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Athletic Muscle Rehabilitation Program (AMRP) completing the surgical treatment of sportsmen's hernia and athletes' pubalgia: Clinical outcomes in 461 athletes

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Abstract

BACKGROUND: Sportsman's hernia and athletic pubalgia (SH/AP) represent a chronic microtrauma groin injury, distinct from typical inguinal hernia, characterized by exertion-related pain due to underlying groin and pubic injury results for muscular imbalance. Mild cases may respond to conservative management, but advanced cases often require surgical repair. Because persistent neuromuscular dysfunction may limit full recovery and contribute to recurrence, structured postoperative rehabilitation is considered an important component of care after surgery. This study aimed to describe the mandatory Athletic Muscles Rehabilitation Program (AMRP), a surgeon-supervised, three-component postoperative protocol initiated immediately after totally extraperitoneal release-and-reinforce technique (TEP-RRT) surgery, and to characterize long-term functional and patient-reported outcomes in athletes treated with TEP-RRT and AMRP, a protocol not widely recognized as essential for successful full recovery.

MATERIALS AND METHODS: We retrospectively surveyed 461 athletes who underwent TEP-RRT for SH/AP between 2016 and 2024 and completed a standardized AMRP. A structured telephone survey (October 2024–January 2025) captured return-to-sport status, time to return, recurrence, additional treatments, and patient satisfaction. Descriptive statistics were used.

RESULTS: During the follow-up of 6 months to 9 years, 98.5% of athletes returned to sports after completing the AMRP and remained active. Rehabilitation lasted 6–12 weeks. Most resumed full activity within 8 weeks, and nearly all resumed full activity within 12 weeks. No recurrences occurred. Additional treatments were required in 10% of the cases. Satisfaction was high (96.2% rated outcomes very good).

CONCLUSIONS: Surgeon-supervised, structured rehabilitation after TEP-RRT for SH/AP was associated with favorable functional outcomes, including high return-to-sport rates and no reported recurrences during the long-term follow-up. Prospective comparative studies are needed.

Keywords:

Athletic pubalgia, endoscopic hernia repair, return to sport, sportsman's hernia, structured rehabilitation

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Introduction

Sportsman's hernia/athletic pubalgia (SH/AP) is a chronic groin injury in athletes that often requires surgical repair.[1-4] Although surgery restores anatomical integrity, it does not address the underlying neuromuscular imbalance, making postoperative rehabilitation essential for functional recovery.[5-11] However, despite well-described surgical techniques,

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rehabilitation protocols remain poorly defined, and existing recommendations are largely nonspecific.[12–16] We developed the Athletic Muscles Rehabilitation Program (AMRP), a structured, surgeon-supervised postoperative rehabilitation protocol initiated immediately after totally extraperitoneal release-and-reinforce technique(TEP-RRT). The aims of this study were to present the AMRP protocol in detail and to report long-term outcomes in a large retrospective cohort.

Materials and Methods

Study design

This investigation was a retrospective outcome study. All operations were performed at a single high-volume sports-hernia center by one experienced surgeon. Eligible patients were contacted for a structured telephone survey in late 2024–early 2025. The follow-up period ranged from 6 months to 9 years (surgeries performed between 2016 and 2024).

Inclusion and exclusion criteria

Athletes were eligible if they (1) underwent TEP-RRT surgery for SH/AP (either primary or revision); (2) completed the full AMRP postoperative rehabilitation protocol; (3) had at least 6 months of follow-up after completing rehabilitation. A total of 467 athletes underwent TEP-RRT for SH/AP during the study period. Four patients did not complete the AMRP rehabilitation protocol, and two declined participations in the telephone survey. Therefore, 461 athletes were included in the final analysis. Follow-up data were available for all athletes included in the study cohort.

Surgical technique (TEP-RRT)

The TEP-RRT procedure integrated a bilateral TEP approach with three targeted surgical maneuvers: (1) release of inflamed and fibrotic tissues from the pubic bone; (2) division of the inguinal ligament to alleviate potential nerve entrapment; (3) reinforcement of the attenuated posterior wall using a wide, mid-weight synthetic mesh. This comprehensive technique was designed to address inflammatory, anatomical, and neurogenic components of SH/AP.[17] An illustration of the surgical steps is provided in Figure 1.

Rehabilitation protocol (AMRP)

The AMRP was a structured, phased protocol designed for both conservative management of early-stage SH/AP and as a postoperative rehabilitation regimen following endoscopic TEP-RRT repair.

The AMRP aimed to restore core stability, promote adductor muscle symmetry, and enhance proprioceptive control, thereby addressing underlying muscular imbalances and maladaptive movement patterns. These corrective mechanisms were intended to reduce the risk of chronic groin pain and minimize the recurrence of SH/AP.

Successful implementation of the AMRP required an individualized treatment plan tailored to lesion severity and to the specific biomechanical demands of the athlete's sport. Progression was supervised by the operating surgeon in collaboration with the physiotherapy team.

The AMRP consisted of three interdependent rehabilitation tracks, initiated 1 week postoperatively. These tracks were delivered across three chronological stages (weeks 1–3, 4–6, and 7–12) and were introduced sequentially but continue in parallel: once the athlete demonstrates adequate progress in one track, the next was added while the prior one continues. Ultimately, all three tracks were pursued concurrently, with

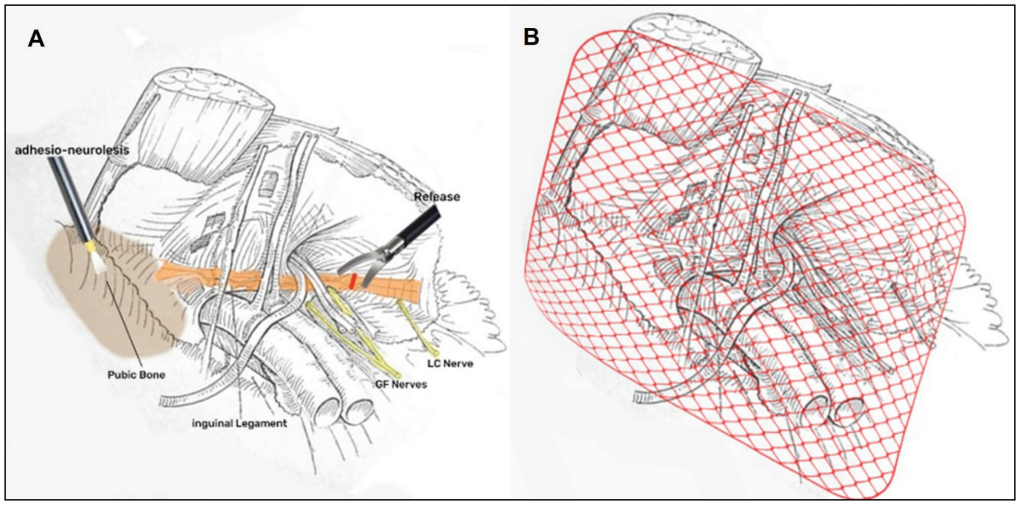

Figure 1: Two main phases of the totally extraperitoneal release-and-reinforce technique surgical procedure. A. Pubic bone debridement and release of entrapped nerves. B. The reinforcement phase, in which a wide synthetic mesh is applied to strengthen weakened tissues and prevent recurrence

relative emphasis on each component determined by the treating physiotherapist. Progression through each phase was personalized, based on clinical guidelines, functional assessments, and the patient's pain tolerance. The program was designed to enable a safe and effective return to sport-specific activity following surgery.

The three rehabilitation tracks of the AMRP:

(1) **Isometric active weight-bearing exercise:** Focuses on progressive loading of trunk and lower limb muscles to restore strength. Representative exercises are shown in Figure 2.
(2) **Core muscle stability and coordination exercise (CMSCE):** Targets core stabilization, neuromuscular control, and proprioceptive function. Examples of CMSCE are illustrated in Figure 3.
(3) **Aerobic running and sprinting:** Gradually reintroduces cardiovascular conditioning and speed-specific activities. Figure 4 provides sample exercises used during this phase.

A comprehensive summary of each track, including structure, duration, goals, key exercises, and recommendations, is provided in Table 1.

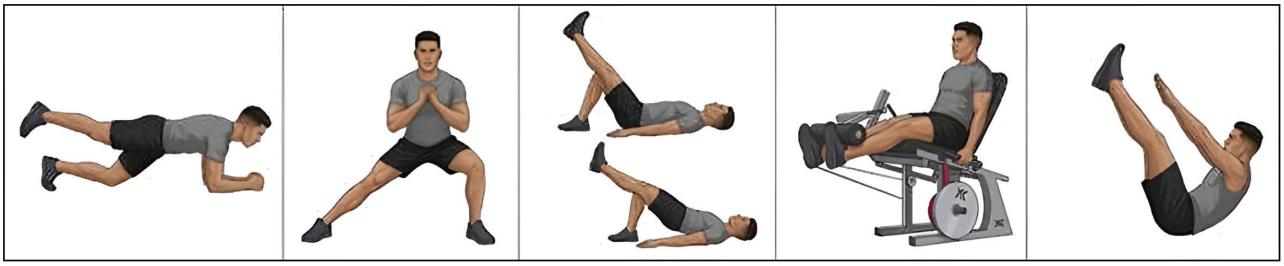

Figure 2: Examples of strengthening exercises implemented during the active weight-bearing exercise track of the Athletic Muscles Rehabilitation Program (AMRP)

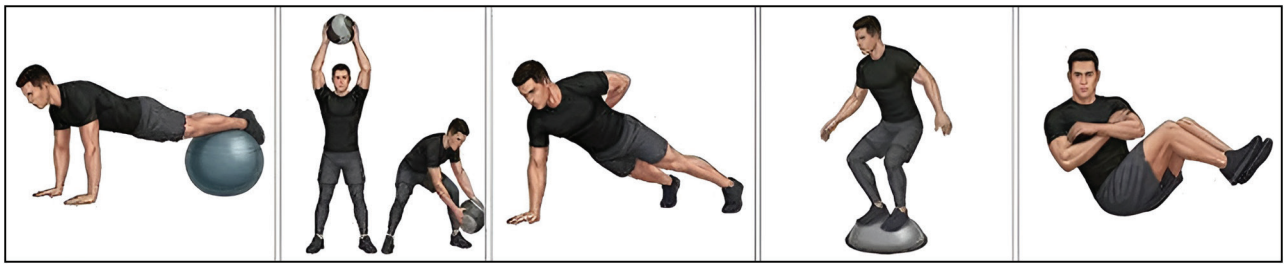

Figure 3: Examples of muscle stability and coordination exercises implemented during the core muscle stability and coordination exercise track of the Athletic Muscles Rehabilitation Program (AMRP)



Figure 4: Examples of muscle stability and coordination exercises implemented during the running/sprinting track of the Athletic Muscles Rehabilitation Program (AMRP)

Table 1: Tracks description of the Athletic Muscles Rehabilitation Program (AMRP)

Track	Time frame within the process (in weeks)	Primary goals	Key exercises	Additional recommendations
(1). Early mobilization and strengthening	1–3	Activate core stability and prevent stiffness	Isometric exercises and weight-bearing movements	Avoid high-impact activities to allow tissue healing
(2). Progressive strength and functional training	4–6	Improve core stability and strengthen specific muscle coordination	Exercises targeting the rectus abdominis, hip adductors, and pelvic stabilizers	Incorporate progressive resistance training for neuromuscular control
(3). Return-to-sport preparation	7–12	Restore full sports functionality	Aerobic training and sport-specific drills	Perform functional assessments before returning to competition

In clinical practice, athletes presenting with a short duration of symptoms and a Grade 1–3 lesion typically began with a 1-month trial of conservative treatment using the AMRP. Based on clinical reassessment, physiotherapy reports, patient feedback, and the surgeon's physical examination, a decision was made whether to continue with conservative management or proceed to surgical intervention. Importantly, patients treated conservatively were not included in the current study cohort.

This study focused exclusively on outcomes in athletes who underwent surgical treatment. For these patients, AMRP rehabilitation commenced 1 week after TEP-RRT surgery and continued for 6 to 12 weeks, depending on injury severity. During this period, the operating surgeon worked closely with the physiotherapy team to monitor progress and adjust the rehabilitation plan as necessary. In rare cases where full recovery was not achieved within the standard timeframe, an extended rehabilitation course was provided.

Postoperative long-term maintenance

Following successful completion of the AMRP and full functional recovery, athletes were prescribed a weekly maintenance training protocol. This program was to be followed consistently, including during rest periods and off-seasons, to maintain muscular balance and prevent reinjury. The maintenance protocol was provided in written form and reviewed with each athlete before discharge. Figure 5 shows example exercises from this maintenance regimen. Full exercise instructions were included as part of the rehabilitation package.

Data collection

The retrospective long-term survey study evaluated outcomes over a 9-year period (2016–2024). An independent, nonclinical team member contacted all eligible athletes via telephone between October 2024 and January 2025. Participants completed a structured survey covering primary outcomes: (1) return to sport (yes/no), defined as return to any sport activity and remained active at or above the preinjury level; (2) recurrence of SH/AP symptoms requiring reoperation (yes/no) and duration of rehabilitation (< 6 weeks, 6 weeks, 8 weeks, or 12 weeks); (3) time to return to sport, categorized into four intervals (< 6 weeks, 6 weeks, 8 weeks, and 12 weeks); (4) requirement for additional treatments beyond the standard rehabilitation program (yes/no); (5) patient-reported satisfaction on a 3-point Likert scale (1 = not satisfied, 2 = satisfactory, and 3 = very good).

Statistical analysis

Descriptive statistics were computed using R (v4.1.4). Categorical variables were reported as counts and percentages.

Ethics

This study was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Informed consent was obtained from all participants.

Results

The study comprised 461 athletes who underwent TEP-RRT between 2016 and 2024 and completed the structured rehabilitation protocol. Of these, 447 were cases of primary repairs, and 14 were revision cases referred after unsuccessful prior surgery performed elsewhere.

At the final follow-up (6 months to 9 years postoperatively), 98.5% of all athletes had returned to sports activity and remained active, no cases of recurrent SH/AP or reoperation were reported during the follow-up period, and overall satisfaction with the outcome was high. Most athletes returned to sports activity within 8–12 weeks of surgery, and adjunct interventions beyond the standardized program (such as extended physiotherapy, corticosteroid injections, or hyperbaric oxygen therapy) were required in few primary cases, whereas no additional interventions were required in the revision subgroup. Outcome distributions for the primary and revision cohorts are summarized in Table 2.

Discussion

AMRP was developed over a span of more than 25 years, integrating the clinical experience of surgeons, physiotherapists, and sports scientists. This retrospective study suggests that combining TEP-RRT with AMRP may yield durable functional recovery in athletes with advanced SH/AP. Nearly all athletes in this cohort ultimately returned to full sport activity, and none reported recurrent SH/AP during the follow-up of up

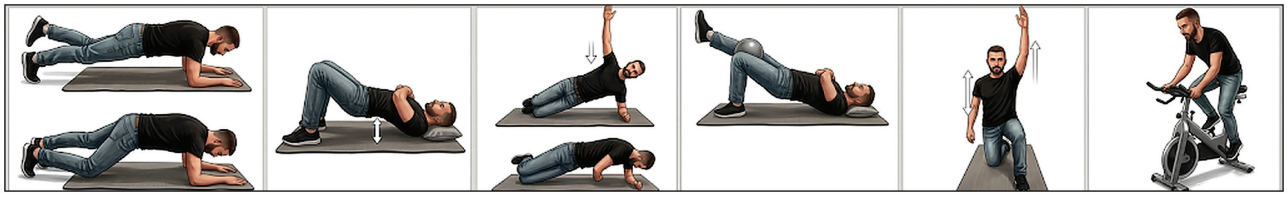

Figure 5: Example exercises from the post-surgery long-term maintenance protocol

Table 2: Distribution of postoperative rehabilitation outcomes in primary and revision cohorts

Outcome	Category	Primary surgeries (*N* = 447), *n* (%)	Revision surgeries (*N* = 14), *n* (%)
Duration of rehabilitation	< 6 weeks	4 (0.9)	0 (0)
	6 weeks	97 (21.7)	3 (21.4)
	8 weeks	190 (42.5)	9 (64.3)
	12 weeks	156 (34.9)	2 (14.3)
Time to return to sport	< 6 weeks	3 (0.7)	0 (0)
	6 weeks	207 (46.3)	9 (64.3)
	8 weeks	120 (26.8)	5 (35.7)
	12 weeks	110 (24.6)	0 (0)
Additional treatments	Yes	47 (10.5)	0 (0)
Recurrence	Yes	0 (0)	0 (0)
Return to sports activity and remained active	Yes	440 (98.4)	14 (100)
Satisfaction with outcomes	Not satisfied (1/3)	12 (2.7)	0 (0)
	Satisfactory (2/3)	5 (1.1)	0 (0)
	Very good (3/3)	430 (96.2)	14 (100)

to 9 years. These findings are consistent with the view that postoperative rehabilitation may play an important role alongside surgical repair in supporting long-term functional recovery.[6-10]

The high return rates and absence of recurrences observed here may reflect the comprehensive nature of the protocol, which emphasizes early initiation, progressive strengthening, neuromuscular retraining, and postoperative supervision by the operating surgeon. Moreover, the addition of a maintenance phase may help sustain muscle balance and mitigate the risk of reinjury.

While the TEP-RRT procedure addresses the structural, inflammatory, and neurogenic components of SH/AP,[17] the AMRP targets the underlying neuromuscular dysfunction. Initiated immediately after surgery under surgeon supervision, the AMRP progresses through three coordinated components: restoration of muscular strength, recovery of lumbopelvic control, and a graded return to sport-specific loading. In addition, it includes a structured maintenance phase aimed at preserving pelvic stability under high athletic demand, supporting long-term muscle balance, and reducing the risk of reinjury. This comprehensive and specific approach may contribute to the high return-to-sport rate and absence of reported recurrences during long-term follow-up.

Notwithstanding these encouraging outcomes, the retrospective design and absence of a comparison group preclude definitive causal conclusions. Self-reported outcomes may be subject to recall bias, and missing demographic data limited assessment of factors that could influence rehabilitation duration. The study was conducted at a single center, and all surgeries were performed by one surgeon, which may limit the generalizability of the findings. In addition, the resource-intensive nature of the protocol requires a close collaboration between surgeons and physiotherapists and may not be feasible in all settings.

Future research should include prospective controlled studies comparing structured rehabilitation programs with standard care and evaluating the cost-effectiveness across multiple centers. Objective measures of function and return to sport should supplement self-reported outcomes. Such studies are needed to confirm whether structured rehabilitation directly contributes to reduced recurrence and improved functional recovery after SH/AP surgery.

Conclusion

In this large retrospective cohort with long-term follow-up, a structured postoperative rehabilitation program following TEP-RRT for SH/AP was associated with rapid functional recovery, high return-to-sport rates, and no reported recurrences. While causality cannot be established, these findings support the integration of standardized rehabilitation into comprehensive care pathways for athletes undergoing surgeon-supervised surgical repair and underscore the need for prospective comparative studies. This protocol was not widely recognized as essential for successful full recovery.

Author contributions

Dr. Moshe Dudai was responsible for the study concept, surgical procedures, development and implementation of the AMRP protocol, supervision of data collection, and drafting and revising the manuscript. Ms. Ruth Marucham, coordinated the telephone survey and data collection. Both authors reviewed and approved the final version and take full responsibility for the content.

Ethical policy and institutional review Board statement

This retrospective observational study was conducted in accordance with the ethical standards applicable to retrospective studies using routinely collected clinical data. Formal IRB approval was not required under the applicable institutional policy for retrospective observational studies using routine clinical follow-up data, in accordance with Israeli Ministry of Health Procedure No. 14, under the category of 'research using existing data and questionnaires.' The study involved

only the analysis of fully data collected through a structured routine postoperative follow-up survey. No intervention, additional procedure, physical examination, medication, radiation exposure, administration of any chemical, biological, radiological, or pharmacological substance, or change in patient care was performed for research purposes.

Declaration of patient consent

Informed consent was obtained from all participants.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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List of abbreviations

AMRP	Athletic Muscles Rehabilitation Program
SH	Sportsman's hernia
AP	Athletic pubalgia
SH/AP	Sportsman's hernia/athletic pubalgia
TEP	Totally extraperitoneal
TEP-RRT	Totally extraperitoneal release-and-reinforce technique
AWBE	Isometric active weight-bearing exercise
CMSCE	Core muscle stability and coordination exercise
IRB	Institutional Review Board

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