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Post traumatic osteoarthritis following acl injury in professional and former soccer player. A short overview.

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Abstract

Background. Isolated or associated non-contact anterior cruciate ligament injuries are frequently found in pivoting, cutting, side-step pivoting, and jump landing sports such as soccer. These injuries represent a serious risk to the footballer's career due to the long process of returning to performance. The risk of further ipsi- and/or contralateral re-injury injuries accelerates the physiological degenerative processes of the knee joint environment. **Objective.** The purpose of this short overview is to extend the results of the literature available on the Post-traumatic osteoarthritis (PTOA) by providing information on the status of the knee joint after Anterior Cruciate Ligament (ACL) reconstructive surgery, both in: active Professional Soccer (PS) and former Professional Soccer athletes (fPSa) as per the specific and common language of international literature. **Unfolding.** We did a search of PubMed, PubMed Central, ResearchGate was performed in relation to 2 inclusion criteria: (a) articles that explored the association between sport and Post-traumatic osteoarthritis (PTOA) of the knee after reconstructive ligament surgery anterior crusader; (b) Articles examining a correlation between PS knee PTOA in activity and fPSa. Exclusion Criteria: Articles that explored a condition other than knee OA and were outside the scope of this short overview. **Results and Discussion** Sports that involve pivots, cuts, and changes of direction, such as soccer, are associated with an increase in joint injuries with a physiological increase in risk factors of knee PTOA. In soccer players, in relation to sport-specific gestures, there is a rapid evolution of the process of degradation of the knee joint environment. At the elite level, in association with an ACL injury there is a higher prevalence of associated chondral and meniscal injuries that compromise the player's very career and future quality of life once they retire. The results of clinical and nuclear magnetic resonance-radiographic evaluations highlight how PSs have to manage their career path and how fPSa with many years of competitive activity have a reduced quality of life, with a markedly unfavorable clinical-symptomatological-imaging and functional status. **Conclusions**. In active Professional Soccer (PS) players, than in former Professional Soccer athletes (fPSa) an increased degradation of the knee joint environment this is also found after ACL reconstructive surgery this to the high mechanical stresses of soccer training and competition. Although much work has been done, the incidence of PTOA among Professional Soccer (PS), who in former Professional Soccer athletes (fPSa) with a history of ACL injury remains high because of the complexity of the progression of knee joint injury. Knee injury events accelerate the joint degenerative process present on imaging , correlated with the symptomatic framework of OA.

Key Words: *knee osteoarthritis in soccer, post-traumatic osteoarthritis, knee inury, acl injury ,retired soccer , former professional soccer, soccer player injury .*

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Premise

Currently, epidemiological studies concerning injuries in Italian soccer are very few and particularly far from its structural homogeneity of research. Thus Flows and epidemiological data, present, do not give exact and homogeneous information about the scientific clinical/rehabilitation status related to return to sport post - injury. Consequently, we can state and infer how it is impossible to identify risk factors and strategies for prevention, rehabilitation and return to sport after anterio Cruciate Ligament (ACL) reconstructive surgery[1].
We can state how the injury mechanisms of the ACL, in soccer, can be traced to complex technical and tactical gestures and "pathological movements" such as cutting maneuvers, side-step cutting and cross-step cutting, side-step cutting Jumping[2,3].
Returning to full-time unrestricted competitive practice after an ACL injury requires long and extensive rehabilitation, and some athletes do not return to their previous level of competition[4]. Rehabilitation and return to sport after ACL reconstructive surgery, not based on objective evidence may concur associated with repetitiveness of simple and complex football technical-athletic gestures, increase risk factors of re injury and overuse pathologies (joint overloads) that may concur in the development of degradation of the knee joint environment[5].
This scenery can be greatly accelerated after joint injury. The reported incidence of Post-Traumatic Osteoarthritis (PTOA) following anterior cruciate ligament injury reaches 87%[6].
It is to be highlighted that Post-Traumatic Osteoarthritis, develops after a joint injury such as an intra-articular fracture, ligamentous injury or other cartilage (articular or meniscus) injury within a joint. It accounts for about 12% of all cases of symptomatic OA[7].
Currently, there is evidence [1,2,9,13,14] to guide interventions aimed at preventing sports-related joint injuries.
Despite this, advances in primary and tertiary prevention there remains a lack of homogeneity of studies and interventions on what to do to delay or stop the onset of symptomatic PTOA after joint injury.
Although a variety of theoretically modifiable risk factors for symptomatic PTOA have been identified, there is limited evidence whether modifying them is truly effective in delaying the onset of the disease. The "risk profile" for PTOA is best characterized by an analysis and personalization of the athlete's clinical/functional status. (*table 1*).
After an ACL injury, soccer players need secondary prevention strategies to identify the joint degradation process in its early stages so that interventions can be implemented to slow the progression to its long-term evolution. Therefore, early diagnosis and identification of associated factors are effective methods to control disease progression and reduce the effects that might be accelerated by sports physical activity. The purpose of this short overview. is to extend data from research published on scientific data bases regarding PTOA after ACL reconstructive surgery in Professional Soccer (PS) and former Professional Soccer athletes (fPSa).

Introduction

Sports and exercise are major causes of joint injuries. Athletes who sustain a knee injury during their football career represent an easily identifiable subgroup of "high at risk" OA athletes.

The Osteoarthritis : focus overview.

The OA, a progressive and degenerative joint disease, the most common form of arthritis, results from the aging process but also from biochemical changes or biomechanical stresses affecting articular cartilage.
Osteoarthritis as well as osteoarthritis from antiquity to the present day is developed through the proceeds studies in the scientific literature, paleopathological findings in skeletal remains, visual representations, and new developments in pathophysiological concepts of the disease[8]. Classically, OA can be classified into two categories: a) primary osteoarthritis and b) secondary osteoarthritis and presents with joint pain and loss of function.

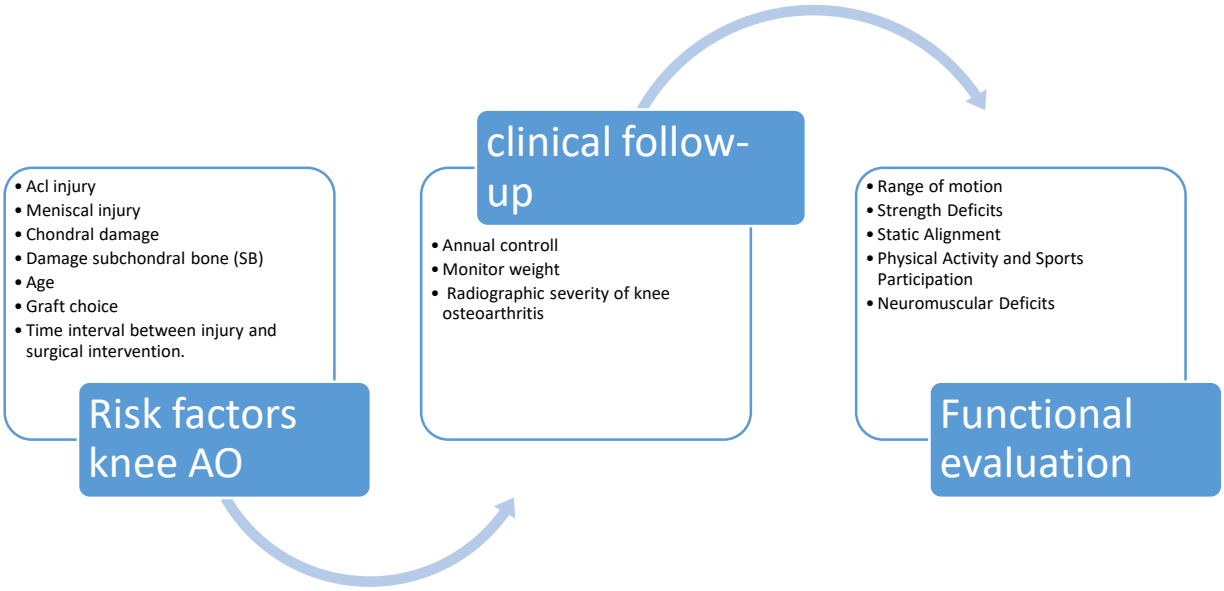

Table 1 . *Risk Profile of PTOA.*

However, the disease is clinically highly variable and can present simply as an asymptomatic incidental finding or as a devastating and permanently disabling disorder. However, osteoarthritis and osteoarthrosis, although both characterized by pain, stiffness, and limitation of movement are two different diseases in terms of etiopathogenesis and age of affected individuals. Osteoarthritis (OA) has long been considered a "wear and tear" disease that leads to cartilage loss. Experimental data[9] have shown that subchondral bone may play a substantial role in the process of OA, as well as being a source of inflammatory mediators implicated in the process of OA pain and degradation of the deep layer of cartilage[8,23]. The prevalence of knee OA varies among studies, and these differences are reflected in the heterogeneity of data reported from studies conducted worldwide. Roughly more than 10% of the world's population suffers from osteoarthritis (OA) of the knee, with a lifetime risk factor of 45%[10]. A comprehensive understanding of the pathogenetic mechanisms underlying this pathology is essential. The inflammatory process of OA begins in the synovial membrane with activation of the immune system, involving both humoral and cellular mediators. A crucial role in this process is played by so-called damage-associated molecular patterns (DAMPs)[11,23]. Mesenchymal Stem Cells (MSCs) may be a promising option among all possible therapeutic options. Recently, much research has been conducted on intra-articular injections of Mesenchymal Stem Cells (MSCs) for the management of knee OA[10,11]. Although most recent publications state that intra-articular injections of MSCs relieve joint pain in the short term, their efficacy remains controversial, as existing scientific information there is no consensus form on MSCs. Evidence from preclinical studies supports the anti-inflammatory and immunomodulatory effects of MSCs, but further investigation into immunomodulatory, chondroprotective, and clinical mechanisms of action is needed [12]. Physical therapy guidance should be based on the assessment of the core set of the International Classification of Functioning, Disability and Health (ICF) for OA. Based on the assessment, four treatment profiles were distinguished: (1) unsupervised exercise education and instruction, (2) short-term supervised exercise education and therapy, (3) long-term supervised exercise education and therapy, and (4) exercise education and therapy before and/or after total hip or knee surgery[13].

Thus the repetitive gestural technique of football athletics (decelerate, accelerate, jump, change direction, kicking) develops high abnormal biomechanical forces on the knee joint. These repetitive movements, associated with injuries, over the years of football career, can be considered as a high risk factor for developing early OA among active professional footballers. anterior cruciate ligament and meniscal injuries contribute to the development of early post-traumatic knee osteoarthritis[14]. The PS who return to play after serious joint injuries (complex capsular-ligament joint injuries) carry out their technical-athletic performances on morphologically compromised joints. We We can state how the prevalence of knee OA, for progressive clinical continuity, is higher among fPSa (range 35-55 years old), as per definitions in the international literature, and this compared to current PS still in activity[14]. Pain is the dominant symptom of knee OA often associated with swelling, stiffness, and joint mobility restriction with side-to-side strength asymmetries[16].

Rehabilitation, after joint injury, that is unstructured or aggressive, with an improper and inappropriate return to sport predisposes the athlete to a future risk not only of complications but also to an acceleration of the joint degeneration process[17]. Prevention strategies during the competitive/sports pathway, improved surgical management, rigorous individualized rehabilitation, and predictive genomic prophylaxis are needed to reduce the incidence and improve the health outlook of soccer players. Management of knee OA should be prioritized among PS, particularly to prevent progressive worsening of future joint condition[18]. According to Flanigan[19] the mean prevalence of full-thickness chondral defects in a group of 931 athletes (mean age 33 years) was 36%, with14% of cases asymptomatic. In 47% of cases, meniscal injuries of varying degrees were observed. It has been shown that both ACL and meniscus injuries are followed over time by changes in the articular environment of the knee joint.

Although PTOA, in SPs during activity have been studied, the epidemiological prevalence of knee OA is not well documented in the literature. The results, of these studies, in soccer and sports in general, are diverse, in terms of analysis, age groups and outcome measures.

The prevalence of PTOA after ACL injury is conflicting because of the different classification methods for defining OA in the literature[3]. In this epidemiological focus, we can highlight that the knee remains the most affected joint, followed by the ankle and hip. Joint injuries are very common in the athletic population, especially professional soccer players the incidence of injury during training was 6.5/1000 h and the injury risk during matchplay was 30.3/1000 h[20]. Astur[21] in a recent study evaluated the incidence of anterior cruciate ligament (ACL) injuries in male athletes of professional soccer clubs. During two consecutive seasons (2018-2019) with a sub-analysis based on age category: under-13 (U-13), under-15 (U-15), under-17 (U-17) and under-20 (U-20) years. A total of 17,108 young male soccer players from sixty-three professional clubs in Brazil's four top soccer divisions were retrospectively examined. In the two seasons, 336 primary ACL injuries were diagnosed (8,167 athletes in the 2018 season and 8,941 athletes in the 2019 season) among all athletes, accounting for 2% of the athletes included. There were 11 cases (0.3%) in the under-13 category, 53 cases (1.3%) in the under-15 category, 107 cases (2.5%) in the under-17 category, and 165 cases (3.8%) in the under-20 category. The incidence of ACL injuries was higher in the older age groups ($p < 0.001$). A total of 336 anterior cruciate ligament injuries were identified in 17,108 youth soccer players from 63 professional clubs, with an overall incidence of 2% over two seasons of competition. The rate of cruciate ligament injuries ranged from 0.3% to 3.8% and was higher in older and more competitive club divisions. Fernandes[22] found a prevalence of radiological knee OA between 28% and 80%, among 1207 retired professional soccer players (average age 59 years). Clinical management of knee OA is limited to an initial conservative treatment phase, that is, management of its symptoms[23] and only then is it directed toward prosthetic surgery (total or single-compartment). The likelihood of osteochondral injury increases significantly with increasing years of sports activity and age[24]. The prevalence of posttraumatic OA is higher in soccer players who have ended their sports career due to injury than in those who have stopped sports activity for other reasons.

A diagnosis of OA, among fPSa, ranges from 32-49%[25]. Football players have an incremental odds ratio of hospital admissions for total joint arthroplasty of the hip, knee, and ankle[25].

PTOA among soccer players in PS and fPSa

In professional soccer, a study presented by the Union of European Football Associations, conducted during the 2001 - 2015 sports seasons, showed an ACL injury incidence of 0.066 per 1,000 hours, a 20-fold increase in injury rates during training[26].

A prospective 5-year cohort[18] study among Australian PS showed that a team of 25 players can expect 4 to 8 serious knee injuries. The prevalence of knee PTOA was 28% among fPSa with an average age of 36 years, reaching up to 40% for the 40-50 age group)[7]. It has been reported[15,17,18,22,25] that the prevalence of PTOA among late-career fPSa is well above, the normal population. Kuijt[27] found, in a systematic review of the literature, a prevalence rate of knee PTOA between 60-80%.

Prien[28] through an online questionnaire surveyed 152 (response rate: 62.0%) former German first league players responded to the survey. About 70% described their current health status as good or very good. More than half (57.9%) reported having knee problems in the past 4 weeks during training and a third (33.6%) during normal daily activities.

Arliani[15] pointed out that radiographic signs of PTOA, in soccer players, in general, are present in 15.5-63% of the knees examined. The clinical and MRI evaluations that group comparisons [27 former professional male soccer players and 30 male volunteers from different nonsports professional areas] performed in this study revealed that former soccer players have a worse quality of life than a control group with regard to physical aspects related to the knee. These aspects include increased pain, increased symptoms, and substantial changes in radiographic and MRI images of the knee joint environment.

The incidence of PTOA is most noticeable in fPSa who have had a major knee injury during their competitive career. Ninety percent of fPSa, who present with a PTOA picture, report moderate to severe pain and joint range limitation and a major strength deficit especially of quadriceps[3]. Sixty-five percent show mobility problems while performing classic daily activities[23,25,28]. Gouttebarge[18] remarked in a very recent study that the prevalence of knee OA was 28% among fPSa (mean age 36 years), reaching 40% for the oldest age group (range 40-50 years).

Of these, 37% report anxiety/depression attributable to the status of the clinical/functional condition. It turns out how up to 17% of fPSa with hip and knee OA report symptomatic clinical pictures with significant discomfort in 'squatting, walking, and climbing and descending stairs[18].

However, the pathological pathways responsible for the development of OA of the hip and knee in professional soccer athletes are still not clearly understood. One study[29] showed that the prevalence rate of OA, of the hip was 8.6% in fPSa is 5.6% in baseline controls. The radiographic rate of OA was 21.2% in fPSa and 9.8% in controls. A total of 14.6-53.7% of fPSa had clinical and radiographic signs of knee OA to 12.9% and 31.9% of controls, respectively.

For Risberg[30], the prevalence of radiographic Tibio Femoral (TF)and Patello Femoral (PF) OA was, after ACL reconstructive surgery, 42% and 21%, respectively. In the study, the author points out that in most subjects it remained radiographically stable over the 5-year interval between follow-ups (15-20 years), but with a statistically significant worsening of symptoms and range of motion and functional levels of strength[3]. A significantly higher prevalence of OA TF was found in subjects with associated knee injuries than in those with isolated ACL injuries.

Pinczewski[31] found a trend toward increasing osteoarthritic changes in both the bone-patellar tendon-bone and the hamstring tendon graft cohorts between 2 and 10 years. However, the percentage of patients with normal (International Knee Documentation Committee grade A) radiographs decreased by 19% in the hamstring tendon group and 34% in the bone-patellar tendon-bone group.

D'Onofrio has in a study[17] evaluated, 5 years after ACL reconstructive surgery, a cohort of 33 subjects, practicing amateur sports. Analysis of the results shows a worsening, at 5-year follow-up of the radiological

images of the knee, at the Kellgren and Lawrence Scale with limitations, at KOOS, of daily and sports gestural expressiveness. The author points out that an early return to sports correlates, with an increase, in points (%), in risk factors of muscle injury, ACL re-injury and joint degenerative framework.

Thus Roos[32] showed that patients with ACL injury (isolated or associated) showed the first radiologic signs (joint space narrowing) of OA at an average age of about 40 years, Both study groups showed the first radiologic signs of PTOA on average about 10 years after injury and showed increasingly severe arthroscopic and radiologic signs of joint injury. For patients who had an isolated meniscal injury aged 17-30 years, the average time until the development of radiological signs of PTOA was about 15 years, while for those who had the same injury over 30 years, the corresponding time interval was only about 5 years. PTOA changes appear earlier in older athletes with knee injuries than in younger athletes. The increase in risk factors has been estimated from 100 to 1000 times in professional soccer[33].

This results in a significant increase in the frequency of knee joint PTOA in fPSa compared with the general population, and this can negatively affect their quality of life. At 12-14 years after an ACL injury, 75% of football players have significant radiographic symptoms: 41-77% show radiographic PTOA[34].

It is confirmed in the literature[35] that the prevalence of knee PTOA among fPSa ranges from 40% (clinical OA) to 80% (radiographic OA). This number is higher than 18-34% of the general population. About 50% of former athletes with partial or total meniscectomy have both symptomatic and radiographic signs of knee PTOA 5 to 20 years after ACL injury.

Approximately 50% of patients with meniscal injury and partial or total meniscectomy have symptomatic and radiographic signs of PTOA of the knee 5 to 20 years after injury. Among former football players, all players who underwent meniscectomy presented radiological signs of PTOA 10 to 20 years after surgery, compared with 40% of football players who did not undergo meniscectomy[36]. Reconstructive surgery after ACL injury does not prevent the development of PTOA, but it can improve knee kinematics and reduce secondary cartilage and meniscal injuries.

Today Advances in imaging studies have enabled earlier detection of degenerative changes in the knee, allowing researchers to study both how new interventions can modify the course of degenerative knee changes and to insert preventive training[14] following anterior cruciate ligament injury[37]designed to slow joint degenerative processes.

Discussion

The purpose of this short overview was to report data from previously published trials regarding PTOA in PS and fPSa. We found that PS and fPSa, compared with a nonsports control population, are easily predisposed to knee OA[6,7]. Injuries to the knee joint (meniscal, ACL, chondral, etc.,) carry a threefold increased risk of developing OA in the football player[22]. As reported[38], 50-90% of ACL injuries progress to PTOA.

This evidence is essential in order to identify levels in the early stage players predisposed for knee OA after acl injury in soccer players:

Recent work (2023) delimits its incidence:

a) Requejo-Herrero[39] analyzed ACL injuries in Spanish soccer players between the 2010-2011 and 2019-2020 seasons. There were 110 ACL ruptures, 15.45% of which were ipsilateral (6.36%) or contralateral (9.09%) ruptures. The anterior cruciate ligament incidence rate was 0.0364 per 1000
b) total playing hours, with a 68-fold higher risk in games than in training. The predominant mechanism of injury was non-contact (56.36%), and the average time away from sports activity was 218.8 days. The goalkeeper was found to be the least affected position.
c) Astur[21] identified 336 anterior cruciate ligament injuries in 17,108 youth soccer players from 63 professional clubs, with an overall incidence of 2% over two seasons of competition. The cruciate ligament injury rate ranged from 0.3% to 3.8% and was higher in older and more competitive club divisions.

Obviously, prevention of the primary injury and its re injury is the most effective tool to manage PTOA as there is still a lack of decisive treatment methods. ACL injury prevention programs play a significant protective role, reducing the incidence of ACL injury by 53%. A systematic review shows that neuromuscular and educational interventions reduce the incidence of ACL injuries by about 50%[7].
Gouttebarge[18] out of a total of 2500 contacted soccer players (70% active; 30% retired) only 1360 gave written informed consent and completed the questionnaire (overall response rate of 54%):

(a) 964 Professional Soccer players PS.

(b) 396 Former Professional Soccer athletes (fPSa).

The active soccer players played at the professional level for an average of 7 years, and 67 percent played at the highest club level in their country. The average age, height and weight of the group of retired professional soccer players were 36 years (SD = 6), 181 cm (SD = 7) and 82 kg (SD = 9), respectively. The retired players had played professional soccer for 11 years on average (81% at the highest club level in their country) and had been retired for 5 years (30% forced to retire). Approximately 90% of these fPSa. players were employed. The prevalence of knee PTOA was 13% in the entire group of current professional soccer players, with rates of 8%, 15% and 19% for the 18-24 years, 25-30 years and >30 years age groups, respectively. About 59% of current soccer players have not suffered a serious knee injury during their career, 35% one or two serious knee injuries and 6% three or more. About 73% of current professional soccer players have not had knee surgery during their careers, 23% one or two surgeries and 4% three or more. Logistic regression analysis indicated that current professional soccer players were almost twice as likely to suffer from knee OA for each additional serious knee injury and each additional surgery.
A cross-sectional study of 1207 fPSa (mean age 59 years) found that the prevalence of radiologic PTOA of the knee ranged from 28-80%, which is higher than the prevalence found in a control groupin the general population (10-50%). In this study recent, by Fernades[40], from 40-65% of fPSa have knee pain incorrelation with 20-30% of the control group.
Additional published data[18] show that 95% of athletes retired from various sports, have obvious chondral injuries. At 13% on average, this prevalence of knee PTOA among current active SPs is significantly lower than among fPSa. Furthermore, as expected, it is shown[18] that the prevalence of knee PTOA evolves over time during a football career and during the post-competitive years. The prevalence of knee PTOA is associated with a lower level of physical and knee function.
Bezuglov[41] states how a high percentage of PS will have asymptomatic intra-articular knee joint changes during competitive sports activity. The intra-articular environment (osteophytes, cartilage, and menisci) in 94 knee joints of 47 adult SPs (mean age ± SD 25.7; body mass index, 22.8 ± 1.4 kg/m2) was studied in this work. Cartilage of both knee joints was affected in 97.9% of the players. Grade 2 cartilage injuries, were the most prevalent (36-60% depending on the location of the injury) and Grade 4 injuries were found in 12.7% of the joints. The medial femoral condyle and medial tibial plateau were most frequently affected by cartilage injuries (85.1%). Meniscal injuries were found in 97.8% of joints, with involvement of both joints in 93.6% of athletes. Among meniscal injuries, Grade 2 injuries were the most prevalent, detected in 71% of cases. Grade 3 injuries were detected in 13.8% of the knees examined. Beals[42] summarized the results of 14 studies on the prevalence of asymptomatic meniscal injuries in amateur and professional athletes (N =295; mean age, 31.2 years). The author found changes in meniscal tissue in 31.1% of participants.
The overall prevalence of PTOA PFJ after anterior cruciate ligament injury in the included studies ranged from 4.5% to 80%[35]. The wide variation in the prevalence of PTOA in PFJ is mainly due to the different follow-up period and surgical techniques. Collected data35 have shown that patellar bone-tendon graft, single bundle ACL reconstruction (ACLR), and delayed ACLR are likely associated with degenerative changes in PFJ after ACL injury[35]. In the literature[35] ACLR, delayed ACLR, body mass index (BMI), meniscectomy, patellofemoral chondral lesions, age at surgery, and PTOA of the TFJ have been identified to induce PTOA of the PFJ after ACL injury. This PTOA-related joint status is further accentuated by an aggressive and non-clinically structured rehabilitation course. Shelbourne[43] showed that patients with lower-than-normal ROM after ACLR were 2.5

times more likely to have radiographic evidence of PTOA at approximately 10 years than patients with normal ROM. In a later study Shelbourne[43] observed that limited ROM of knee flexion on return to play increased the risk of radiographic evidence of PTOA. In this short overview, we highlighted how the prevalence of knee PTOA in active Professional Soccer (PS), which in former Professional Soccer athletes (fPSa) can be considered an evolved process compared to the general population. To identify players at risk of PTOA, a health surveillance program should be implemented in elite and amateur soccer as a preventive measure. Recommendations for the prevention and management of PTOA are based on the best available evidence. Primary injury prevention, self-management strategies, body weight maintenance, and an adequate level of physical activity should be especially encouraged in fPSa. Education of physicians, trainers, physical therapists, and athletes regarding PTOA is also critical for effective prevention and management of the progression of this degenerative process. Mechanical factors play a key role in the progression of PTOA. Consequently, chronic changes in static and dynamic loading of the knee can lead to accelerated degradation of cartilage and other joint structures[44].

Conclusion

The lower limb is subject to high levels of stress during technical and athletic soccer gestures. The knee joint is the one most prone to high risk of injury, both macrotrauma (particularly cruciate ligament or meniscus ruptures and fractures involving the knee joint) and microtrauma (as a result of sprains and contusions) and to overload pathologies. Although much work has been done, the incidence of PTOA among Professional Soccer (PS), who in former Professional Soccer athletes (fPSa) with a history of anterior cruciate ligament injury remains high because of the complexity of knee joint injury progression to PTOA, Improved standardized and quantitative assessment techniques are needed to guide interventions. In addition, treatments targeting different pathogenic pathways could be crucial for the management of PTOA in the future.

Future directions

The development of PTOA is a chronic and progressive condition. Patients with ACL injury have a high risk of developing PTOA. Although much has been done the incidence of PTOA among patients with a history of ACL injury and associated pathologies remains high because of the complexity of the progression of capsular ligamentous injury of the knee. In its advanced stages, changes in the knee joint are irreversible, and arthroplasty may be the only treatment choice. Therefore, early diagnosis and assessment of the severity of OA are necessary to guide therapy and prevent a very important process of knee joint degradation. Future research directions should be the improvement of standardized and quantitative assessment techniques to detect OA at an early stage, monitor the progression and severity of OA development, and evaluate the effectiveness of treatments. Clinicians should focus not only on primary prevention of knee injuries, a key risk factor for the onset of PTOA, but also on secondary prevention of long-term sequelae of OA.

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