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Successful treatment of groin pain syndrome in a pole-vault athlete with core stability exercise: a case report

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Abstract

CONTEXT: The purpose of this case report is to present a case of groin pain in a pole vault athlete describing the biomechanical features of the injury’s mechanism, acute medical management, and its successful rehabilitation. CASE REPORT: A 22 years old professional pole-vaulter sustained an injury during a regular training session. The athlete reported significant left lower abdominal and left proximal adductor discomfort in all activities, including basic trunk motion when moving in bed, sit to stand, and walking, and was unable to return to the regular training. Clinical evaluation and imaging studies addressed the injury to a case of adductor-related groin pain associated with pubic symphysis degeneration. Treatment consisted of an exercise-based therapeutic protocol based on trunk and core muscle strengthening and stability program, with progressive motor and functional demands. RESULTS: Significant improvements in the overall clinical findings and functional outcomes were reported after 52 days of intervention when the athletes returned to his full athletic activity. CONCLUSION: These results suggest that an appropriate rehabilitation program, focused on trunk and core musculature stability exercise addressing to sport-related specific demands, should be considered as an optimal conservative method in the multidisciplinary approach for treatment of groin pain and prior to any surgical intervention.

Key words: functional training, muscle asymmetry, rehabilitation.
**Context**

Groin pain is a common syndrome of persistent pain from chronic, repetitive trauma or mechanical stresses involving the pelvic joints and many musculotendinous structures that cross the anterior pelvis.\(^1\) The incidence has been reported as high as 5% of all athletic injuries\(^1-4\) but is often poorly understood given its potentially complex etiologies. It occurs most commonly in sports that require a combination of sudden **and sharp movements including cutting and change of direction actions** involving the hip adductor and the abdominal musculature.\(^4-6\) The recurrent mechanism of injury is the chronic tensile overload of the pelvis structures and the associated muscular attachments.\(^4-6\) Based on the available literature, adductor muscle weakness, greater hip adductor to abductor strength ratio, sport specificity of training and amount of preseason sport specific training are the targeted individual risk factors in groin strain injury.\(^2,4,5,7-9\) The management of groin pain consists of multidisciplinary conservative measures including pharmacological, physical rehabilitation (i.e., soft tissue mobilization techniques, joint manipulation techniques to the pelvis and manual stretching) and instrumental therapies (i.e., laser therapy, diathermy or heat therapy with resistive to capacitive system, extracorporeal shock) balancing each other and depending on the clinical phase\(^5,10\) and tailored individually to each athlete.\(^4,5,11,12\) **Athletes commonly follow the conservative protocol steps, where the primary focus is the pain control and the reduction of any edema, and then the ability to perform correctly exercises with adequate levels of motor control and core stability.**\(^13\) Therapeutic exercises should aim to restore normal
range of motion and correct abnormal shear forces across the pelvis generated by relative weakness of any of the major muscle groups attaching around.\textsuperscript{5,14,15}

In this scenario, core stability and trunk stabilization exercises are likely to be useful for groin injuries rehabilitation, since they address the contextual and synergic strengthening of abdomens, adductor and lumbar muscles. In fact, considering the anatomical (position, attachments, length, path and relationship with the other musculo-skeletal structures) and neurophysiological features (fiber type and motor recruitment) of the trunk and core muscles, exercises targeting the deep abdominals produce a “corset” type action to support and stabilize the abdominal wall. Interestingly, Cowan et al.,\textsuperscript{16} demonstrated the stabilizing role of the transversely oriented abdominal muscles (i.e., Transversus Abdominis (TrAb) and Internal Oblique (IO)) at the anterior pelvic ring during voluntary movements, thus suggesting that optimal control of these muscles may be a desired outcome for the treatment of long-standing groin pain. The same authors reported that, in individuals with long-standing groin pain, the onset of TrAb resulted delayed when compared with the that of uninjured control subjects, thus hypothesizing that this change in coordination of TrAb muscle activity may leave the pelvic ring unprotected from shear forces. Moreover, TrAb resting thickness was proven to be smaller in athletes with longstanding adduction-related groin pain and may thus be considered as a risk factor for recurrent groin injuries.\textsuperscript{17} Previous studies, measuring trunk and core muscles activity by the mean of intramuscular and surface EMG, demonstrated that trunk and core stability exercises were most able to activate both the local deep and the global
superficial muscular stabilization systems. With this in mind, Hölmich et al. proved that an active training program based on core stability and balance exercises was very effective in athletes with long-standing adductor related groin pain. These evidences might be useful when trying to understand any dysfunction in postural control and when designing rehabilitation programs in that context. Finally, when all the previous therapeutic strategies have failed surgical intervention may be necessary. We report a case of adductor-related groin pain treated with core stability and trunk stability with complete resolution of symptoms, and discuss the potential roles and advantages of this rehabilitation methodology.

Case report
At the time of injury, the athlete (age 22.5 years, height 1.82 m, mass 71.2 kg) was a pole vault athlete with an experience of 4 years in national and international competitions. He was in a healthy status with no history of acute groin pain or abdominal injury reported previously to this incident. The injury occurred in the first week of June 2014, during a training session with the athlete performing a pole vaulting jump. The athlete reported that he was approaching the transition phase between the take-off and the pole bending with the pole already planted in the take-off box (Figure 1). During this phase, as consequence of a technical mistake, the athlete’s trunk was forced into extension followed by left hip abduction and extension as his weight was erroneously transferred medially (Figure 1).
Following this unsuccessful approach, the subject’s trunk and upper body moved into sudden flexion as he struggled to recover and maintain his balance. The athlete reported experiencing an immediate sharp pain in the lower abdomen and left adductor region. The day after, the athlete reported significant left lower abdominal and left proximal adductor discomfort in all activities, including basic trunk motion when in bed, sit to stand, and walking. The clinical evaluation was performed by two medical entities, one orthopedic specialist and one physiotherapist in order to ensure inter-observer reliability of the clinical findings. Specifically, negative responses during a Flexion-abduction-external rotation (FABER) and Flexion-adduction-internal rotation (FADIR) tests excluded hip joint injury as possible causes of the groin pain. The absence of pain on resisted hip flexion and on stretching of the hip flexors excluded a case of Iliopsoas-related groin pain due to the Iliopsoas tenderness. Finally, Inguinal-related and Pubic-related causes of groin pain were excluded given that there was no palpable defect or hernia and the pain was not aggravated with resistance testing of the abdominal muscles and during a voluntary Valsalva maneuver. Conversely, Adductor tenderness and increased pain were reported on resisted adduction testing.\textsuperscript{21} Magnetic resonance imaging (MRI) demonstrated: 1) bone marrow edema around the articular disc of the pubic symphysis; 2) a secondary cleft sign; 3) edema along the insertion of the left adductor longus; 4) no significant abdominal findings (Figure 2). Additionally, dynamic ultrasonography (US) was performed to exclude an inguinal-related groin pain and confirmed the presence of adductor tendinopathy associated with early signs of pubic symphysis degeneration (Figure 3).
A diagnosis of adductor-related groin pain was formulated according to the aforementioned clinical findings and the imaging responses. The injury was initially managed conservatively with a variety of modalities:

- Pharmacological: oral NSAIDs.

- Instrumental therapies: laser therapy (pulsed Nd-YAG laser) aimed to promote tendon enthuses regeneration. All painful points of the adductor-tendon insertion at the pubic bone were treated with the probe in contact with the skin at 90° angle, receiving 0.9 mJ per treated point. This procedure was applied twice a week.

- Physical rehabilitation: postural balance techniques through global and site specific stretching re-education exercises of hip and abdominal muscles. The contract-relax technique was used. The stretching was repeated three times and the duration of each stretch was 30s. These exercises were performed on a frequency of 3 times a week.

After 4 weeks of multidisciplinary treatment, the rehabilitation protocol resulted in the following changes:

a) At rest, the referred pain decreased from 7/10 to 5/10, from 10/10 to 8/10 during the daily basic activities (bed mobility, supine to sit and reverse, ascent to stairs) but worsened during athletic activities thus limiting any training ability.

b) AROM differences between pre- and post-4-week of multidisciplinary treatment for the major hip muscles were: 3°, 3°, 2°, 1° and 1° for the flexors,
extensors, abductors, internal and external rotators, respectively. However, the athlete reported discomfort and pain in performing the assessment.

c) No strength testing were performed at this stage due to the athlete’s functional limitations.

Given the poor response to the above conservative regimen, a specialist consultation was obtained for possible surgical intervention. The surgeon recommended that he continue non operative treatment after confirming: absence of inguinal or femoral hernia, absence nerve entrapment (Obturator, Ilioinguinal, Genitofemoral) or avulsion fracture (Anterior superior iliac spine, Anterior inferior iliac spine, Pubic bone). At this point, we felt that additional and intensive rehabilitation program was warranted. The athlete was fully informed about the procedures, the nature, and the associated risks and benefits of the exercise-based therapeutic protocol, and gave voluntary written consent to be treated. Additionally, the subject was informed that the data concerning the case would be matter for possible publication.

Our rehabilitation program was organized in three phases and, at the beginning of each, referred pain, hip active range of motion (AROM), hip muscles strength and core musculature endurance were assessed. The Numeric Pain Rating Scale (NPRS) was used to measure the pain intensity at rest, during regular daily activities, and during sport activities. Accordingly, pain level was rated with a verbal analog scale from 0 to 10, where 0 represents an absence of pain, and 10 represents the worst pain imaginable. The AROM was assessed by the mean of a digital goniometer (Halo digital goniometer, Model 01131; Lafayette Instrument Company, Lafayette, IN). Maximal isometric hip strength (abduction, adduction,
lateral rotation, medial rotation) was measured using a handheld dynamometer (Model 01165; Lafayette Instrument Company, Lafayette, IN). Participants positioning during the maximal isometric hip strength tests followed the protocol of Bazett-Jones et al., as described below:

a) Hip abduction: participants were side-lying with 2 pillows between their legs and the test hip at approximately 0° of abduction; the handheld dynamometer was placed 5 cm proximal to the lateral condyle.

b) Hip adduction: participants were side-lying with the test side against the table at 0° of adduction and the opposite leg crossed over in front of the testing leg; the handheld dynamometer was placed 5 cm proximal to the medial condyle.

c) Medial hip rotation: participants were seated with knee and hip flexed at 90°; the handheld dynamometer was placed 5 cm proximal to the lateral malleolus.

d) Lateral hip rotation: participants were seated with knee and hip flexed at 90°; the handheld dynamometer was placed 5 cm proximal to the medial malleolus.

For each test, we used a non-elastic strap to secure the handheld dynamometer 5 cm proximal to the end of the distal joint segment. The athlete performed three maximal isometric trials against the non-elastic strap in each testing position. We also used a sliding caliper (Model 01293; Lafayette Instrument Company, Lafayette, IN) to measure thigh (distance from the greater trochanter to the lateral femoral epicondyle) and leg (distance from the medial femoral epicondyle to the medial malleolus) lengths for subsequent muscle-torque computation. The same experienced observer performed all the analyses to avoid inter-observer variability. Handheld dynamometry was chosen because previous report documented high reliability (ICC 0.87-0.98 for
all values) for measurement of hip strength, and the wide availability of handheld
dynamometers in clinical settings.27,28

Anterior, posterior, and lateral core muscular-endurance testing consisted of a single
time-to-failure trial in each position as described by McGill et al.29 The anterior,
posterior-extension and lateral bridge hold tests provide highly reliable measurements
of core musculature performance capabilities.29 These three tests were performed with
the following modifications: rather than using straps to stabilize the pelvis and lower
extremities for the posterior-extension hold test, manual stabilization was provided by
a physiotherapist, and the lateral-bridge hold test was performed with the top foot
resting on the lower foot, rather than with both feet in contact with the floor. A flow
chart describing the injury diagnosis process, the treatment and the rehabilitation
program is represented in Figure 4.

***Figure 4 near here***

The overall rehabilitation program was designed to address the main
impairments in: pain during daily and specific pole vault activities, joint
mobility, AROM or a combination of both, strength and stability levels of the
muscles surrounding the hip and the pelvis. The protocol was designed according
to the guidelines of Wollin and Lovell13 with several critical modifications.
Specifically, the overall rehabilitation process included therapeutic exercises aiming
to recruit the targeted muscles in a functional manner, similar to that required by the
whole body configuration and the skills demands of the pole vault discipline. The
protocol was approved by the Institutional Review Board, presented by oral and
written instructions at all rehabilitation stages and the athlete gave informed written consent. The athlete was reassessed at the end of each phase and moved through the further steps after been able to perform the exercises adequately, with improved levels of hip muscles’ strength and greater scores of core stability endurance. A summary of the clinical findings, outcomes and all exercise by stage are shown in Table I and Figure 5a-c.

Rehabilitation Program

Phase 1 - Core and trunk stabilization

The subject performed the rehabilitation program 5 days a week. The treatment initially focused on exercises in isometric modality aimed to achieve synchronized co-contraction of the different muscle groups around the pelvis. Once the athlete was able to tolerate and control basic exercises, an additional strengthening program was initiated to address weaknesses in trunk, hip and pelvic muscles. Criteria for advancement to Phase 2 of rehabilitation included verbal pain scale rating of “0”, pain-free basic activities including ambulation and climbing of stairs. Phase 1 of rehabilitation lasted ten days.

Phase 2 - Core strength and stability progression

During this phase, the subject performed the rehabilitation program 4 days a week. Additionally, two low impact aerobic sessions (30 minutes each at 70% of the maximal Heart Rate (HRmax) previously calculated during an algometric test for medical clearance), on a cross trainer machine, were included in order to restore basic metabolic capacities and stimulate the musculoskeletal system in an upright position.
The activity progression incorporated reciprocal upper and lower extremity motion with resistance bands (Model Slastix Pro, Stroops™, Clearfield, UT, USA), and progressive exercise stressing multiple planes of motion (see Figure 3) while controlling stability of the trunk and pelvis. Criteria for advancement to Phase 3 included a verbal pain rating of minimal (1-2 on a scale of 0 to 10) with moderate effort exercises, pain-free progression during standing stability exercises. Phase 2 of rehabilitation lasted fourteen days.

**Phase 3 - Functional progression and return to sport**

The third phase of the rehabilitation program included 4 sessions a week. It began when tolerance to all advanced stability exercises was achieved without pain in erect postures and through exercises overloading the tendon muscle system in a “Functional standing position”. Specifically, the muscle strengthening was realized with the body assuming specific postures, similar to those usually involved during the athlete’s performance. Additionally, on field rehabilitation began with straight running of approximately 40% effort for a time period of 30 minutes twice a week. Each subsequent session addressed advancing of running time, increasing subject effort, and adding skills. The subject was progressed to 45 minutes on the second week, and skills were advanced to include forward skipping, bouncing and low intensity plyometric (≈ 50%). By the third week, the effort level was increased to 60% of maximum, field time to 60 minutes including single leg continuous jumps, hurdles training and specific pole vault jumps up to an height around 60% of the athlete’s best performance. In the fourth week, the primary goal was to increase
effort toward 90% of maximum and to return the athlete to a complete pole vault training session. This field progression lasted additional 10 days and, overall, the entire duration of the Phase 3 of rehabilitation was 28 days. It should be reported that the subject continued a maintenance stability warm-up program prior to each training session for the rest of 2014-2015 season.

***Figures 5a-c near here***

Statistical Analysis

For the intra-test reliability, the typical error of measurement, expressed as a Coefficient of Variation (CV%), was determined for the hip AROM and hip strength tests measures. Knowledge of the Standard Error of Measurement (SEM) allowed the calculation of the minimal detectable change at the 95% confidence interval (MDC95). The MDC95, calculated as $\text{MDC}_{95} = \text{SEM} \times \sqrt{2} \times 1.96$, reflects the minimum amount of change in the measurement that would be required to exceed the level of measurement error.$^{30}$

Results

The clinical findings, motion testing outcomes and physical performance measures are shown in Table I. The MDC9s of the clinical measurements were: 4.3 (4.2-4.4) for hip flexion AROM, 6.2 (6.1-6.3) for hip extension AROM, 4.1 (4-4.2) for hip abduction AROM, 6.3 (6.2-6.4) for hip internal rotation AROM, 5.6 (5.4-5.8) for hip external rotation AROM, 0.33 (0.31-0.34) for hip abduction strength, 0.27 (0.26-0.29) for hip adduction strength, 0.055 (0.052-0.058) for hip internal rotation strength, 0.08 (0.07-0.09) for hip external rotation strength, 5.5 (5.2-5.8) for anterior
core endurance, 6.3 (6.1-6.6) for posterior core endurance and 4.7 (4.6-4.8) for lateral core endurance. The level of pain in daily and athletic activities decreased progressively through the rehabilitation period (Table I). AROM of the involved leg progressively increased during the 52 days of intervention up to normative and symmetrical values at the end of the Phase 3 (Table I). In addition, the strength values of the assessed hip muscles increased between 10% and 32% in the uninvolved leg and between 43% and 73% in the involved leg. Improvements in the core endurance assessment ranged between 63% and 89%.

Finally, the subject returned to train with no decrease in performance or achievements, and kept his previous national ranking.

***Table I near here***

**Discussion**

Although, the incidence of groin pain in athletes is high,\textsuperscript{1,3} to our knowledge this condition had not been previously reported in pole vaulter. The rehabilitation program implemented in this case report emphasized lumbopelvic stabilization based on incorporation of trunk and core muscle control into functional return to sport.

Studies investigating the biomechanics of the support leg during the pole-vault take-off phase reported kinetic response characterized by great values of the ground reaction forces (GRF).\textsuperscript{31,32} Passive peak vertical forces equal to 10.2 times the body weight and vertical impulse of 228 Ns occur at contact, highlighting the requested ability of athletes to overcome high impacts over less than 150ms. In addition, in pole vault take-off more emphasis should be given to forward than to upward direction to
determine the efficient trajectory of the athlete’s center of mass (COM). Anterior-posterior horizontal forces range between 2.8 and 5 times the body weight, with the athlete trying to produce a forward angular moment and an optimal configuration of body segments during the next phases of the vault. Conversely, the pattern of medio-lateral horizontal forces, as well as impulses, is not often discussed, possibly because of their lower magnitude. Nevertheless, an abnormal development of medio-lateral forces, and horizontal-shear forces in general, may represent the primary pathomechanical factor leading to pelvic insults.\textsuperscript{4,6} In fact, when training for specific sport tasks, athletes are forced to use their lower limbs unilaterally in almost all skills; this alters the strength balance between synergistic muscles or between agonist/antagonist muscle groups. Thus, consistent asymmetrical workloads and functional adaptations gradually induce asymmetries in the myodynamic characteristics of the athlete. In turn, specific kinetic adaptations and strength asymmetries are suspected to influence the degree of preexisting anatomic and functional asymmetries, thus leading to injuries.\textsuperscript{33,34}

The core muscles exert a functional role in postural control and stability during unilateral weight bearing.\textsuperscript{33,35} Core strengthening and stabilization is achieved through muscles’ synchronization and co-contractions occurring before initiation of limbs’ pattern movement, according to the mechanisms of anticipatory postural adjustment (APA).\textsuperscript{36} Indeed, co-contraction of the abdominal muscles has been reported to increase posterior-anterior spinal stiffness and may be effective to enhance pelvic and lumbar spinal stability.\textsuperscript{15} The procedural basis for our exercise protocol is similar to the “shutter” mechanism described by Condon.\textsuperscript{37} In fact,
considering the anatomical and neurophysiological features (attachments, path, fiber type and motor recruitment) of the trunk and core muscles, exercises targeting the deep abdominals produce a “corset” type action to support and stabilize the abdominal wall. This contraction produces a “bracing” effect throughout the lower abdomen to aid in stability of the lower trunk, pelvis and hips.

The findings of this case report are in line with those of Holmich et al., who demonstrated that young, active individuals with hip adductor pain, unable to participate in sport, benefited from supervised active rehabilitation protocols. These authors reported that 79% of the participants returned to their full athletic activities following rehabilitation programs performed 3 times a week and including hip, abdominal, core strengthening exercises and balance and coordination drills. Moreover, previous studies highlighted that exercise targeting the hip adductors of athletes with hip adductor-to-abductor strength ratios of less than 80% may be an effective means of decreasing incidence of groin strains. In light of these evidences, the outcomes achieved through our rehabilitation protocol, in terms of bilateral hip muscle symmetries and agonist/antagonist strength ratios, may also guide the design of training strategies with the intent to prevent recurrent injuries, since muscular imbalances and asymmetries are commonly identified as concurrent injury-risk factors.

Further, some authors have proposed training for the deep core muscles (i.e., TrAb and IO) as well as other muscles to stabilize the pelvis and, in turn to improve hip strength and decrease functional discomfort. In fact, it is well
known that delayed firing of the TrAb and IO is a common issue in patients with
instability or pelvic injuries and is generally addressed by a program promoting
pelvic strengthening and core stability.\textsuperscript{16,19} Therefore, training programs, which
consists of strengthening of the hip muscles, and both superficial and deep core
muscles are recommended since each of these muscle groups has been implicated
in groin pain syndrome etiology.

Several authors suggest including core exercises as regular training regimens aimed
to prevention and manage injuries since the core is central to almost all kinetic chains
involved in athletic activities.\textsuperscript{15,19} From a methodological point of view, it is
noteworthy that the activation patterns of trunk and core muscle are distinctly
dependent on the whole body position and orientation, the level of postural demands,
and the symmetry in the movements of the involved limbs. Accordingly, the local
stabilizing muscles respond with a delayed onset of activation while sitting with a
back support (i.e. less postural demand) than in upright standing, when performing
rapid upper arm movements.\textsuperscript{41} Moreover, despite the isometric and stabilization
nature of most of the trunk and core stability training, significant asymmetry in side-
to-side muscle activation was previously noted for some muscles in many common
exercises.\textsuperscript{18,36} Furthermore, the bilateral activation of the core muscles does not
reflect the normal motor pattern for rapid unilateral ballistic patterns of movement
and, therefore, the efficiency of symmetrical training methodologies is questionable
in individuals who require such fast actions (i.e., elite athletes). Conversely, a
centrally programmed diagonal postural pattern between postural segments has been
reported during APAs associated with asymmetrical movements such as pole vault
jumps. 36,42. The muscle synergies during asymmetrical arm movement are diagonal in the upper and lower limbs with correspondent co-activation in the trunk.43,44 The methodological approach used in our case report is in agreement with that of Woodward et al.,45 who suggested the inclusion of progressive peripheral extremity and postural demands, with incorporation of core control and functional drills into the rehabilitation program of a hockey player affected by groin pain. The exercises used in our rehabilitation protocol replicated the unique motor demands and muscle recruitment of pole vault actions (Figure 3). The exercises design and the progressive overload during core stability training should be referred specifically to performance-oriented goals.33,46 Indeed, our core strengthening program aimed to create a rigid anatomical cylinder around the skeletal and articular structures to limit the mechanical stresses experienced as a consequence of biomechanical perturbations. Finally, successful APAs strategies that recruit and involve the core musculature adequately and preventively may allow the upper and lower extremities to have a stable functional base of support for an efficient, successful and safe mobility.

The main limitations of this case report consists in the impossibility of generalizing its outcomes to larger and different athletic populations. This case report represents a single individual. A larger number of subjects would help to distinguish the effectiveness of such conservative measures in the treatment of groin pain. In review of the literature, no case studies were found specifically addressing conservative treatment of groin pain in pole vault athletes. While this patient responded exceptionally well to conservative methods, the authors do not
believe this is an exclusive treatment option. However, in our experience, conservative treatments similar to that outlined in this case report have proven successful in a number of different individual and team sport athletes with groin pain diagnoses. Therefore, an appropriate, successful rehabilitation program should be adapted and modified depending on the anatomic contributions to the injury and the patient’s response to each phase of the program.

**Conclusion**

An appropriate, successful rehabilitation program should be addressed and modified depending on the anatomic and mechanical contributions to the injury and the patient’s response to each phase of the program. Treatment of adductor-related groin pain, through trunk and core stability exercise is a suitable cost effective method to manage this syndrome. Successful rehabilitation should be based on patient outcomes measurement, and rely on the specific biomechanical demands of their sport. The current report may also help in developing stabilization training techniques that target the treatment of muscle imbalance and asymmetry as a risk factor for future injuries.
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Notes

Authors` contribution statement

With the submission of this manuscript, the authors state that:

Johnny Padulo contributed with his assistance with interpretation of data, drafting the article and final approval of the version to be submitted. Nicola Maffulli contributed with his critical revision inherent to important
intellectual content and final approval of the version to be submitted. Lior Laver contributed with his assistance with the interpretation of the clinical and functional findings and the final approval of the article.

**Conflicts of interest:**

There are no conflicts of interest in this paper.

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**Titles of tables and figures**

**Table I.** Summary of the clinical findings and outcomes by stage

**Figure 1.** Athlete’s body posture during injury event

**Figure 2.** MRI T2-Weighted axial view of the superior pubic ramus and pubic symphysis. The black solid arrow shows bone marrow edema around the pubic symphysis. The black dot line shows edematous origin of the adductor longus origin at the left side.
Figure 3. Long-axis sonographic image of the adductor longus and pubic bone. The white solid line shows thickened origin of the adductor longus tendon at the left side (LT) when compared to the right side (RT). The white dot line shows cortical irregularities of the pubic bone on the LT compared to the normal RT.

Figure 4. Flow chart of the injury diagnosis process, treatment management and rehabilitation program.

Figure 5a, b, c. Therapeutic protocol at Phase 1 (a), Phase 2 (b), Phase 3 (c).