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INGUINAL SYMPTOMS NOT TO BE MISSED: INGUINAL HERNIA IN ATHLETES. A NARRATIVE REVIEW

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ABSTRACT

Inguinal hernia (IH) represents one of the potential causes of groin pain in athletes and should be distinguished from sports hernia, which lacks a true fascial defect despite presenting with similar clinical symptoms. This narrative review summarizes the current evidence on IH in athletes, with particular emphasis on epidemiology, risk factors, distinction from sports hernia, treatment strategies and their implications for postoperative recovery and return to sport. The review was based on nearly 60 scientific articles retrieved from PubMed, Scopus, Web of Science and Google Scholar databases, including meta-analyses, systematic reviews, cohort studies, case-control studies and original research. Owing to the heterogeneity of study designs and outcome measures, the available evidence was synthesized qualitatively without meta-analysis. Current evidence indicates that the development of IH is influenced by a combination of individual factors, with potential contribution from external factors such as exposure to increased intra-abdominal pressure. Management strategies range from watchful observation in selected patients to surgical repair using open or laparoscopic techniques. Minimally invasive approaches are generally associated with faster recovery, however, reported outcomes regarding return to sport remain heterogenous, and current technique choice recommendation are largely based on individual surgeon experience rather than standardized guidelines. Overall, IH in athletes requires accurate diagnosis and individualization of management. Although laparoscopic repair appears to facilitate earlier recovery and return to sport compared with open techniques, further high-quality studies are needed to establish uniform, evidence-based recommendations, particularly regarding postoperative activity restriction and return to sport protocols.

KEYWORDS

Inguinal Hernia, Athletes, Groin Pain, Hernia Repair, Herniorrhaphy, Return to Sport

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1. Introduction

An inguinal hernia (IH) is defined as the displacement of intra-abdominal contents through a defect in the abdominal wall within the inguinal canal and constitutes one of the most common indications for elective surgical intervention in the European Union [1, 2]. IH are classified into two main types depending on their anatomical location relative to the inferior epigastric vessels (IEV). An indirect IH passes through the internal inguinal ring, lateral to the IEV, whereas a direct IH protrudes through the posterior wall of the inguinal canal, medial to the IEV. A common anatomical characteristic of both entities is that their orifices are positioned superior to the inguinal ligament [1]. In athletes, groin pain is a frequent complaint, and IH represents one of the potential underlying causes with a broader differential diagnosis of exercises-related groin pain. [3] High global prevalence of IH combined with repetitively elevated intra-abdominal pressure (IAP) and regular exposure for activities needing higher physical effort [4,5], should heighten clinical awareness, particularly in individuals with coexisting other individual risk factors [6]. The disorder typically presents as a palpable groin bulge accompanied by discomfort or pain, which may limit or even preclude athletic performance. In athletes, IH may also manifest primarily as exercise related groin pain without a clearly visible bulge, and the diagnosis is therefore established during the differential diagnostic work-up. [7] A wide range of treatment options is currently available, including conservative “watchful waiting”, open tissue and tension-free (mesh-based repair) techniques, as well as minimally invasive laparoscopic and robotic approaches [8]. This review aims to summarize current evidence on the occurrence, risk factors and the outcomes of different management strategies for IHs in athletes with specific emphasis on their implications for return to sport.

2. Methodology

We analyzed over 50 scientific articles indexed in the PubMed database, supplemented by selected papers from Scopus, Web of Science and Google Scholar. The review included meta-analyses, systematic reviews, cohort studies, case-control studies and original research focusing on IH in athletes, including epidemiology, risk factors, treatment strategies and postoperative recovery process, regarding return to sports activities.

The collected data were synthesized and organized according to the key aspects of the manuscript: definition of the IH, distinction between true IH and sports hernia, epidemiology, individual and biomechanical risk factors, treatment strategies (conservative management, open and minimally invasive surgical techniques) and postoperative recovery process, including return-to-sport outcomes. Results were presented in a structured narrative format to enable clear comparison and interpretation of current evidence.

3. True inguinal hernia and sports hernia. A clinical distinction.

When discussing IH in athletic populations, it is essential to clearly distinguish true IH from sports hernia (athletic pubalgia), as these represent two separate clinical entities (Figure 1.) [1,7,9]. In contrast to true IH, which has been defined above, sports hernia is a chronic exertional groin pain syndrome without a true fascial defect or hernia sac [9, 10]. Symptoms of sports hernia are the result of functional insufficiency or injury of the posterior inguinal wall and muscular imbalance between the anterior abdominal wall (rectus abdominis, internal oblique and transversus abdominis) and adductor group, particularly adductor longus [9, 10]. Differentiation is therefore primarily clinical and supported by imaging. True IH shows a definable defect of the abdominal wall with a hernia sac, whereas sports hernia shows no discrete herniation, with possible MRI findings such as rectus abdominis and adductor longus tendinopathy, bone marrow edema in region of pubic symphysis or abnormalities of the rectus abdominis-adductor aponeurotic complex. [11, 12]

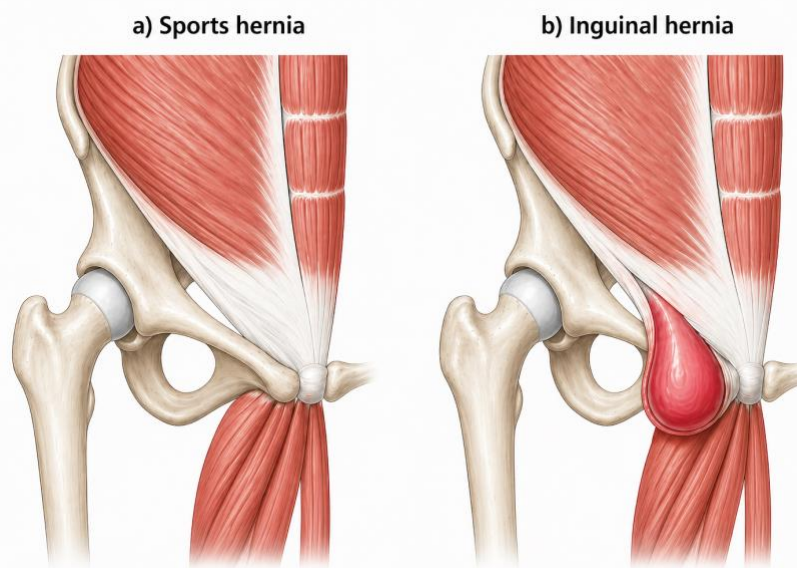


Fig. 1. Comparative overview of true inguinal hernia and sports hernia.

4. Epidemiology

Overall prevalence of IH was estimated at 7.7% (95% CI, 6.06 - 9.34) based on ten population-based studies included in a systematic review and meta-analysis by Abebe et al. encompassing over 51 million individuals. Prevalence varied geographically, ranging from 4.7% in the Americas, 6.1% in Europe to 12.7% in Asia, and was substantially higher in males (9.61%; 95% CI, 6.46 - 12.76) than in females (1.31%; 95% CI, 0.36 - 2.26) [4]. This high prevalence is reflected in the number of surgical interventions: in the United States, an estimated one million IH repairs are performed annually [13], and across the European Union, IH repairs were performed at rates of approximately 142 - 231 operations per 100 000 inhabitants in 2022 [2]. In a cross-

sectional study conducted by Alqahtani et al., including 594 athletes in Saudi Arabia, the prevalence of IH was reported at 12.3%. In this study, IH was more frequently observed in male than in females, with a prevalence of 22.2% compared to 8.3%, respectively. Risk of hernia formation was also at least 3.46 times higher in individuals ≥ 25 years old [14]. In cohorts of athletes presenting with groin pain ($n=43$) analyzed by de Oliveira et al., IH has been identified in 20.9% of cases, representing the only non-orthopedic cause of symptoms. [15]. Furthermore, an imaging-based study by Vasileff et al., using dynamic ultrasound in athletes with persistent groin pain, demonstrated findings consistent with true IH in approximately 89% of symptomatic individuals. In the same study, individuals in asymptomatic control group demonstrated IH findings in approximately 5% of cases. [16]. In herniographic study by Kesek et al., involving 51 athletes, mainly soccer players, with chronic unclear groin pain, IH was identified in 12 individuals (23.5%), including 8 cases of direct and 4 cases of indirect IH. [17] Nevertheless, most available epidemiological data among athletes is derived from symptom-based or small cohorts which limit the ability to establish robust population-level estimates.

5. Risk Factors

5.1. Individual Predisposing Factors

The development of primary IH in adults is influenced by a range of individual predisposing factors. High-level evidence supports the role of male sex, increasing age, collagen abnormalities (decreased collagen type I / type III ratio); family history of IH; history of prostatectomy and low body mass index. Other factors recognized as clinically relevant include primary hernia type (bilateral association of indirect and direct subtypes, meaning that a hernia on one side increases the risk of hernia occurrence on the opposite side), increased systemic levels of matrix metalloproteinase-2 (MMP-2), connective tissue disorders (such as Ehlers-Danlos syndrome), race (lower incidence in Black populations), chronic constipation, tobacco use, socio-occupational factors (including physically demanding work type, repetitive trunk movements, occupational class, access to healthcare) and heavy lifting or workload. Factors such as pulmonary diseases associated with chronic cough (such as COPD), liver disease, renal disease, and alcohol consumption [1, 4, 18-20], higher total activity index, coexisting hiatal or umbilical hernia, rural residence and greater height in women [21] may also contribute to risk, forming part of the overall susceptibility to the primary IH.

5.2. Biomechanical and Training-Related Factors

Evidence regarding the causative role of occupational and recreational physical exposures remains limited [22]. However, biomechanical risk factors are potential activity-related contributors to the development of IH in athletes [6, 23, 24]. In this context, biomechanical forces exhibit a multifactorial nature, forming a dynamic system whose interaction with the abdominal wall is not yet fully understood [25]. Repetitive increases in IAP, with transient peaks during high-intensity activities, generate forces acting on the posterior inguinal wall leading to fascial stress and progressive structural weakening of the inguinal canal [24, 25]. Biomechanical analyses suggest that IAP is highly movement-dependent, with increases observed during dynamic trunk loading conditions, particularly under greater trunk velocity and asymmetrical loading [26]. Another potential biomechanical factor is exposure to strenuous events (occasional, repetitive or even single episodes), for which the current evidence remains inconclusive [27].

The number of studies evaluating IH in athletes is limited and predominantly observational, which does not allow for a reliable assessment of individual sports as risk factors for true IH. Currently available data are derived from cohorts engaged in field-based sports such as football, while herniographic studies have focused on symptomatic athletes, also mainly participating in field sports [14,17]. Sports that frequently involve the Valsalva maneuver, performed to enhance core stability, such as weightlifting, may be associated with additional exposure to raised IAP [28]. On the other hand, these sports are also typically associated with substantial strengthening of abdominal wall muscles, which may counteract the potentially harmful effects of increased IAP [14]. Current evidence indicates that weightlifters do not have an increased risk of IH development [1].

Taken together, the biomechanical pathology of abdominal wall results from an imbalance between applied mechanical stresses, driven by IAP and muscle activation, and the tissue's intrinsic elastic capacity to resist deformation. [29]

6. Treatment Strategies and Return to Sport

European Hernia Society (EHS) and subsequent HerniaSurge Guidelines recommend surgical repair for symptomatic individuals with IH. The decision to undergo elective surgery in this group is primarily based on high risk of hernia incarceration or strangulation, which may necessitate emergency surgical intervention, as well as the increased morbidity and mortality associated with urgent procedures when compared to elective repairs. All patients should be informed about the natural history of IH and risk of emergency surgery. Education regarding these consequences may reduce the avoidance of surgical treatment and contribute to increased social awareness, thereby supporting a more comprehensive model of hernia care. [7]

The choice of surgical technique is a complex issue, representing a significant clinical challenge. The optimal operative approach should be associated with a low risk of complications, including postoperative pain (acute and chronic) and recurrence, while allowing for rapid recovery and return to physical activity. The selection between open tissue repair (non-mesh), open mesh-based, and minimally invasive laparoscopic techniques is based on a multifactorial assessment. The most important factors influencing the choice of primary hernia repair technique are summarized in Table.1. [8]

Table 1. Determinants of the choice of primary hernia repair technique.

Surgeon	- Surgeon expertise - Local resources
Patient characteristics	- High preoperative pain - Gender - Comorbidity - Previous medical history - Occupation - Physical activity - Age - Contraindications for general anesthetics
Hernia characteristics	- Size - Type - Reducibility - Unilateral or bilateral
Emergency situations	- Incarcerated hernia - Strangulated hernia

6.1 Conservative management

“Watchful waiting” (WW) is a non-operative, symptom driven strategy based on careful clinical observation rather than immediate surgical repair. It involves periodic clinical reassessment and patient education regarding warning signs, such as increasing groin pain, functional limitation, irreducibility or acute symptoms onset, which may indicate the need for urgent surgical intervention. [1,7] Evidence from systematic reviews and randomized controlled trials shows that WW is a safe initial strategy in selected patients. WW may be considered in asymptomatic or minimally symptomatic men, as available evidence indicates that risk of acute complications such as incarceration or strangulation in this subgroup is low [7].

Nevertheless, a substantial proportion of these patients will eventually require elective surgical intervention [1,30-32]. In pooled analyses including 1,755 patients, approximately 27.1% crossed over to surgery, with about 50% requiring operation within 5 years and up to 96% at 12 years of follow-up. [32] Long term randomized data confirm similar findings, with cumulative crossover rates of 28.7% at 1 year, 51.5% at 5 years, and 70.6% at 10 years. [31] In 12-years follow-up study, the overall crossover rate reached 54.2% with higher rates in mildly symptomatic compared with asymptomatic patients (71.7% vs 60.4%), and a median time to crossover of approximately 2 years vs 7 years respectively. [30] Across studies, the main reason for conversion to surgery is pain progression, accounting for 57-66% of cases, while incarceration remains uncommon at approximately 3.9-4.4% of cases. [30-32]. Importantly, delayed surgery after initial WW has not been associated with increased complications ratio, regarding recurrence and postoperative pain. Quality of life is generally similar between WW and early repair, although WW shows higher rates of long-term pain

or discomfort [30]. In women, an observational strategy is generally not recommended due to the risk of misdiagnosis of femoral hernias, which are associated with a high risk of complications. [1,7] Evidence regarding safety of WW in symptomatic men remains limited and current recommendations favor surgical management in this population. [7] Overall, in some specific groups, as mentioned above WW may be a reasonable option, however, in athletic populations it may not be the optimal choice with respect to participation in sports, due to potential limitations in comfort and symptom exacerbation during physical activity.

6.2 Open surgical repair

Open IH repair techniques are divided into two main groups: tension-free repairs using synthetic mesh and suture repairs, utilizing the patient's own tissues [1]. In general, suture techniques are not routinely recommended, as they are associated with a recurrence risk of approximately 50 – 75% when compared with mesh-based methods [7, 33]. Therefore, suture methods are reserved for selected cases in which mesh use is contraindicated (e.g. high risk of contamination, patient refusal) or in situations where mesh implantation is technically not possible [7]. The Shouldice technique is the recommended tissue-based technique associated with the lowest recurrence rates among all suture techniques [34]. However, surgical outcomes of Shouldice repair are strongly dependent on operator experience, which plays a pivotal role in optimizing overall surgical effectiveness of this method and reducing the incidence of postoperative complications. [1,7].

Mesh-based techniques are recommended for IH repair, primarily due to its markedly lower risk of recurrence, as previously highlighted. This is reflected in the reported international practice patterns from the GLACIER (Global Practice of Inguinal Hernia Repair) international survey of 1014 surgeons across 81 countries, where open mesh repair was the preferred method of inguinal repair, being selected by 42.7% of participants [35].

In the same survey study, nearly 90% of surgeons favored the Lichtenstein technique [35], based on the onlay placement of a flash mesh, regarded as the gold standard in open IH repair [7, 36]. Other open mesh repair modifications include techniques such as plug repair, which consist of insertion of a conical mesh device into the internal inguinal ring, or the Prolene Hernia System (PHS), which combines a preperitoneal and onlay mesh component. Based on high-quality evidence from the meta analyses comparing Lichtenstein repair with PHS and plug techniques, the PHS is associated with increased technical complexity and a higher risk of postoperative complications, whereas plug repair shows no additional clinical benefits across most analyzed outcomes [37, 38]. Therefore, both plug repair and PHS are not recommended over the standard Lichtenstein method [7].

Trans-inguinal preperitoneal (TIPP) is the anterior open approach technique, extended with meticulous dissection of an additional working plane, also allows for mesh placement in the preperitoneal space. Within 1-year follow-up period, TIPP may be associated with reduced acute postoperative pain, a lower incidence of chronic pain and faster recovery while demonstrating comparable efficacy to the Lichtenstein technique [7, 39-41]. TIPP remains subject of ongoing investigation to provide robust comparative evidence against Lichtenstein repair and laparoscopic approaches. In contrast, high-quality evidence on preperitoneal mesh placement, in terms of efficacy, safety and feasibility, is well established in laparoscopic approaches.

Additionally, meta-analytic data indicate that mesh-based repairs are associated with superior postoperative recovery outcomes, including a shorter time to resumption of daily activities and a lower incidence of persistent pain. These findings may suggest a more favorable and accelerated return to athletic training and sports participation following tension-free methods [33].

It should also be highlighted that, in contrast to laparoscopic techniques, open mesh repair can also be performed under local or regional instead of general anesthesia. Availability of such anesthetic strategies enables a more individualized perioperative approach based on patient characteristics, comorbidities and general anesthetic risk profile. Local anesthesia may also contribute to faster recovery and earlier return to daily activities, which are expected to be of particular importance in athletes [42].

6.3 Laparoscopic repair techniques

Laparoscopic IH repair techniques are based on the implantation of a mesh positioned in preperitoneal space. There are two main approaches to access this space: through abdominal cavity with a peritoneal incision – transabdominal preperitoneal (TAPP) or without opening the peritoneal cavity by creating the preperitoneal space between the abdominal wall muscles and the peritoneum, often in the assistance of a dissection balloon – totally extraperitoneal (TEP). Both approaches require general anesthesia. [1, 43].

Laparoscopic approaches should be considered in active young patients [7], as they are associated with reduced postoperative pain, earlier resumption of daily routine and faster return sports-related activity [43]. An additional advantage of minimally invasive laparoscopic techniques is the possibility of simultaneous bilateral hernia repair through the same incisions, which may preclude the necessity for a second surgical procedure and thereby prevent an additional period of training restrictions. Furthermore, in female patients, wide visualization of the operative field in techniques such as TAPP facilitates the identification of femoral hernias, which are more prevalent in this population and associated with a higher risk of complications. Thereby, TAPP approach reduces the risk of missed clinically relevant pathology. [1,7] These techniques are also specifically addressed in the guidelines for the management of recurrent hernias. A posterior laparo-endoscopic approach is recommended in recurrence following primary open anterior repair, according to the “opposite approach” strategy, which favors dissection within a tissue plane that remained unviolated during the initial procedure. [1,7, 43]

Meta-analyses comparing laparoscopic IH repair performed by adequately trained operators with the Lichtenstein technique shows comparable operative times with no significant differences in overall perioperative complication rates [1, 44, 45]. Overall complication profiles are broadly similar between open and laparo-endoscopic approach, including rates of seroma/hematoma, surgical site infection, testicular complications and mesh-related events. A low but clinically relevant risk of major vascular or visceral injury remains specific to laparoscopic techniques. Evidence regarding recurrence is heterogeneous, with studies reporting either comparable outcomes or a modest increase following laparoscopic repair [44, 45]. These findings are largely attributed to the greater technical complexity of laparoscopic approaches and the need for structured, supervised training programme to minimize the risk of such events [46,47]. Within these meta-analyses, laparoscopy is consistently associated with reduced early postoperative pain and faster recovery, despite a longer learning curve. [44,45]

TAPP and TEP demonstrate comparable outcomes in terms of overall complication rates, acute and chronic postoperative pain, recurrence rates and quality of life [43,48]. However, TAPP is associated with a slightly higher, although still very low, risk of visceral injury and port-site hernia, whereas TEP carries a marginally increased risk of vascular injury and a higher conversion rate to other method (open or TAPP). TEP is also characterized by a longer learning curve. Therefore, the choice of laparoscopic technique should primarily depend on the surgeon’s operative experience within a patient shared decision-making model. [1,7,48]

In recent years, a progressive expansion and increasing adoption of robotic-assisted surgeries has been observed. In herniology, predominantly utilizing the robotic TAPP (rTAPP). Compared with conventional laparoscopic TAPP, rTAPP is associated with a modest increase in operative time (approximately 18 minutes), without statistically significant differences in perioperative complication rates and without evidence of clear clinical superiority. [49] When compared with TEP, rTAPP is similarly associated with longer operative time and a potential reduction in postoperative pain, however, both techniques demonstrate comparable efficacy, safety profiles and recurrence rates. [50]

6.4 Postoperative recovery process

Surgeons’ recommendations on physical activity restrictions after hernia repair vary widely, however, recommendations are usually based on experts’ opinions and experiences rather than quality evidence [7, 51, 52]. What is more, no studies have shown that early return to normal activities increases the risk of recurrence or complications [7]. From a patient perspective, postoperative pain and fatigue are the main limiting factor for activity resumption, suggesting that recovery following IH repair is rather guided by individual tolerance to physical activity rather than rigid time-based period. In athletes, returning to sport is generally described using a three-step model: return to participation (RTP), return to sport (RTS) and return to performance (RTP), with progression defined by sport type and desired level of competition [53]. This framework has limited applicability following herniorrhaphy due to inconsistent recovery recommendations and poorly defined activity restrictions. The HerniaSurge guidelines indicates that return to physical activity, including sport, is

commonly allowed within approximately 1-3 weeks postoperatively [7]. However, the training intensity details are not provided in these guidelines, leaving uncertainty regarding the appropriate progression from low-demand to higher-intensity or competitive sports.

The systematic review by Harmankaya et al., which included 91 studies - 50 addressing convalescence after Lichtenstein and 58 after laparoscopic repair - revealed substantial heterogeneity in time to return to sports activities. In studies concerning Lichtenstein repair, restrictions on sports-related activities were evaluated only in 16% of studies, ranging from immediate resumption to 84 days and a median of 7 days (IQR 0-29). For laparoscopic repair, restrictions on sports-related activities were evaluated in 28% of studies and were generally less restrictive, with a shorter upper range (up to 30 days) compared with Lichtenstein repair (up to 84 days), although the median restriction period was 12 days (IQR 0-30). Additionally, one study included in the analysis stated that restriction should apply primarily to contact sports, allowing an earlier return to low-demand sports activities, however, no specific duration was provided. [51]

In a prospective cohort of 86 patients, Schrenk et al. compared Shouldice (n = 34), TAPP (n = 28) and TEP (n = 24) repairs and reported differences in recovery times to pain-free activities across techniques. Mean time to pain-free walking was approximately 8.5 days in all groups, while stair climbing occurred at 13.0 days after Shouldice, 12.3 days after TAPP and 14.2 days after TEP. Return to cycling was observed at 29.6 days (Shouldice), 26.6 days (TAPP) and 27.4 days (TEP), whereas pain-free running was achieved at 29.5, 29.0 and 27.0 days, respectively. The shortest recovery times were generally observed after TAPP repair for stair climbing and bicycling and after TEP for running. [54]

Furthermore, Johansson et al., in the randomized multicenter study, including 613 male patients aged 40-75 years, compared conventional repair, TIPP and TAPP. At postoperative day 7 the proportion of patients reporting no pain-related restriction of physical activity was highest in the TAPP group (40.9%), compared with TIPP (28.5%) and conventional repair (19.4%). Consistently, severe discomfort limiting physical activity was reported in 11.6% of patients after conventional repair versus 4.6% after TAPP and 5.4% after TIPP, with these differences reaching statistical significance. [55]

In a randomized multicenter trial, Liem et al. found a faster return to athletic activity after laparoscopic TEP compared with open repair, with median times of 24 days (IQR 14-38) versus 36 days (IQR 24-44), respectively. [56] Consistently in the Coala Trial Group, analysis revealed that patients after laparoscopic repair returned to normal activities earlier (6 vs 10 days) and demonstrated superior early functional recovery. At 1 week postoperatively, laparoscopic patients achieved more repetitions in straight leg raises (14 vs 2) and curl-ups (16 vs 7), alongside significantly higher of daily living scores (ADL) - 89 vs 72. [57]

Fujita et al., in a prospective non-randomized study including 253 patients treated with either laparoscopic repair (TEP patients - 92; TAPP - 18 patients) or tension-free open repair (143 patients), evaluated return to athletic activity in a subgroup of patients aged < 65 years (laparoscopic - 21 patients; open - 19 patients). The mean time to resumption of athletic activities was 9.19 ± 1.18 in the laparoscopic group, compared with 12.05 ± 1.25 days in the open repair group. However, this finding did not reach the threshold of statistical significance. [58]

Finally, Dirksen et al., in a randomized controlled trial including 175 patients (Bassini technique - 87 and TAPP - 88 patients), found a significantly shorter time to return to physical activity after laparoscopic repair, occurring at 17 ± 12.2 days (range 1-43) compared with 27 ± 12.6 days (range 1-57) after Bassini repair ($p < 0.001$). [59]

Overall, the available evidence shows a consistent trend toward earlier return to physical activity and sport after laparoscopic compared with open IH repair. However, there is a marked variability in reported convalescence periods and recovery times, reflecting heterogeneity in the study design and outcome definitions, as well as difficulties in standardizing return-to-sport recommendations. This is mirrored in clinical practice: in a survey by Kulacoglu et al., 92.7% out of 447 questioned surgeons, always or usually provide specific advice on activity restriction when asked, yet about two-thirds consider the evidence insufficient and 82.9% call for specific guidelines. [52] As Harmankaya et al. additionally noted, inconsistent convalescence recommendations may lead to unnecessarily prolonged avoidance of work and physical activity [51], representing a further argument for the need to establish more precise recommendations in this field.

7. Conclusions

IH may represent one of the causes of exercise-related groin symptoms in athletes and therefore requires careful differentiation from other entities responsible for groin pain such as sports hernia. Although laparoscopic repair is generally associated with earlier recovery and faster resumption of physical activity compared with open techniques, considerable variability exists in reported convalescence timelines for return-to-sport recommendations. This heterogeneity, together with the lack of standardized criteria for postoperative activity restrictions, highlight the need for more structured and evidence-based guidance to optimize safe and timely return to athletic activity.

Author's contribution: Conceptualization JA, BC, MZ, AS; methodology JA, BC, MZ, WW, KZ; software JA, AB, ABl ; check BC, MZ, WW, AH; formal analysis JA, BC, MZ; investigation JA, BC, MZ, WW, MM, AB, AS, KZ, AH, ABl; resources WW, MM, AH; data curation BC, MZ, AB, ABl; writing - rough preparation JA, BC, MZ, WW; writing - review and editing JA, BC, MZ, WW, MM, AB, AS, KZ, AH, ABl; visualization BC, AB, AS; supervision JA, BC; project administration JA. All authors have read and agreed with the published version of the manuscript.

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