehabilitation

or back to training should be planned. After reconstruction of the Achilles tendon, it is performed: ten to twelve months after surgery in a non-professional sports patient and about eight months after surgery in professional athletes. The assessment time may shift due to the individual elements that the patient must fulfill before the assessment: functional range of ankle joint motion, no swelling, no pain, and no fear.

Tests used in the assessment:

- Knee to wall test
- Star Excursion Balance Test
- Load distribution test using the Gamma system
- Toe climbing test on one leg on an oblique platform
- One-legged long jump
- Vertical jump on one leg measured using the "MyJump" mobile application for jumping analysis
- Isometric strength test of the ankle flexors and extensors using the Biodex system
- Strength and endurance test for the gastrocnemius muscle in concentric and eccentric contractions using the Biodex system.

The results of the biomechanical assessment carried out by our team, presented in the work of Bąkowski *et al.,* 2020, were the basis for creating this protocol and confirming the use of biomechanical assessment tests to control it.

The norm of results for a patient is the condition and results achieved in the opposite leg. The difference in results between the limbs acceptable by our team is 10%. This is a number that is presented in many scientific studies on functional and physiotherapeutic test evaluations. (Silbernagel *et al.,* 2006; Plisky *et al.,* 2009; Olsson *et al.,* 2014; Bäcker *et al.,* 2019).

The choice of tests was dictated by the involvement of the Achilles tendon in their performance, repeatability, simplicity, safety, and a well-estimated value in clinical evaluation (Silbernagel *et al.,* 2006; Olsson *et al.,* 2014).

The results of the performed tests, analysed by the therapist, are the basis for planning a further level of rehabilitation or deciding to end the treatment process.

Discussion

This study presents a physiotherapy program after the Achilles tendon reconstruction with hamstring grafts. This program has evolved over several years and is based on experience in daily work with patients, including professional athletes. It has been analyzed and compared with the protocols available in the scientific base (Maffulli *et al.,* 2013; Brumann *et al.,* 2014; Gordon, 2016; Rosińska *et al.,* 2016; Kiedrowski *et al.,* 2018; Tarantino *et al.,* 2020). To our knowledge, this is the first paper describing rehabilitation protocol after minimally invasive Achilles tendon reconstruction using the hamstring grafts.

In other reconstruction methods, a graft is taken from the area of the operated joint, e.g., the tendon of flexor hallucis longus, which in our opinion may disturb rehabilitation, make it difficult, and delay the restoration of foot functions. However, the authors agree that harvesting a flexor hallucis longus graft does not impair foot function (Hossman *et al.,* 2018; Jordi *et al.,* 2018). Despite the loss of the range of dorsiflexion of the toe joints, the patients returned to total physical activity (Wegrzyn *et al.,* 2009). Other authors show that harvesting a flexor hallucis longus graft causes a permanent loss of flexion of the toe, which significantly reduces the quality of life of patients (Lee *et al.,* 2009).

In some studies, the return to dynamic activity is based on time after the surgery (Gordon 2016). This period is divergent and requires further research and scientific confirmation. None of the available research presents the study before returning to physical activity and sport as detailed as our study. Analysis of the problems after Achilles tendon reconstruction and the results of the isokinetic and functional assessment led to the development of this program. I was also based on our previous experience with

post-operative assessment after percutaneous Achilles tendon suture (Bąkowski *et al.,* 2017; Bąkowski *et al.,* 2017). To minimize the reconstructed Achilles tendon's stretching, we use heel pads for about three months. The available rehabilitation protocols also include the use of an orthosis. Gordon, in his 2016 publication, recommends using the orthosis for six weeks without using the heel pads after this period. According to our protocol, a patient wears the orthosis for approximately two weeks, which is dictated by the wound healing. In our opinion, it enables faster restoration of the function of walking while protecting the operated tendon. Quick implementation of loading the operated limb in orthopedic Walker shoe makes it easier for patients to return to their daily activities. The quick burden of the operated area, painlessly, is recommended by the authors of the available protocols (Gordon 2016; Rosińska *et al.,* 2016; Tarantino *et al.,* 2020).

Many studies on Achilles tendon surgery refer to its suturing. We believe that due to the significant similarity of the surgical procedure, they can be the basis for creating post-reconstruction protocols. They also assume a quick load of the operated area (Aufwerber *et al.,* 2019).

An individualized rehabilitation program focusing on the return of strength and endurance parameters of the calf muscles and the correct movement pattern gives a chance to reduce the harmful effects of an injury. Thanks to the minimally invasive method, small postoperative scars reduce the possibility of postoperative adhesions, and therefore faster restoration of the full range of motion. In our opinion, it minimizes restrictions on the sliding of the skin and fascia layers relative to each other and the reconstructed tendon. The early healing of more minor scars allows for faster load and training in the water. Due to the minimally invasive technique, there are fewer infections and complications of postoperative wounds (Maffulli *et al.,* 2008; Bąkowski *et al.,* 2020). Also, less damage to the surrounding tissues was observed than open techniques (Molloy *et al.,* 2009; Piontek *et al.,* 2016). Minimally invasive techniques around the Achilles tendon significantly reduced the risk of superficial wound infection, with a patient satisfaction three times greater, which provided good or excellent results compared to conventional open surgical approaches (McMahon *et al.,* 2011).

A rigid time frame does not limit the above-described program. It is constantly modified by the attending therapist depending on the patient's condition and needs. However, the rehabilitation should follow the physiological processes of regeneration of the reconstructed tendon, tissue healing, and collagen remodeling.

Conclusion

In conclusion, the rehabilitation protocol presented by our team describes the stages of post-operative rehabilitation after Achilles tendon reconstruction with a hamstring graft. A comprehensive approach to the problem gives a chance to return to pre-injury activity.

REFERENCES

Abubeih, H., Khaled, M., Saler, WR, Said, GZ. (2018) *'Flexor hallucis longus transfer clinical outcome through a single incision for chronic Achilles tendon rupture'.* In Orthop., Nov, 42 (11), pp. 2699–2704.

Aufwerber, S., Heijne, A., Silbernagel, K.G., Ackermann, P.W. (2019) *'High Plantar Force Loading After Achilles Tendon Rupture Repair With Early Functional Mobilization'.* Am J Sports Med., Mar, 47 (4), pp. 894–900.

Bąkowski, P., Cisowski, P., Rubczak, S., Wolf-Stefaniak, M., Bąkowska, A., Piontek, T. (2017) *'Clinical functional assessment of patients after achilles tendon percutaneous suture.'* Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 21, pp. 19–29.

Bąkowski, P., Cisowski, P., Rubczak, S., Wolf-Stefaniak, M., Bąkowska, A., Piontek, T. (2017) *'Results of biomechanical isokinetic evaluation of patients after achilles tendon percutaneous suture'*. Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 21, pp. 31–38.

Bąkowski, P., Ciemniewska-Gorzela, K., Talaśka, K., Górecki, J., Wojtkowiak, D., Kerkhoffs, G., Piątek, T. (2020) *'Minimally invasive reconstruction technique for chronic Achilles tendon tears allows rapid return to walking and leads to good functional recovery'.* Knee Surg Sports Traumatol Arthrosc., 28 (1), pp. 305–311.

Bäcker, HC., Yenchak, AJ., Trofa, DT., Vosseller, JT. (2019) *'Strength Measurement After Achilles Tendon Repair'.* Foot Ankle Spec., Oct, 12(5), pp. 471–479.

Brumann, M., Baumbach, SF., Mutschler, W., Polzer, H. (2014) *'Accelerated rehabilitation following Achilles tendon repair after acute rupture – Development of an evidence-based treatment protocol'.* Injury., Nov, 45(11), pp. 1782–1790.

Gordon D. (2016) *'Achilles Tendon Insertion Reconstruction: Post Operative Accelerated Rehabilitation Protocol'.* Consultant Orthopaedic Surgeon, A Patient Guide. Retrieved August 20, 2021, from http://www.davidgordonortho.com.

Kiedrowski, B., Bąkowski, P., Kozinoga, M., Piontek, T. (2018) '*Rehabilitation protocol after percutaneous Achilles tendon suture'.* Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 25, pp. 59–66.

Lee, KB., Park, YH., Yoon, TR., Chung, JY. (2009) *'Reconstruction of chronic Achilles tendon rupture using the flexor hallucis tendon'.* Knee Surg Sports Traumatol Arthrosc., 17, pp. 316–20.

Maffulli, N., Longo, U.G., Gougoulias, N., Denaro, V. (2008) *'Ipsilateral free semitendinosus tendon graft transfer for reconstruction of chronic tears of the Achilles tendon'.* BMC Musculoskeletal Disord., 9, pp. 100.

Maffulli, N., Loppini, M., Longo, UG., Mafuli, GD., Denaro, V. (2013) *'Minimally Invasive Reconstruction of Chronic Achilles Tendon Ruptures Using the Ipsilateral Free Semitendinosus Tendon Graft and Interference Screw Fixation'.* Am J Sport Med., May, 41 (5), pp. 1100–1107.

McKeon, P., Hartel, J., Bramble, D., Davis, I. (2014) *'The foot core system: A new paradigm for understanding intrinsic foot muscle function'.* British Journal of Sports Medicine., March, 49 (5), pp. 290.

McMahon, SE., Smith, TO., Hing, CB. (2011) '*A meta-analysis of randomised controlled tri- als comparing conventional to minimally inva- sive approaches for repair of an Achilles tendon rupture*'. Foot Ankle Surg., 17 (4), pp. 211–217.

Molloy, A., Wood, EV. (2009) *'Complications of the treatment of Achilles tendon ruptures.'* Foot Ankle Clin., 14, pp. 745–59.

Olsson, N., Nilsson-Helander, K., Karlsson, J., Eriksson, B.I., Thomee, R., Faxen, E., Brorsson, A., Lundberg, M., Silbernagel, K.G. (2014) *'Ability to perform a single heel- rise is significantly related to patient-reported outcome after Achilles tendon rupture'.* Scand J Med Sci Sports., Feb, 24 (1), pp. 152–158.

Piontek, T., Bąkowski, P., Ciemniewska-Gorzela, K., Grygorowicz, M. (2016) *'Minimally invasive, endoscopic Achilles tendon reconstruction using semitendinosus and gracilis tendons with Endobutton stabilization'.* BMC Musculoskelet Disord., Jun, 3, pp. 17:247.

Plisky, PJ., Gorman, PP., Butler, RJ., Kiesel, KB., Underwood, FB., Elkins, B. (2009) *'The reliability of an instrumented device for measuring components of the star excursion balance test'.* North American journal of sports physical therapy: NAJSPT., May, 4 (2), pp. 92.

Powden, C., Hoch, M., Hoch, C. (2015) *'Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review.'* Man Ther., Aug, 20 (4), pp. 524–532.

Rosińska, A., Syrek, M. *„Rehabilitacja ścięgna Achillesa. Kompletny protokół usprawniania po trójpłaszczyznowej rekonstrukcji ścięgna Achillesa."* 1st Ed. Warsaw: Sport Medica 2016.

Silbernagel, KG. (2011) '*Major functional deficits persist 2 years after acute Achilles tendon rupture'.* Knee Surg Sports Traumatol Arthrosc., 19 (8), pp. 1385–1393.

Silbernagel, KG., Gustavsson, A., Thomee, R., Karlsson, J. (2006) *'Evaluation of lower leg function in patients with Achilles tendinopathy'.* Knee Surg Sports Traumatol Arthrosc., 14 (11), pp. 1207–1217.

Tarantino, D., Palermo, S., Sirico, F., Corrado, B. (2020) *'Achilles Tendon Rupture: Mechanisms of Injury, Principles of Rehabilitation and Return to Play'*. J Funt Morphol Kinesiol., Dec 17, 5 (4), pp. 95.

Vega, J., Vila, J., Batista, J., Malagelada, F., Dalmau-Pastor, M. (2018) *'Endoscopic Flexor Hallucis Longus Transfer for Chronic Noninsertional Achilles Tendon Rupture'*. Foot Ankle Int., Dec, 39 (12), pp. 1464–1472.

Wegrzyn, J., Luciani, JF., Philippot, R., Brunet-Guedj, E., Moyen, B., Besse, JL. (2009) *'Chronic Achilles tendon rupture reconstruction using a modified flexor hallucis longus transfer'*. In Orthop., Dec, 34 (8), pp. 1187–1192.

Zellers, JA., Christensen, M., Kjær, I.L., Rathleff, MS., Silbernagel, KG. (2019) *'Defining Components of Early Functional Rehabilitation for Acute Achilles Tendon Rupture: A Systematic Review'*. Orthop J Sports Med., Nov 25, 7 (11).