Role of low-field magnetic resonance imaging in the detection of floating meniscus sign as consequence of sport-related trauma

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SUMMARY

Aim. To assess the role of magnetic resonance (MR) imaging performed with a low-field scanner in the detection of floating meniscus sign as a consequence of sports-related trauma.

Methods. Retrospective review of 2436 MR knee examinations executed, in 18 months, using a low-field scanner of 0.2T, was performed by three musculoskeletal radiologists of varying experience. Diagnostic criteria to define the presence of a complete floating meniscus were as codified in the literature. If the thickness of the fluid signal band between the meniscus and tibial plateau was comprised in the range \( \geq 3 \) mm and \( \leq 5 \) mm the floating meniscus was defined as partial. Patients with the sign were called to learn what treatment had been performed; in those submitted to surgery the surgical chart was evaluated.

Results. Floating meniscus was detected in 8/2436 cases (0.25%), 5 complete, arthroscopically confirmed, and 3 partial; in 5/8 cases the lateral meniscus was involved. Associated lesions were observed, ligamentous in 7/8 cases and meniscal in 2/8 cases; a bone bruise of varied extension was identified in 3/8 cases.

Conclusion. Floating meniscus sign could be detected at MR imaging although performed using a low-field scanner. Its presence should be carefully identified, especially in severe traumatic events, as it has some important prognostic implications.

KEY WORDS: Meniscocapsular separation - Meniscus - Magnetic resonance - Knee - Floating meniscus.

RIASSUNTO

Obiettivo. Valutare il ruolo della risonanza magnetica (RM) a basso campo nel riconoscimento del segno del “menisco galleggiante” in seguito a trauma riportato durante attività sportiva.

Metodi. Tre radiologi con varia esperienza in radiologia muscolo-scheletrica hanno analizzato retrospettivamente ed in consenso 2436 indagini RM di ginocchio eseguite in 18 mesi con apparecchiatura dedicata a basso campo con magneti da 0,2T. I criteri diagnostici utilizzati per la definizione del “menisco galleggiante” completo sono stati quelli codificati in letteratura. Il “menisco galleggiante” è stato definito parziale se lo spessore del liquido articolare tra menisco e piatto tibiale era \( \geq 3 \) mm e \( \leq 5 \) mm. I pazienti con il segno sono stati contattati per conoscere il tipo di terapia effettuata; in quelli sottoposti a chirurgia è stata valutata la relazione chirurgica.

Risultati. Sono stati identificati 8/2436 casi (0,33%) di “menisco galleggiante”, 5 completi, confermati all’artroscopia, e 3 parziali; in 5/8 casi il menisco interessato era quello laterale. Sono state osservate lesioni associate, ligamentose in 7/8 e meniscale in 2/8 casi; una contusione ossea di varia entità è stata identificata.

Conclusioni. Il segno del “menisco galleggiante” può essere identificato alla RM anche se eseguita con apparecchiature a basso campo. La sua presenza dovrebbe essere attentamente ricercata, specialmente nei traumi severi, avendo importanti implicazioni prognostiche.

Parole chiave: Disinserzione meniscocapsulare - Menisco - Risonanza magnetica - Ginocchio - Menisco galleggiante.
The knee is a special joint whose classification can prove difficult; a number of features of the femoro-tibial compartment may in fact be referable to the condyloid joints, others point to the angular ginglymus. While theoretically, in view of the conformation of the joint surfaces, one might think of extensive freedom of movement over all axes (transverse, sagittal and vertical), in effect the knee’s complex ligament system determines severe limitation, permitting movement exclusively on the transverse axis with flexo-extension.\(^1\) The stability of the knee depends on the manifold ligamentous components that comprise it. Apart from the central pivot, made up of the cruciate ligaments, an equally important part is played by the peripheral capsule-ligamentous structures, including those making up the corner points.\(^2,3\) It has been shown that the lesion associated with the anterior cruciate ligament (ACL) and the corner points with menisco-capsular disinsertion, compared to isolated ACL lesion, means a worse prognosis.\(^4\) In menisco-capsular disinsertion an albeit minimal diastasis is observed between the peripheral component of the meniscus, the meniscal wall and the capsular insertion components. Diagnosis of these modifications is more difficult than that of meniscal lesion and lesion of the central pivot; in these eventualities MR and arthro-MR imaging are the most suitable techniques for evaluating the capsule-ligamentous structures. Lesion of the menisco-femoral and menisco-tibial ligaments is one of the three forms of menisco-capsular disinsertion.\(^5\) Bikkina et al.\(^6\) were among the first to describe this change in MR images, recognising it as the sign of floating meniscus already described in the arthrographic literature. This sign is noted when the joint fluid flows between the joint cartilage covering the tibial plateau and the free tibial margin of the meniscus (internal or external) following rupture of the coronary ligaments.\(^5\) It is important to identify this sign as the avulsed meniscus should be reattached as soon as possible to the underlying tibial plateau to prevent possible complications. In our paper we describe the role of low field MR imaging in recognising the floating meniscus sign.

**Materials and methods**

Using our Radiodiagnosis department’s PACS system, we carried out a retrospective analysis

**Materiali e metodi**

Abbiamo analizzato, in maniera retrospettiva, usando il sistema PACS del nostro dipartimento
of 2436 MR knee examinations carried out in the period between January 2006 and June 2007. The MR studies were carried out using a dedicated low field scanner with 0.2T magnet (Artoscan C; Esaote Biomedica, Genova, Italia). The parameters used were as follows: T1-weighted FSE sagittal sequences and STIR, coronal GE, T2-weighted axial FSE, with 16 cm FOV, layer thickness of 4 mm, matrix of 256x192 and single excitation. All examinations were assessed retrospectively by 3 radiologists with experience of between 3 and 15 years of musculoskeletal radiology. The diagnostic criteria used for the definition of floating meniscus were those codified in the literature (6):

— posterior or anterior horn of the meniscus completely surrounded by joint fluid with thickness of ≥5 mm in sagittal and coronal images;
— joint fluid with thickness >5 mm between the meniscus and the tibial plateau.

Bearing in mind the considerations of Bikkina et al. (6), in addition to previously described criteria floating meniscus was diagnosed in cases in which the thickness of the joint fluid between the meniscus and the tibial plateau was ≥3 mm but ≤5 mm. We defined the floating meniscus sign as being in complete agreement with the first two criteria while we defined as partial respect for the last criterion only.

In cases in which the floating meniscus sign was identified, the history of the patient obtained at the moment of the MR investigation was reassessed by analysing the essential traumatic mechanisms, but not the fine traumatic pathomechanics. Patients with the sign and a history of sporting trauma were contacted telephonically to learn what type of therapy they had undergone; in those who had been operated on, the operating report was evaluated. In the present study only the presence, but not the degree or type, of associated ligament or meniscal alteration was evaluated; further no careful evaluation and analysis of the number, localisation and extent of the associated bone bruising was carried out.

Results

On the basis of the previously defined diagnostic criteria we identified retrospectively 8/2436 cases of floating meniscus (0.33% of the total).
The sign was recognised in 6 men and 2 women in an age range between 18 and 40 years (average 29). It emerged from anamnestic matching that all patients had suffered a severe trauma or had reported sharp pain following sporting practice, 6 were footballers and 2 played volley ball.

2 donne, con range d’età compreso tra 18 e 40 anni (età media di 29 anni). Dal raccordo anamnestico emergeva che tutti i pazienti avevano subito un trauma severo o riferivano un forte dolore in seguito a pratica sportiva, 6 praticavano il calcio e 2 la pallavolo. In 5 pazienti abbiamo rilevato la presenza di un “menisco galleggiante” completo (Figure 1 e 2A,B) e nei restanti 3 di quello parziale (Figura 3). In 5 pazienti il menisco interessato era quello laterale e nei restanti 3 casi il mediale. si associava a lesioni legamentose e/o meniscale oltre che a contusioni ossee nel ginocchio. In 7/8 casi, come illustrato nella tabella 1, l’evidenza del segno del “menisco galleggiante” si associava a lesioni legamentose: in 1/8 pazienti una lesione del LCA e del LCP; in 2/8 del LCA; in 1/8 del LCM, LCA e del LCL; in 1/8 solo del LCM; ed in 1/8 del LCA (neolegamento ricostruito in arroto) e del LCM (Figura 4). In 7/8 casi è stata evidenziata una lesione meniscale associata (Figura 5). In 3/8 casi è stata rilevata, inoltre, una contusione ossea di varia entità.

I pazienti con il segno del “menisco galleggiante” completo (5/8 casi) sono stati sottoposti ad intervento chirurgo in arroto, che ha confermato la corretta detezione del segno del “menisco galleggiante” e delle lesioni meniscale. I 3/8 pazienti con il segno parziale sono stati trattati due in maniera conservativa e l’altro, in cui coesisteva la presenza della lesione del LCA, chirurgicamente in arroto, con conferma della presenza del menisco galleggiante.

Figure 1.—Complete floating meniscus. Sagittal STIR MR image shows the posterior horn of lateral meniscus completely surrounded by fluid and lifted > 5 mm from the tibial plateau (arrow). B: coronal GE-weighted image of the same case (arrow).

Figura 1.—Menisco galleggiante completo. Immagine RM sagittale STIR che evidenzia il corno posteriore del menisco laterale completamente circondato dal liquido articolare con sollevamento >5 mm dal piatto tibiale (freccia).

Figure 2.—A-B) Complete floating meniscus. A: sagittal STIR MR image shows the anterior horn of the lateral meniscus partially surrounded by fluid and lifted >5 mm from tibial plateau (arrow). B: coronal GE-weighted image of the same case (arrow).

Figura 2.—A-B Menisco galleggiante completo. A: immagine RM sagittale STIR che evidenzia il corno anteriore del menisco laterale parzialmente circondato dal liquido articolare con sollevamento >5 mm dal piatto tibiale (freccia). B: immagine RM coronale GE T2-pesata dello stesso caso (freccia).
In 5 patients we noted the presence of a complete floating meniscus (Figures 1 and 2A,B) and in the remaining 3 it was partial (Figure 3). In 5 patients the meniscus involved was lateral, in the other 3 medial, and they were associated with ligamentous and/or meniscal lesions as well as bone bruising in the knee. In 7/8 cases, as shown in table 1, the evidence of the floating meniscus sign was associated with ligamentous lesions: in 2/8 patients a lesion of the ACL and of the PCL; in 2/8 of the ACL, in 1/8 of the MCL, ACL and LCL; in 1/8 only of the MCL, and in 1/8 of the ACL (neoligament reconstructed in arthroscopy) and of the MCL (Figure 4). In 2/8 cases an associated meniscal lesion was highlighted (Figure 5). In 3/8 cases, furthermore, bone bruising of varying intensity was observed.

Patients presenting complete floating meniscus sign (5/8 cases) were subjected to surgery in arthroscopy which confirmed correct detection of the sign and of the meniscal lesions. The 3/8 patients with the partial sign were treated as follows: 2 conservatively and the other, in whom an ACL lesion coexisted, surgically in arthroscopy, with confirmation of the presence of the floating meniscus.

**Discussion**

Le strutture di stabilizzazione dei comparti mediale e laterale del ginocchio sono capsule-legamento-tendine-muscolo. Diverse descrizioni riportano in modo incompleto e a volte contraddittorio la conformazione delle strutture anatomiche dei comparti laterali e posterolaterali, mediolaterali, mediolatero-mediolaterali, e poste- 

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Discussion

The stabilisation structures of the medial and lateral compartments of the knee are capsulo-ligamentous, tendinous and muscular. A number of descriptions report incompletely and at times in contradictory fashion the conformation of the anatomic structures of the lateral and postero-lateral,\textsuperscript{3, 7-8} medial and postero-medial\textsuperscript{2, 5} compartments of the knee. The different description of the different ligament components is, as can be seen from a review of the literature, subject the anatomic variability and different nomenclature attributed to them.\textsuperscript{2, 3, 6-9}

The capsulo-ligamentous structures of the medial compartment can be subdivided into three layers.\textsuperscript{5} The first, the most superficial, consists of the deep crural fascia. The middle third of this is separate and independent of the second layer and in its posterior third it lies superficially over the tendons of the gracilis and semitendinous muscles and includes superiorly the tendon and the sartorius muscle belly.

The second layer, the intermediate, consists of the superficial portion of the medial collateral ligament (MCL); this layer in its posterior third combines with the third to make up the oblique posterior ligament (OPL) the distal insertion of which consists of three arms,\textsuperscript{3} wraps round the posteromedial portion of the femoral condyle and lies in close contiguity with the posterior meniscal horn.

The third layer, the deepest, consists of the joint capsule and the deep portion of the MCL and principally inserts into the edges of the joint and the medial meniscus; the deep portion of the MCL is attached to the meniscus and fine ligament extensions may be observed represented by the menisco-femoral and menisco-tibial (coronary) ligaments which run respectively from the superior and inferior superficial edges of the meniscus to the femur and the tibia.

As for the lateral compartment of the knee, various tendinous and muscular capsulo-ligamentous structures can be identified. Contrary to what was said about the capsule-ligamentous structures of the medial compartment it is not possible to subdivide those of the lateral compartment into layers.\textsuperscript{4}

In correspondence with the postero-lateral region of the knee some orthopaedists identify the complex of the arcuate ligament (ALC) as a func-
tional tendino-ligamentous unit consisting of: the lateral collateral ligament; the tendon of the femoral biceps; the popliteal tendon and muscle; the popliteo-meniscal and popliteo-fibular ligaments; the oblique, arcuate and fabello-fibular popliteal ligaments; and the lateral gastrocnemius muscle. Gollehon et al. in a biomechanical study with selective section of tendinous and ligamentous structures have shown that the structures that best prevent postero-lateral instability are the popliteal tendon and the LCL.10 Further, the menisco-capsular structures, consisting of the menisco-femoral and coronary ligaments should be added to the ALC structures.

The meniscal fibrocartilages favour the congruency of the joint surfaces of the femoral condyles and tibial plateaux; they have other important functions: attenuation of bumps, load distribution and stabilisation.

The menisco-capsular structures, particularly the coronary ligaments, are delegated to the connexion of the meniscal fibrocartilages with the tibial plateaux. Menisco-capsular disinsertion is an important consequence (albeit rare) of knee trauma and is characterised by the avulsion of the peripheral portion of the meniscus from its capsular insertions. This lesion can lead to meniscal hypermobility and joint instability; contrary to meniscal lesions, it can resolve spontaneously as it occurs in an area of the meniscus that is abundantly vascularised, so much so that in arthroscopically treated cases the success percentage of surgical repair is very high.11,12

Menisco-capsular separations may occur in three ways: 1) changes to the menisco-capsular junction; 2) lesions to the menisco-femoral and coronary ligaments; and 3) lesions involving the meniscal wall.5 Lesions in the menisco-femoral and coronary ligaments may determine knee instability. In an acute trauma, the menisco-tibial ligaments may become detached and, consequently, lead to avulsion of the meniscus from the tibial plateau. It is believed that an avulsed meniscus or a meniscus detached from the tibial plateau, should if possible be reinserted. The meniscus is typically sutured around its anatomical position.6

The MR images on the sagittal and coronal plains are those which best demonstrate the relationship between the meniscus and the tibial plateau and hence are optimal for identifying meniscal avulsions as a result of menisco-tibial ligament arcurato (CLA), un’unità funzionale tendinea-legamentosa composta: dal legamento collaterale laterale; dal tendine del bicipite femorale; dal tendine e dal muscolo popliteo; dai legamenti popliteo-meniscale e popliteo-fibulare; dai legamenti popliteo obliquo, arcurato e fabello-fibulare; e dal muscolo gastrocnemio laterale. Gollehon et al. in uno studio biomeccanico con sezione selettiva delle strutture tendinee e legamentose hanno dimostrato che le strutture che prevengono maggiormente le instabilità postero-laterali sono il tendine popliteo e il LCL.10. Alle strutture del CLA bisogna, inoltre, aggiungere le strutture menisco-capsulari, costituite dai legamenti menisco-femorale e coronario. Le fibrocartilagini meniscale favoriscono la congruenza delle superfici articolari dei condili femorali e dei piatti tibiali; esse hanno anche altre importanti funzioni: attenuazione degli urti, distribuzione del carico e stabilizzazione. Le strutture menisco-capsulari, in particolare i legamenti coronari, sono deputate alla connessione delle fibrocartilagini meniscale con i piatti tibiali. La disinserzione menisco-capsulare è una conseguenza importante ma poco comune di un trauma del ginocchio ed è caratterizzata dall’avulsione della porzione periferica del menisco dalle sue inserzioni capsulari. Tale lesione può comportare un’iper mobilità meniscale ed un’instabilità articolare; contrariamente alla lesione meniscale, è suscettibile di guarigione anche spontanea, in quanto avviene in una zona ricca mente vascolarizzata del menisco tanto che, nei casi trattati artroscopicamente, la percentuale di successo della riparazione chirurgica è molto elevata11,12. Le disinserzioni menisco-capsulari possono manifestarsi sotto tre forme come: 1) alterazioni della giunzione menisco-capsulare; 2) lesioni dei legamenti menisco-femorale e coronario; e 3) lesione coinvolgente il muro meniscale.5 La lesione dei legamenti menisco-femorale e coronario possono determinare l’instabilità del ginocchio. In un trauma acuto, i legamenti menisco-tibiali possono distrarsi e, di conseguenza, determinare un’avulsione del menisco dal piatto tibiale. Si ritiene che un menisco avulsion o distaccato dal piatto tibiale dovrebbe se possibile essere reinserto. Il menisco è tipicamente suturato intorno alla sua posizione anatomica.6 Le immagini RM sui piani sagittale e coronale sono quelle che dimostrano meglio la relazione tra il menisco ed il piatto tibiale e pertanto sono ottimali per l’identificazione di avulsioni meniscale quali risultato di distrazioni dei legamenti menisco-tibiali.6,11. Bikkina et al.6 sono stati i primi a descrivere il segno del “menisco galleggiante” nelle immagini RM e ne hanno riportato il ricono-
ament detachments,6,11 Bikkina et al.6 were the first to describe the floating meniscus sign in MR images and they have reported it in 21 cases, with subsequent perspective identification in a further 4 cases. In our experience we identified the floating meniscus sign retrospectively in 8 cases out of 2436 MR scans (0.33%). Bikkina et al.6 reported the involvement of the lateral menisco-capsular ligamentous complex in 14/21 (66.67%); similarly in our own study we observed in a higher number of cases, 5/8 (62.5%), the involvement of the lateral menisco-capsular ligamentous complex. In our experience, unlike what was observed by Bikkina et al.,6 who did not observe meniscal lesions in the MR images but reported their presence in 3/21 cases (14.28%) at surgery, we evidenced the presence of a meniscal lesion in 2/8 cases (25%) in MR images.

As stated by Bikkina et al.6 the saving of the avulsed meniscus is probably related to a different stress mechanism under load, with most of the effort leading to cutting of the menisco-tibial ligaments rather than rupture of the meniscus.

In our study we evidenced associated ligamentous and/or meniscal lesions in 7/8 patients (87.5%); in the series of Bikkina et al it is not possible to identify the exact number of subjects with associated lesions.

We observed a ligamentous lesion in all cases in which an associated lesion was observed (100%). Carrying out a comparative evaluation between our findings and those of Bikkina et al. the following emerges. The ACL was the ligament most involved, respectively in 6/8 cases (75%) in our series as against 11/21 cases (52.38%) reported by them. In our series incidence was as follows: MCL in 3/8 cases (37.5%), PCL in 2/8 cases (25%) and LCL in 1/8 cases (12.5%). Bikkina et al.6 report lesions of the PCL in 9/21 (42.86%), lesion of the MCL in 6/21 (28.57%) and lesion of the LCL in 4/21 (19.05%). In our study lesions of the MCL showed a higher incidence than was observed by Bikkina et al., who reported PCL as the ligament most involved after the ACL. In the two series there is no significant difference in the incidence of LCL lesions. In 3/8 cases (37.5%) we found the presence of one or more areas of bone bruising while Bikkina et al.6 reported bruising in 9/21 cases (42.86%); this associated lesion therefore presented a fairly similar incidence in the two series.

scimento in 21 casi, con identificazione retrospettiva in 17 casi su 4096 indagini RM (0,4%) e successiva identificazione prospettica in altri 4 casi. Nella nostra esperienza abbiamo identificato retrospettivamente il segno del “menisco galleggiante” in 8 casi su 2436 indagini RM (0,33%). Bikkina et al. segnalavano il coinvolgimento del complesso legamentoso menisco-capsulare laterale in 14/21 (66,67%); in modo simile nel nostro studio abbiamo riscontrato in un maggiore numero di casi, 5/8 casi (62,5%), il coinvolgimento del complesso legamentoso menisco-capsulare laterale. Nella nostra esperienza, contrariamente a quanto riscontrato da Bikkina et al.,6 i quali non rilevavano lesioni meniscale nelle immagini RM ma riferivano la loro presenza in 3/21 casi (14,28%) alla chirurgia, abbiamo evidenziato nelle immagini RM la presenza di una lesione meniscale in 2/8 casi (25%).

Come affermato da Bikkina et al.6 il relativo risparmio del menisco avulso sarebbe probabilmente correlato ad un differente meccanismo di stress sotto carico, con la maggior parte delle forze che portata ad un troncamento dei legamenti menisco tibiali, piuttosto che ad una rottura del menisco stesso.

Nel nostro studio abbiamo evidenziato lesioni associate legamentose e/o meniscale in 7/8 pazienti (87,5%); nella casistica di Bikkina et al non è possibile rilevare il numero esatto di soggetti con lesioni associate. Abbiamo rilevato una lesione legamentosa in tutti casi in cui era stata rilevata una lesione associata (100%). Effettuando una valutazione comparativa tra i nostri rilievi e quelli di Bikkina et al. emerge quanto segue. L’LCA era il legamento maggiormente coinvolto, rispettivamente in 6/8 casi (75%) nella nostra versus i 11/21 casi (52,38%) da loro riportati. Nella nostra casistica seguono per incidenza di coinvolgimento l’LCM in 3/8 (37,5%), l’LCP in 2/8 casi (25%) e l’LCL in 1/8 casi (12,5%). Bikkina et al.6 riportano in 9/21 (42,86%) la lesione del LCP, in 6/21 (28,57%) la lesione del LCM e in 4/21 (19,05%) la lesione del LCL. Nel nostro studio le lesioni del LCM hanno una maggiore incidenza rispetto a quanto riscontrato da Bikkina et al., i quali riportano l’LCP come legamento maggiormente coinvolto dopo l’LCA. Non si rileva nelle due casistiche una differenza significativa nell’incidenza delle lesioni del LCL. In 3/8 casi (37,5%) abbiamo evidenziato la presenza di una o più aree di contusione ossea mentre Bikkina et al.6 ne riportavano la presenza in 9/21 casi (42,86%); pertanto questa lesione associata presentava nelle due casistiche un’incidenza abbastanza simile.
Conclusions

We can therefore hypothesise that the different incidence of associated ligamentous and bone lesions is probably related (as no adequate comparative evaluation of the pathomechanics has yet been carried out) to the different severity and the different modalities of the trauma suffered by patients; as reported above, fine analysis of the pathomechanics of the traumatic event was not one of our objectives in the present study. Here, also taking into account the considerations of Bikkina et al. and Rubin et al., we decided to classify the floating meniscus sign on two different levels:

- partial, in cases in which the presence of joint fluid between the joint cartilage and the meniscus has a thickness of ≥3 mm and ≤5 mm;
- complete in cases in which the interposed joint fluid thickness is >5 mm.

The purpose of this classification is to help the orthopaedic surgeon manage the patient, since a minimum avulsion, sign of partial floating meniscus, can be treated conservatively if it is not associated with ligamentous lesions of the central pivot, whereas a higher degree of avulsion, sign of a complete floating meniscus, should be managed surgically. At the preoperative stage, warning the surgeon of the possible presence of a floating meniscus permits a better estimate of the surgical repair. Arthroscopy requires the instillation of a saline solution into the joint; an avulsed meniscus permits a better estimate of the time of tourniquet and preparation time for appropriate surgical repair. Arthroscopy requires the instillation of a saline solution into the joint; an avulsed meniscus that is otherwise normal could be relocated on the tibial plateau, so rendering its observation more troublesome.

An object that can mimic floating meniscus is a rare variant of lateral discoid meniscus, Wrisberg’s eccentric ligament; this does not have posterior insertions on the tibial plateau. This lateral meniscal variant can mimic an avulsion and should be considered if the meniscus appears discoid on MR imaging. This form of discoid meniscus has only one insertion, the lateral menisco-femoral ligament or Wrisberg’s ligament. The anterior horn of this discoid meniscus is appropriately inserted on the tibial plateau, although the meniscus itself may suffer significant subluxation with flexion and extension. The patient’s clinical history should help us distinguish this variation from true floating meniscus, with meniscal avulsion suggested in the event of severe acute trauma. These vari-

Conclusioni

Possiamo ipotizzare pertanto che la differente incidenza delle lesioni legamentose e ossee associate sia da riferire verosimilmente, non essendo stata condotta una adeguata valutazione comparativa della patomeccanica, alla differente severità e alla differente modalità del trauma subito dai pazienti; come sopra riportato non rientrava tra gli scopi che ci eravamo prefissi la fine analisi della patomeccanica dell’evento traumatico. Nel nostro studio, anche in base alle considerazioni di Bikkina et al. e di Rubin et al., abbiamo ritenuto di classificare il segno di “menisco galleggiante” in due gradi:

- parziale, nei casi in cui la presenza di fluido articolare interposto tra la cartilagine articolare ed il menisco, abbia uno spessore ≥3 mm e ≤5 mm;
- completo nei casi in cui lo spessore del fluido articolare interposto sia >5 mm.

Questa classificazione ha lo scopo di aiutare il chirurgo ortopedico nel management del paziente, in quanto un’avulsione minima, segno del “menisco galleggiante” parziale, se non associata a lesioni legamentose del pivot centrale può essere trattata in maniera conservativa, mentre un’avulsione di grado maggiore, segno del “menisco galleggiante” completo, dovrebbe essere trattata chirurgicamente. In fase preoperatoria allertare il chirurgo ortopedico sulla possibile presenza di un “menisco galleggiante” consente una migliore stima del tempo di tourniquet e di preparazione per un’appropriata riparazione chirurgica. L’artroscopia richiede l’instillazione di soluzione salina nell’articolazione, un menisco avulso, ma altrimenti normale, potrebbe essere riaccolto sul piatto tibiale, rendendo così il suo riscontro più difficoltoso.

Un’entità che può mimare il “menisco galleggiante” è una rara variante del menisco discoide laterale, il legamento eccentrico di Wrisberg, questo non ha inserzioni posteriori sul piatto tibiale. Questa variante meniscale laterale può mimare un’avulsione e deve essere presa in considerazione se il menisco appare discoido alla RM. Questa forma di menisco discoide ha una sola inserzione, il legamento menisco-femorale laterale o legamento di Wrisberg. Il corno anteriore di questo menisco discoide è appropriatamente inserito sul piatto tibiale, anche se il menisco stesso può sublussarsi significativamente con la flessione e l’estensione. La storia clinica del paziente dovrebbe aiutare a distinguere questa variante da un vero “menisco galleggiante”, con avulsione meniscale suggerita in caso di severo trauma acuto. Queste varianti sono delle condizioni para-fisiologiche e anche se non rientrano nelle
ants are paraphysiological conditions and even if they do not come under meniscocapsular disinsertions they should be reported and managed surgically.\(^{14}\)

In our experience, using a low-field MR scanner we have observed the presence of the floating meniscus sign in 0.33% of cases, an incidence that is not significantly different from that reported by Bikkina et al. using high field equipment.\(^{6}\)

It is also important to identify this finding because the avulsed meniscus reattached to the underlying tibial plateau can prevent the onset of early arthrosic degeneration of the knee joint. The “floating” meniscus sign may be identified in MR images even if the investigation has been carried out with low-field equipment and its presence should be carefully sought in cases with severe trauma associated with multi-ligamentous luxation or lesion or both as it has important prognostic implications.

References/Bibliografia


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Synthetic turf: risk of the onset of muscular-skeletal lesions in young football players

Terreni in erba sintetica: rischio di insorgenza di lesioni muscolo-scheletriche in giovani calciatori

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SUMMARY

Aim. To assess the influence of different types of playing surface (natural grass and synthetic turf) on the onset of muscular-skeletal lesions and possible relapses, and on recovery times after rehabilitation by football players at a developing age.

Methods. We assessed 133 young football players who belonged to two different sports clubs: 69 athletes who trained on a pitch of artificial turf (group A), and 64 athletes of the same age who trained on a pitch of natural grass (group B). All the athletes were divided into 3 teams by date of birth (1995, 1994, 1993). The athletes who reported muscular-skeletal pain during training or competitions, were given a medical examination, and a therapy was decided, specific for each type of pathology, and they underwent rehabilitation treatment, specific for each type of pathology.

Results. The athletes in group A presented a significantly higher number of muscular-skeletal pathologies than those in group B (16 vs. 4, p<0.01, R.R.=3.7). The largest differences were noted in athletes born in 1994 (9 vs. 2, p<0.02, R.R.=4.28). The commonest lesions were 1st degree muscular lesions and tendonitis of the adductor muscles for group A, and delayed muscular pain for group B. No significant difference emerged regarding recovery times, although these were longer for the athletes in group A. The number of relapses was different, although not significantly so, for muscular lesions (2 for group A vs. 0 for group B) and for ankle sprains (1 for group B vs. 0 for group A).

Conclusion. From our results it emerged that training on synthetic turf increases the risk of muscle and tendon pathologies.

KEY WORDS: Synthetic turf - Muscular-skeletal lesions - Young football players.

RIASSUNTO


Metodi. Sono stati valutati 133 giovani calciatori appartenenti a due diverse società sportive: 69 atleti che si allenavano su campo in erba artificiale (gruppo A), 64 atleti di pari età che si allenavano su campo da calcio in erba naturale (gruppo B). Tutti gli atleti erano suddivisi in 3 squadre per età (1995, 1994, 1993). Gli atleti che durante allenamento o competizione riferivano una sintomatologia dolorosa muscoloscheletrica venivano sottoposti a visita medica, imposta una terapia, la stessa per lo stesso tipo di patologia, e sottoposti a trattamento riabilitativo, lo stesso per lo stesso tipo di patologia.

Risultati. Gli atleti del gruppo A avevano presentato un numero di patologie muscolo-scheletriche significativamente maggiore rispetto a quelli del gruppo B (16 vs 4, p<0,01, R.R.=3,7). Le maggiori differenze sono state note per gli atleti dell’anno 1994 (9 vs 2, p<0,02, R.R.=4,28). Le lesioni più comunemente riscontrate erano state le lesioni muscolari di 1° grado e le tendinopatie dei muscoli addutori per il gruppo A e il dolore muscolare ritardato per il gruppo B. Nessuna significativa differenza era emersa per quanto riguarda i tempi di recupero, anche se questi sono risultati maggiorn
Football pitches in natural grass are currently being replaced, for economical and practical reasons, primarily by pitches of artificial turf. The technical and economic qualities of these innovative surfaces have been studied in great depth; numerous studies have examined the possible toxicity of the materials used.1-3 In recent years, only a few studies have been performed on the incidence of acute traumatic events linked to competitions or training on pitches of artificial turf.4-8 However, in spite of the relevance and great interest being shown in the issue, there is no information available about the possible problems that training on surfaces of synthetic turf can generate in the muscular-skeletal structure of the football player.8 Although the age of these new playing surfaces has arrived, and is in fact in full-blown development, numerous questions remain to be answered. The technical aspects of the movements and the bounce of the ball have still to be studied in depth, but above all, there is still no single, clear definition of the biomechanical aspects of running and all athletic movements, typical of a sport like football, on these playing surfaces.9-12 In the light of the above, it is difficult to envisage the risk of the onset of muscular-skeletal pathologies caused by overloading that are associated with this type of surface. Acknowledgement of a possible link between artificial turf and the increased risk of muscular-skeletal pathologies is even more important, absolutely indispensable in fact, when the athlete is still growing. A developing skeleton has flexible bones, soft cartilage structures and ligaments which are proportionally stronger than the adjacent areas of growing bone. Although bone plasticity during development increases its remodeling capacity and allows lesions to be repaired rapidly, it also creates areas of intrinsic weakness in the skeletally immature athlete. In many cases the type of lesion in the child is similar to that in an adult, although there are differences due to the presence of growing cartilage, the...
growth process, the level of activity and children’s attitude to sports activities.

Because we envisage that in the near future, many natural grass football pitches will be replaced by pitches of synthetic turf, new studies of this subject are absolutely necessary, even to understand the possible long-term effects on the locomotor structures of the athletes.

The purpose of this study is to assess the influence of the different types of playing surfaces (natural and synthetic) on the onset of muscular-skeletal lesions, possible relapses and recovery times after rehabilitation treatment, on a population of young football players.

**Materials and methods**

*Population studied*

From November 2005 to April 2006 we assessed 133 young male football players (age: 10.9±0.8 years) belonging to two different sports clubs: 69 athletes who trained on pitches of artificial turf (group A) and 64 athletes of the same age who trained on pitches of natural grass (group B). Three teams were assessed from each club, each made up of football players born in 1995 (27 athletes in group A and 26 athletes in group B), 1994 (20 athletes in group A and 19 in group B) and 1993 (22 athletes in group A and 19 athletes in group B). The teams in group B had always trained on a natural grass pitch, the football players in the teams in group A had trained on artificial turf for at least a year and a half.

A physical examination with a postural assessment prior to the start of the study led us to exclude three athletes (one from group A and two from group B), who presented evident alterations to their skeletal structure, of constitutional and/or postural origin (one with dysmetria of the pelvis, one with flat feet, one with pes cavus).

Athletes born in 1994 and 1993 had three 2-hour training sessions a week, plus a final game. Athletes born in 1995 had two 2-hour training sessions a week, plus a final game.

*Methods*

The athletes who reported a traumatic event or the onset of pain of a muscular-skeletal nature during training or a match, were given a physical examination, and were treated if necessary with pharmaceutical products and non-instru-
mental physiotherapy suitable for the pathology reported. All the athletes were encouraged to immediately report any type of symptom as soon as it emerged.

The same therapy was applied and the same rehabilitation protocol was adopted for a specific pathology, adapted in each case to the specific biomechanical characteristics of each athlete and obviously to the gravity of the lesion.

Each athlete of each team was assessed by the same doctor and rehabilitated by the same physiotherapist. Rehabilitation was carried out directly on the playing field (on synthetic turf for the athletes in group A and on natural grass for the athletes in group B).

The traumatic pathologies considered in this study were: inflammatory tendinopathies, muscular lesions from indirect trauma classified by Reid's system, and sprains to lower limb joints.

All the athletes were suitably informed about the procedures of the study.

**Pitch of artificial turf**

The athletes in group A trained on pitches of third generation synthetic turf. Most of these football players had belonged to their club for at least one and a half years, during which time the training sessions had taken place on a pitch of third generation artificial turf.

This playing surface, which was developed about six years ago, is made of a system formed of filaments of grass created from polyolefin copolymers filled with small fragments of rubber obtained by recycling seals for civilian use and other components; these include elastic material which is present in all third generation artificial turf football pitches and which, because it makes it more similar to natural grass, also makes the pitch surface more regular, for better play, a better technical response and therefore a better competitive performance from the athlete.

The visual effect is similar to that of a pitch of natural grass, but the impact of the foot with this pitch, which is softer on the surface but harder underneath, is different, although there are no studies of the subject in the literature.

**Statistical analysis**

The incidence of injury during training for each group (athletes trained on synthetic turf and athletes trained on natural grass) and for each team.
of athletes has been calculated both as the ratio between the number of injuries and the number of individuals observed, and as the number of injuries/1000 hours of exposure. The incidence of the various types of injury was calculated as the number of cases among those exposed and the number of cases among those not exposed. The incidence of relapses was calculated as the number of relapses per pathology against the number of cases per pathology. Wherever possible, the values of the incidence between the two groups were compared by calculating the relative risk (RR) with a confidence level of 95%. The significance level was established as p<0.05. The data related to recovery times were expressed as the average ± standard deviation. The proportions were also compared, wherever possible, using the $\chi^2$ test by applying the Yates correction. The statistical significance level was established as p<0.05.

The data were analysed by the SPSS program version 13.0 for Windows software.

**Results**

Table I illustrates the results for the number of injuries out of the total number of athletes in the two clubs. The number of injuries reported among athletes who trained on pitches of synthetic turf was significantly higher than that of athletes who trained on pitches of natural grass. Even in the team born in 1995, the incidence of injuries was higher for athletes who trained on synthetic turf, with a relative risk that indicates a moderate association between exposure to the synthetic surface and the number of injuries. However, these data are not statistically significant (Table II).

Table III illustrates the results for injuries to the teams born in 1994. The incidence of injury is significantly higher in athletes who trained on pitches of synthetic turf, with a fair relative risk of injury.

<table>
<thead>
<tr>
<th>Table I.—Total athletes injured.</th>
<th>Table II.—Athletes injured 1995.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total athletes</strong></td>
<td><strong>Total athletes</strong></td>
</tr>
<tr>
<td><strong>Artificial turf</strong></td>
<td><strong>Natural grass</strong></td>
</tr>
<tr>
<td>Athletes injured</td>
<td>Athletes injured</td>
</tr>
<tr>
<td>Incidence of injuries (%)</td>
<td>Incidence of injuries (%)</td>
</tr>
<tr>
<td><strong>Pitch of artificial turf</strong></td>
<td><strong>Pitch of natural grass</strong></td>
</tr>
<tr>
<td>Total athletes</td>
<td>Total athletes</td>
</tr>
<tr>
<td>Athletes injured</td>
<td>Athletes injured</td>
</tr>
<tr>
<td>Incidence of injuries (%)</td>
<td>Incidence of injuries (%)</td>
</tr>
<tr>
<td><strong>Pitch of natural grass</strong></td>
<td><strong>Pitch of natural grass</strong></td>
</tr>
<tr>
<td>Total athletes</td>
<td>Total athletes</td>
</tr>
<tr>
<td>Athletes injured</td>
<td>Athletes injured</td>
</tr>
<tr>
<td>Incidence of injuries (%)</td>
<td>Incidence of injuries (%)</td>
</tr>
</tbody>
</table>

**Table II.—Athletes injured 1995.**

| **Total athletes**               | **Total athletes**              |
| **Artificial turf**              | **Natural grass**               |
| Athletes injured                 | Athletes injured                |
| Incidence of injuries (%)        | Incidence of injuries (%)       |
| **Pitch of artificial turf**     | **Pitch of natural grass**      |
| Total athletes                   | Total athletes                  |
| Athletes injured                 | Athletes injured                |
| Incidence of injuries (%)        | Incidence of injuries (%)       |
| **Pitch of natural grass**       | **Pitch of natural grass**      |

**Table III.—Athletes injured 1994.**

| **Total athletes**               | **Total athletes**              |
| **Artificial turf**              | **Natural grass**               |
| Athletes injured                 | Athletes injured                |
| Incidence of injuries (%)        | Incidence of injuries (%)       |
| **Pitch of artificial turf**     | **Pitch of natural grass**      |
| Total athletes                   | Total athletes                  |
| Athletes injured                 | Athletes injured                |
| Incidence of injuries (%)        | Incidence of injuries (%)       |
| **Pitch of natural grass**       | **Pitch of natural grass**      |

The incidence of the various types of injury is statistically calculated as the number of cases among those exposed and the number of cases among those not exposed. The incidence of relapses is calculated as the number of relapses per pathology against the number of cases per pathology. Wherever possible, the values of the incidence between the two groups are compared by calculating the relative risk (RR) with a confidence level of 95%. The significance level is established as p<0.05. The data related to recovery times are expressed as the average ± standard deviation. The proportions are also compared, wherever possible, using the $\chi^2$ test by applying the Yates correction. The statistical significance level is established as p<0.05.

The data were analysed by the SPSS program version 13.0 for Windows software.

**Results**

Table I illustrates the results for the number of injuries out of the total number of athletes in the two clubs. The number of injuries reported among athletes who trained on pitches of synthetic turf was significantly higher than that of athletes who trained on pitches of natural grass. Even in the team born in 1995, the incidence of injuries was higher for athletes who trained on synthetic turf, with a relative risk that indicates a moderate association between exposure to the synthetic surface and the number of injuries. However, these data are not statistically significant (Table II).

Table III illustrates the results for injuries to the teams born in 1994. The incidence of injury is significantly higher in athletes who trained on pitches of synthetic turf, with a fair relative risk of injury.

**Risultati**

In tabella I sono mostrati i risultati relativi al numero di infortuni sul totale degli atleti delle due società. Il numero di infortuni verificatosi tra gli atleti che si allenavano su campo in erba sintetica è risultato significativamente maggiore rispetto a quelli degli atleti che si allenavano su campo in erba naturale. Anche nella squadra dell’anno 1995 l’incidenza di infortuni è risultata maggiore per gli atleti che si allenavano su campo in erba sintetica,
The team born in 1993 was the one that had the lower incidence of injury among the athletes who trained on synthetic turf, and the lower incidence of injury/1000 hours of training for athletes who trained on both synthetic turf and natural grass. The association between synthetic turf and the probability of the onset of a muscular-skeletal pathology proved modest (Table IV).

The number and percentage of injuries divided by type are illustrated in Table V. Among the athletes who trained on a pitch of artificial turf, 1st degree muscular lesions and insertional proximal tendonitis of the adductor muscles represented the most frequently found pathologies, with an incidence of 7.2% out of the total athletes in group A, followed by muscular lesions from physical exercise or delayed muscle pain (4.3%) and Achilles paratenonitis,14 associated with plantar fascitis (2.9%). Muscular lesions from physical exercise were the principal cause of injury among the athletes who trained on pitches of natural grass, with an incidence of 3%. The association between the type of playing surface and the onset of muscular-skeletal pathologies was only significant for 1st degree muscular lesions and insertional proximity tendonitis of the adductor muscles.

### Table IV.—Athletes injured 1993.

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Artificial turf</th>
<th>Natural grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total athletes</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Athletes injured</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Incidence of injuries (%)</td>
<td>13.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Incidence of injuries (no./1000 hours)</td>
<td>20.8/1000</td>
<td>6.94/1000</td>
</tr>
</tbody>
</table>

P=0.39, R.R.=2.7 (95% C.I. 0.51-23.5).

### Table V.—Number and incidence of injuries by type.

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Artificial turf</th>
<th>Incidence</th>
<th>Natural grass</th>
<th>Incidence</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>16</td>
<td>0.23</td>
<td>4</td>
<td>0.06</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Muscular lesions</td>
<td>5</td>
<td>0.07</td>
<td>0</td>
<td>0</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Muscular lesions from physical exercise (delayed muscle pain)</td>
<td>3</td>
<td>0.04</td>
<td>2</td>
<td>0.03</td>
<td>P=0.07</td>
</tr>
<tr>
<td>Tendonitis adductor musc.</td>
<td>5</td>
<td>0.07</td>
<td>0</td>
<td>0</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Achilles paratenonitis and plantar fascitis</td>
<td>2</td>
<td>0.029</td>
<td>0</td>
<td>0</td>
<td>P=0.17</td>
</tr>
<tr>
<td>Achilles paratenonitis</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.015</td>
<td>P=0.29</td>
</tr>
<tr>
<td>1st degree sprained ankle</td>
<td>1</td>
<td>0.014</td>
<td>1</td>
<td>0.015</td>
<td>P=0.9</td>
</tr>
</tbody>
</table>
One single 1st degree sprained ankle, with straining of the front peroneal-astragalic ligament, was reported in each group.

Pathologies such as plantar fascitis and insertional tendonitis of the adductor muscles were not reported in athletes who trained on pitches of natural grass.

Table VI illustrates the recovery times after therapy and rehabilitation, assessed for the muscular-skeletal pathologies that emerged in both study groups. Where ankle sprains are concerned, we can note that the results are entirely similar (15 days for both groups). The difference is however minimal for both Achilles paratenonitis (16.6 ±2.8 days for athletes who played on artificial turf, 15 days for those on natural grass) and for muscular contractures (8.7 ±3.5 days for athletes who trained on artificial turf, 7 days for those on natural grass).

Table VII illustrates the number of relapses reported for each group studied. There were 3 relapses among athletes who trained on pitches of artificial turf; among athletes who trained on natural grass, on the other hand, there was only one relapse for a sprained ankle. The differences were not statistically significant. Where Achilles paratenonitis and plantar fascitis are concerned, there were no relapses in either of the two study groups.

**Discussion and conclusions**

The purpose of this comparative study performed on a sample of young football players was to verify the incidence of muscular-skeletal pathologies, recovery times after rehabilitation and possible relapses in athletes who trained on football pitches of artificial turf compared to those who trained on pitches of natural grass.

Table VI.—Recovery times after rehabilitation for comparable muscular-skeletal pathologies.

<table>
<thead>
<tr>
<th>Patologie muscolo-scheletriche</th>
<th>Erba artificiale (giorni)</th>
<th>Erba naturale (giorni)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distorsione caviglia di 1° grado</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Paratenonite achillea</td>
<td>16,6±2,8</td>
<td>15</td>
</tr>
<tr>
<td>Lesioni muscolari da esercizio fisico (dolore muscolare ritardato)</td>
<td>8,7±3,5</td>
<td>7</td>
</tr>
</tbody>
</table>

In tabella VI sono mostrati i tempi di recupero dopo terapia e riabilitazione, valutati per quelle patologie muscolo-scheletriche che si sono manifestate in entrambi i gruppi di studio. Per quanto riguarda la distorsione della caviglia si nota che i risultati sono del tutto sovrapponibili (15 gg per entrambi i gruppi). La differenza è comunque minima sia per la paratenonite achillea (16,6±2,8 gg per gli atleti che giocavano su erba artificiale, 15 gg per quelli su erba naturale) che per le contratture muscolari (8,7±3,5 gg per gli atleti che si allenavano su erba artificiale, 7 gg per quelli su erba naturale).

In tabella VII è mostrato il numero delle recidive che si sono verificate per ogni gruppo di soggetti studiati. Negli atleti che si allenavano su campo in erba artificiale si sono manifestate 3 recidive; negli atleti che si allenavano su campo in erba naturale, invece, si è verificata solo una recidiva per la distorsione alla caviglia. Le differenze non sono risultate statisticamente significative. Per quanto riguarda la paratenonite d’Achille e la fascite plantare non si sono verificate recidive in nessuno dei due gruppi di studio.

<table>
<thead>
<tr>
<th>Muscular-skeletal pathology</th>
<th>Pitch of artificial turf</th>
<th>Pitch of natural grass</th>
<th>RR (95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>3</td>
<td>1</td>
<td>0.72 (0.10-5.11)</td>
</tr>
<tr>
<td>Muscular lesions from physical exercise (delayed muscle pain)</td>
<td>2</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Insertional tendonitis adductor muscles</td>
<td>1</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>1st degree sprained ankle</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
</tbody>
</table>
Previous studies, which have assessed the incidence and the principal causes of traumatic events during matches and training on synthetic turf, did not highlight significant differences compared to natural grass. These studies, however, tended to analyse acute traumatic events in American football.\(^4^\)\(^-^8\) Association football is a completely different sport, in which the most significant element is not the physical contact between players, but the impact with the ground, particularly during sprints and changes of direction.\(^15\) A study performed on Swedish football players assessed the pattern of movement, the capacity to pass the ball and the impression of the game of football by players on synthetic turf compared to natural grass, with negative results where the artificial surface was concerned.\(^16\) No study has so far examined athletes at a developing age, who are clearly more difficult to study, but also more subject to possible stress from unsuitable playing surfaces, and those who use artificial turf surfaces more extensively.

Our study, which examined this particular category of individuals, reveals a positive association between training on artificial turf and the onset of muscular and tendon pathologies. Longer recovery times were also noted, albeit not significantly so, as well as an increase in the probability of a relapse.

The greatest differences were noted for athletes born in 1994, who recorded 45% of the injuries for athletes in group A compared to 10.5% among athletes in group B. In any case, for every age group of the athletes studied, the incidence of muscular-skeletal pathologies proved to be higher for athletes who trained on pitches of artificial turf.

For the athletes who trained on a synthetic playing surface, the most frequent pathologies were muscular lesions from indirect trauma (all 1\(^{\text{st}}\) degree lesions) and proximal insertional tendonitis of the adductor muscles. The possible causes of these pathologies must be looked for in alterations to the coordination of different muscle groups. A physical examination before the study excluded any type of postural problem or imbalance between the muscles of the lower limbs; the higher incidence of muscular lesions among athletes in group A may therefore by attributed in part to the different playing surface, which could in fact be responsible for an alteration in the podalic biomechanics and therefore of the muscle coordination.

**Discussione e conclusioni**

Questo studio comparativo eseguito su un campione di giovani calciatori ha avuto lo scopo di verificare l'incidenza di patologie muscolo-scheletriche, i tempi di recupero dopo riabilitazione e le eventuali recidive in atleti che si allenano su campo da calcio in erba artificiale rispetto a coloro che si allenano su campo da calcio in erba naturale.

Precedenti studi, che hanno valutato l'incidenza e le cause principali di eventi traumatici durante le competizioni e gli allenamenti su erba sintetica, non hanno evidenziato significative differenze rispetto all'erba naturale. Tali studi hanno tuttavia analizzato per lo più eventi traumatici acuti nel football americano.\(^4^\)\(^-^8\) Il calcio è una disciplina sportiva completamente diversa, in cui non prevale il contatto fisico tra i giocatori, ma l'impatto con il terreno soprattutto durante gli sprints e i cambi di direzione.\(^15\) Un lavoro eseguito su calciatori svedesi ha valutato il pattern di movimento, la capacità di passaggio della palla e l'impressione del gioco del calcio da parte dei giocatori su sintetica rispetto all'erba naturale, con risultati negativi per quanto riguarda il terreno sintetico.\(^16\) Nessuno studio ha preso in esame finora atleti in età evolutiva, evidentemente più difficili da studiare, ma anche maggiormente soggetti ad eventuali sollecitazioni da parte di superfici di gioco non idonee, e per i quali i terreni in erba sintetica sono più largamente utilizzati.

Dal nostro studio, che ha indagato invece questa particolare categoria di soggetti, emerge un'associazione positiva tra allenamento su terreno in erba sintetica ed insorgenza di patologie muscolari e tendinee. Si assiste infatti, anche se non significativamente, ad un allungamento dei tempi di recupero e ad un'aumentata probabilità di recidiva.

Le maggiori differenze sono state note per gli atleti dell’anno 1994, tra i quali si è verificato il 45% degli infortuni per gli atleti del gruppo A rispetto al 10,5% fra gli atleti del gruppo B. In ogni caso, per ogni classe di età dei soggetti studiati, l’incidenza di patologie muscolo-scheletriche è risultata maggiore per gli atleti che si allenavano su campo in erba artificiale.

Per gli atleti allenati su terreno sintetico le patologie più frequentemente riscontrate sono state le lesioni muscolari da trauma indiretto (tutte lesioni di 1\(^{\text{st}}\) grado) e le tendiniti inserziali prossimali dei muscoli adduttori. Le possibili cause di tali patologie sono da ricercare anche nell’alterata coordinazione dei diversi gruppi muscolari. Una valutazione medica precedente allo studio aveva escluso ogni tipo di problema posturale o squilibrio tra i muscoli degli arti inferiori; la maggiore incidenza di lesioni muscolari tra gli atleti del gruppo A può...
For the athletes who trained on pitches of natural grass, the main cause of injury was due to muscular overload syndromes (muscular lesions due to physical exercise), probably deriving from a state of muscle fatigue, taking into consideration the fact that they appeared to coincide with tournaments that envisaged several matches in a single week.

The inflammation of the Achilles tendon, on the other hand, was only found on a small number of athletes in both groups. It is curious that, in athletes in group A, Achilles paratenonitis was always associated with and aggravated by plantar fascitis, a pathology that was never reported among the athletes in group B. The plantar fascia is a fibrous layer that extends forward from the front edge of the heel in the flexor system of the toes, and helps to maintain the physiological longitudinal turning of the foot. Because it has a lower damping capacity and is harder than a natural grass pitch, a pitch of artificial turf probably causes an incorrect podalic position, with an anomalous pronation that determines excess stress on the arch of the foot, which is then aggravated by the Achilles tendon pathology. This type of tendonopathy often has technical-structural concomitant causes that may be linked to a type of athletic movement linked to the surface on which it is performed. The elements most likely to negatively condition the athletic movement are the rigidity of the surface and the elimination of the torsional compensation on the horizontal plane; the latter may force the tendon to work with a strain in projections that are not physiologically advisable.

The recovery times necessary for the athlete, after rehabilitation treatment provided by the physiotherapist directly on the training ground, before going back to play with the group, were marginally longer than those for the athletes rehabilitated directly on a pitch of natural grass, for muscular lesions due to physical exercise and Achilles heel.

In young athletes who trained on pitches of artificial turf and who reported symptoms of muscular overload, there were 2 relapses. There were no relapses for the same problem among those who trained on natural grass.

On the other hand, the athlete who sprained his ankle when training on a pitch of natural grass had a relapse during the rest of the season, revealing a possible role of the natural surface in the onset of traumatic sprains, because it quindi essere in parte imputabile al diverso terreno di gioco, che potrebbe essere esso stesso responsabile di un'alterazione della biomeccanica podalica e quindi della coordinazione muscolare.

Per gli atleti che si allenavano su campo in erba naturale la principale causa di infortunio era rappresentata da sindromi da sovraccarico muscolare (lesioni muscolari da esercizio fisico), derivanti, probabilmente, da uno stato di affaticamento muscolare, considerata la loro comparsa in concomitanza con tornei che prevedevano più partite durante l'arco della stessa settimana.

La patologia infiammatoria del tendine di Achille si è manifestata invece con una bassa incidenza in entrambe gli gruppi di atleti. Un dato curioso è che la paratenonite Achillea, negli atleti del gruppo A, risultava sempre associata ed aggravata da fascite plantare, patologia che non si è mai presentata tra gli atleti del gruppo B. La fascia plantare è uno strato fibroso che si estende dal bordo anteriore del calcagno in avanti nell'apparato flessore delle dita, ed aiuta a mantenere la volta longitudinale fisiologica del piede. Il campo in erba sintetica, avendo una capacità ammortizzante inferiore ed essendo più duro di quello in erba naturale, causa probabilmente uno scorretto appoggio podalico, con un'anomala pronazione che determina un'eccessiva tensione sulla volta plantare, aggravata poi dalla patologia del tendine di Achille. Quest'ultima tendinopatia trova spesso dello delle concause tecnicoclinimpiantistiche che possono essere legate ad una tipologia di gesto atletico in relazione alla superficie di esecuzione dello stesso. Gli elementi che in maggior misura possono condizionare negativamente il gesto atletico risultano essere la rigidità della superficie e l'eliminazione dei compensi torsionali sul piano orizzontale; questi ultimi possono costringere il tendine ad un lavoro con strenuità in proiezioni non consone alla migliore fisiologia.

I tempi di recupero, necessari all'atleta, dopo trattamento riabilitativo, eseguito dal fisioterapista direttamente sul campo di allenamento, per tornare a giocare insieme al gruppo, sono stati lievemente più lunghi rispetto a quelli degli atleti riabilitati direttamente su campo in erba naturale, per le lesioni muscolari da esercizio fisico e la tendinitis Achillea.

Nei giovani atleti, che si allenavano su campo in erba artificiale e che avevano presentato delle sindromi da sovraccarico muscolare, si sono manifestate ben 2 recidive. Nessuna recidiva per la stessa problematica si è avuta in coloro che si allenavano su erba naturale.

Al contrario l’atleta che aveva subito un trauma distorsivo di caviglia allenandosi su campo in erba naturale ha presentato una recidiva nel corso della stagione sportiva, denotando un possibile ruolo del
is not always perfectly flat like an artificial surface. But this element clashes with other cases in literature, in which ankle lesions are more frequent on pitches of artificial turf. However these data must be considered with caution because of the small number of this type of lesion in each study conducted.

The results of this study must be seen in the context of an almost total absence of literature on the subject. Unfortunately the limits of the research are numerous and not easily overcome. There are subjective differences between the various athletes being studied, due to the elements typical of the physiological growth of the age of development. This poses some problems in the assessment of a direct correlation between the type of playing surface and tendon or muscular pathologies. Another confusing factor is certainly the type of shoes worn. If the surface and consistency of the playing pitch are different from those of a natural grass pitch, it is very probable that athletes should wear shoes with studs that are suited to the new surface. However, there is still too little information to allow us to give certain advice on the matter.

We do however feel that the limit that has most affected this study is the intensity of the training that the young football players undergo. Although the number of training sessions and the duration of each one were identical for the two teams compared, it is possible that the work load during the training was greater for athletes in group A. This could explain in part the greater incidence of muscular-skeletal lesions among athletes born in 1994. The sample universe is also too small for us to draw certain conclusions, particularly regarding recovery times and relapses reported.

This study is nonetheless an important starting point for future studies, whether transverse, eliminating every variable, or longitudinal, reducing the importance of the “growth” factor in the genesis of muscular-tendon pathologies. As things stand, this research has revealed a clear negative effect of a playing surface of artificial turf on the muscular-skeletal structure of young football players.

References/Bibliografia

5) Ekstrand J, Timpka T, Hägglund M. Risk of injury in elite football played on artificial