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Review

# Knee and ankle osteoarthritis in former elite soccer players: A systematic review of the recent literature

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**Abstract**

*Objectives:* To investigate the prevalence of knee and/or ankle osteoarthritis in former elite soccer player.
*Design:* Systematic review.
*Methods:* Medline, Embase and SPORTDiscus (2000 to January 2012) were used. To be included, studies were required to be a primary study, written in English, Dutch, French or German, former elite soccer players had to be the study population, and presenting knee or ankle OA had to be the outcome measure.
*Results:* The search strategy resulted in four studies. Two studies, evaluated as having a high methodological quality, found a prevalence rate of knee OA between 60 and 80%. Both studies used radiographic examination as their measurement instrument to diagnose OA; the presence of ankle OA was not determined. The other two studies, evaluated as having a moderate methodological quality, found a prevalence rate of knee OA between 40 and 46% and a prevalence rate of ankle OA between 12 and 17%. These studies used a questionnaire as their measurement instrument wherein players were asked if they had ever been diagnosed with OA by a medical specialist.
*Conclusions:* The prevalence of knee and ankle OA in former elite soccer players can be considered high compared to the general population and to other occupations. To identify players at risk for OA, a health surveillance program should be implemented in elite soccer as a preventive measure. Further research should be conducted to determine if the risk of developing OA varies among different subgroups of elite soccer players and what the consequences of this high OA prevalence are.
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*Keywords:* Osteoarthritis; Osteoarthritis knee; Osteoarthritis ankle; Prevalence; Soccer; Athletes

## 1. Introduction

Because they are exposed to high intensity and prolonged sports activity as a part of their work, elite athletes are particularly vulnerable to sports related health risks. The most obvious risk of sports activity, which has been shown to occur more often during competition and at higher levels of participation, is the development of musculoskeletal injuries.[1–3] According to several studies, soccer has one of the highest injury rates among sports.[4] The most common injury types described in elite soccer are muscle strains, ligament sprains and contusions, particularly involving the thigh, knee and ankle.[5–8] Less common risks of exercise include sudden cardiovascular death, acute myocardial infarction and arrhythmia.[1,9,10] Additionally, continuous excessive training in combination with insufficient time to recover has been suggested to result in so-called 'overtraining syndrome', which manifests in overuse injuries, poorer performance, mood disturbances and immune system deficits.[11]

A significant long-term effect of vigorous physical activity is the development of osteoarthritis.[12] Osteoarthritis (OA), or 'degenerative joint disease', is the most common form of arthritis and results in irreversible pathologic changes in affected joints.[13] The main symptoms are joint pain, stiffness, reduced function, instability, deformity, swelling and crepitus.[14] The disease has been shown to have major consequences. In high-income countries it is the 10th leading cause

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of disability and is responsible for 2.5% of total disability adjusted life years (DALYs).[15] In addition, compared to age- and sex-matched controls, patients with OA are more likely to suffer from comorbid conditions, both musculoskeletal and non-musculoskeletal, with an odds ratio (OR) of 2.35.[16] Risk factors for developing OA are well known and can be divided into two categories: systemic and local factors.[17] Systemic risk factors are thought to make the joint vulnerable to local factors and are thereby associated with the development of OA. They include age, gender, hormonal status and genetics. Local risk factors cause abnormal biochemical loading on joints and include obesity, occupational activities (squatting, kneeling, lifting), joint injury and certain types of sports participation.[17,18] High-intensity and prolonged sports activity, especially at an elite level, have been associated with the development of OA.[19]

As mentioned above, elite soccer players are at considerable risk of obtaining joint knee and ankle injuries. In a recent prospective cohort study by Ekstrand et al., which followed European elite soccer players for seven consecutive seasons, the overall injury rate was 8.0 injuries per 1000 hours of exposure; during matches the injury rate was as high as 27.5 injuries per 1000 hours.[20] Furthermore, in a study among 91 English professional soccer clubs during two competitive seasons, ankle and knee injuries combined represented 34% of all injuries.[4] In addition to this high injury rate, elite soccer players are exposed to a sport that is both high-intensity and extensive. Because these factors have been described to increase the risk of OA, the development of knee and/or ankle OA could, in the long term, pose a serious problem in this group of athletes. In 1981, a Dutch study revealed that the prevalence of knee and ankle OA is higher among former elite soccer players than in age-matched controls. Knee and ankle OA were diagnosed in 33 and 42% of former elite soccer players and in 7 and 5% of controls, respectively.[21] Additionally, in 1994, Kujala et al. reported that former elite soccer players are at increased risk for the need of hospital care for knee and ankle OA than their healthy age-matched controls, which consisted of men liable for military service with an OR of 2.10.[22] Furthermore, the same author conducted a study among former elite athletes, including soccer players and shooters (aged 45–68 years), that revealed that the prevalence of knee OA was 29% in former elite soccer players compared to 3% in shooters.[23]

Because the intensity, speed and behaviour (aggressiveness) of elite soccer have changed in recent years, the aforementioned studies may have become outdated. The purpose of this study is to systematically review the recent literature regarding the prevalence of knee and/or ankle osteoarthritis in former elite soccer players.

## 2. Methods

The electronic databases Medline (biomedical literature) via PubMed, Embase (biomedical and pharmaceutical literature) via Ovid and SPORTDiscus (sports and sports medicine literature) via EBCOhost were searched from 2000 to January 2012. All literature was limited to studies in humans and to English, French, German and Dutch languages. The key words and their synonyms were divided into categories to provide a systematic search. The first category consisted of synonyms for 'elite soccer players'; the second category consisted of synonyms for 'knee and/or ankle osteoarthritis', and the last category consisted of synonyms for 'prevalence'. The different synonyms of each category were combined by the Boolean command OR, and the different categories were linked by the Boolean command AND. In Medline, we strived to use existing medical subject headings [MeSH]. For terms that did not have a medical subject heading, we searched the text [tw] or the title and/or abstract [tiab]. In Embase, we used the same search terms as in Medline, in combination with the term 'football' and with the addition of the terms used in the medical subject heading and their synonyms listed in the MeSH database. Finally, we conducted a more sensitive search strategy in SPORTDiscus because this database is smaller than the others. We combined 'soccer or football' with 'osteoarthritis' and 'knee or ankle osteoarthritis'. To truncate search terms and to find all terms that begin with a specific word, we used a * symbol in Medline and a $ symbol in Embase and SPORTDiscus. The exact search strategy can be obtained from the authors.

Eligibility criteria were defined to retrieve relevant original articles. To select studies eligible for our review, the following inclusion criteria were applied:

1. the article had to be an original, i.e., primary study,
2. the article had to be written in English, Dutch, French or German,
3. the population of interest had to be former elite soccer players,
4. osteoarthritis of the knee or ankle had to be described as an outcome.

After identifying and deleting all duplicates, two reviewers (M-TKK and VG) independently applied the inclusion criteria to the titles and abstracts of the retrieved literature to identify potentially relevant articles. Studies were included for full text selection if they met the inclusion criteria or if the title and abstract did not provide enough information to determine whether the inclusion criteria were met. Then, full articles of these studies were obtained, and both reviewers independently applied the inclusion criteria to the full text. Disagreements, if any, on the inclusion or exclusion of full articles were resolved by consensus. To avoid missing any relevant publications, we conducted a reference check of all included studies. Furthermore, references of retrieved literature/systematic reviews meeting the last three inclusion criteria were also screened.

Data were extracted from the original articles by one author (M-TKK) with a standardized data extraction form that included the following topics: (1) article information (author, year, country, reference number), (2) information

Table 1
Criteria for methodological assessment.[24,25]

| |
|---|
| **Participants selection** |
| + Sources and selection methods of participants were clearly described. |
| − No description of sources or selection methods of participants. |
| **Characteristics of participants** |
| + A minimum of three of the following characteristics of participants were presented: number, age, sex, nationality, duration of professional career. |
| − Less than three characteristics of participants were presented. |
| **Non-responders (if applicable)** |
| + A minimum of two of the following information about non-responders were presented: number, age, reasons for non-participation. |
| − Less than two informational items were presented about non-responders. |
| **Definition of outcome** |
| + The outcome (knee/ankle osteoarthritis) was defined. |
| − The outcome (knee/ankle osteoarthritis) was not defined. |
| **Measurement of outcome** |
| + The instrument to measure the outcome was valid or had been previously used in a peer-review. |
| − The instrument to measure the outcome was not valid or had not been previously used in a peer-review. |
| ? Unclear if instrument to measure the outcome was valid. |
| **Presentation of outcome** |
| + The outcome (knee/ankle osteoarthritis) was presented as a prevalence (in %). |
| − The outcome (knee/ankle osteoarthritis) was not presented as a prevalence (in %). |

about the study population (population size, age, sex, nationality, duration of professional soccer career, method/sources of selection), (3) information about non-responders (number, age, reasons for non-response), (4) study design (cross-sectional, cohort), (5) definition of outcome (knee and/or ankle osteoarthritis) and measurement instrument and (6) main result(s) of the study (prevalence of knee and/or ankle osteoarthritis).

The methodological quality of all included articles was assessed by the first author and independently checked by another author (VG). The quality assessment was conducted based on criteria from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist and the criteria created by Radulescu et al. (2009) for prevalence studies.[24,25] Some of these criteria were adapted to better suit the purpose of our review. The criteria used to judge the methodological quality included the following: sources and selection methods of participants had to be described; a minimum of three characteristics of the participants (number, age, sex, nationality, duration of professional career) had to be presented; a minimum of two items of information about non-responders (number, age, reasons for non participation) had to be presented; a definition of knee or ankle OA had to be given; the measurement instrument for knee or ankle OA had to be valid, and the prevalence of knee or ankle OA had to be presented (in %). All items can be found in Table 1. If possible, each item was qualified as 'positive', 'negative', or 'unclear'. Any disagreements were solved by consensus. A total quality score was calculated for each study by adding up all positive criteria (maximum score is six). Studies with five or more positive criteria were considered to be of high quality; those with three or four positive criteria were of moderate quality, and those with less than three positive criteria were of low quality.

## 3. Results

After deleting duplicate articles from the different databases and applying the inclusion criteria to the titles and abstracts, our search strategy resulted in 37 articles to be included for full text review. From these full texts, 33 were excluded for one of the following reasons: no primary study ($n = 14$), the population of interest did not consist of former elite soccer players, and/or the prevalence of knee and/or ankle OA was not described as an outcome ($n = 17$). Furthermore, the study by Drawer et al. was published in two different articles (2001 and 2002).[26,27] In our analysis, we used the publication from 2001 because of its more detailed results.[26] Also, one French article was excluded because we had already included its identical version in English. Consequently, four original studies remained after our systematic search strategy. The reference check of these studies resulted in no additional inclusions. The flowchart of our search procedure can be obtained from the authors.

Four original studies were included as a result of our systematic search strategy.[26,28–30] Based on our quality assessment, two studies were evaluated as having high methodological quality (Elleuch et al. (2008) and Krajnc et al. (2010)) whereas the other two studies had moderate methodological quality (Drawer et al. (2001) and Turner et al. (2000)). Results of the methodological quality assessment can be found in Table 2 whereas the complete data extraction of the included studies is presented in Table 3.

Because they scored positive on all six items of our criteria for methodological quality, both studies by Elleuch et al. (2008) and Krajnc et al. (2010) were evaluated as high concerning their methodological quality.[29,30] These studies found a prevalence rate of knee OA between 60 and 80%. Elleuch et al. (2008) studied the prevalence of knee OA in 50 male former top-level soccer players from a first division local club in Tunisia.[29] Their mean age (SD) was 49.2 (3.8) years, and the mean total duration (SD) of their professional career was 10.7 (4.6) years. The OA prevalence was determined by radiographic examination with the following criteria: narrowing of joint space, subchondral condensation and osteophytosis. The prevalence of this radiographic-diagnosed knee OA was 80%. The study by Krajnc et al. (2010) measured the prevalence of knee OA by radiographic examination in 40 former Slovenian soccer players.[30] This group had a mean age (SD) of 49.2 (9.7) years and a mean total duration of their professional career of 11.3 (4.2) years. They defined OA as a radiographic Kellgren–Lawrence stage $\geq 2$. More than 60% of these retired soccer players had radiological signs of knee OA in one or both legs; no exact percentage

Table 2
Results of quality assessment.

| Study | Sources and methods of participant selection | Characteristics of participants | Information about non-responders | Definition of outcome | Measurement of outcome valid and described | Prevalence of outcome (%) | Total |
|---|---|---|---|---|---|---|---|
| Drawer[26] | + | + | − | − | + | + | 4 |
| Turner[28] | + | + | − | − | ? | + | 3 |
| Elleuch[29] | + | + | + | + | + | + | 6 |
| Krajnc[30] | + | + | + | + | + | + | 6 |

is mentioned. In addition, 50% of all knees had radiological signs of OA.

Both studies by Drawer et al. (2001) and Turner et al. (2000) were evaluated as studies of moderate methodological quality.[26,28] In these studies, the prevalence rate of knee OA was between 40 and 46%. These studies also assessed the prevalence of ankle OA, which had a prevalence rate between 12 and 17%. Drawer et al. (2001) distributed a questionnaire to 500 retired English professional soccer players registered with the English Professional Footballers' Association

Table 3
Results of data extraction from included studies.

| Article information | Study population | Non-responders | Study design | Outcome measure | Main results |
|---|---|---|---|---|---|
| Author: Drawer<br>Year: 2001<br>Country: UK<br>Reference: 26 | *N* = 185<br>*A* = 47.6 (SD = 13.2)<br>S = ?<br>Nat = ?<br>PC = 14.3<br>M = English Professional Footballers' Association | *N* = 313<br>A = ?<br>R = ? | Cross-sectional | Osteoarthritis of the lower limbs, not defined<br>Measurement instrument:<br>Questionnaire: based on established published knowledge and criteria for assessing the presence of OA. Data were obtained when a medical specialist first officially diagnosed OA. | Prevalence of OA: 32% (59)<br>Percentage of respondents diagnosed with OA of:<br>–Right knee: 19.0%<br>–Left knee: 21.3%<br>–Right ankle: 5.7%<br>–Left ankle: 6.3%<br>Mean age (SD) at diagnosis, in years:<br>–Right knee: 36.1 (12.8)<br>–Left knee: 35.2 (11.5)<br>–Right ankle: 29.5 (4.2)<br>–Left ankle: 31.6 (5.8) |
| Author: Turner<br>Year: 2000<br>Country: UK<br>Reference: 28 | *N* = 284<br>*A* = 56.1 (SD = 11.8)<br>S = ?<br>Nat = ?<br>PC = 13.5 (SD = 5.3)<br>M = Former Players Associations | *N* = 231<br>A = ?<br>R = ? | Cross-sectional | Osteoarthritis, not defined.<br>Measurement instrument:<br>Questionnaire: respondents were asked if they had been diagnosed with OA and at what age they were diagnosed. | Prevalence of OA: 49% (138), whereof:<br>–60% (83) in two or more joints<br>–30% (42) in three or more joints<br>Locations of OA (*n* = 314):<br>–26% (82) right knee<br>–20% (62) left knee<br>–11% (33) right ankle<br>–6% (20) left ankle<br>Mean age (SD) at diagnosis of OA: 40.4 (12.5) years |
| Author: Elleuch<br>Year: 2008<br>Country: Tunisia<br>Reference: 29 | *N* = 50<br>*A* = 49.2 (SD = 3.8)<br>S = Male<br>Nat = ?<br>PC = 10.7 (SD = 4.6)<br>M = former first division soccer players from a local club were invited | No non-responders | Cross-sectional | Knee osteoarthritis<br>Definition: narrowing of joint space, subchondral condensation, osteophytosis<br>Measurement instrument:<br>Radiographic examination | Prevalence of OA: 80% (40) |
| Author: Krajnc<br>Year: 2010<br>Country: Slovenia<br>Reference: 30 | *N* = 40<br>*A* = 49.2 (SD = 9.7)<br>S = ?<br>Nat = ?<br>PC = 11.3 (SD = 4.2)<br>M = list of former players from the football club NK Maribor | No non-responders | Cross-sectional | Knee osteoarthritis<br>Definition: Kellgren–Lawrence grades ≥ 2<br>Measurement instrument:<br>Radiographic examination. | Prevalence of OA: >60% of participants had radiological signs of knee OA in one or both legs (no specific percentage given)<br>50% (40) of knees had OA |

*A*: mean age (in years); M: method of participant selection; *N*: number; Nat: nationality; OA: osteoarthritis; PC: mean total length of professional career (in years); R: reason for non-response; S: sex (male/female); SD: standard deviation; ?: unknown/unclear.

(PFA).[26] The response rate in this study was 37%; 185 former professional footballers returned the questionnaire. No additional information about non-responders was presented. The mean age (SD) of the respondents was 47.6 (13.2) years and their professional career had a mean duration of 14.3 years. The questionnaire obtained data on when a medical specialist diagnosed OA for each joint. However, OA was not specifically defined. Fifty-nine respondents (32%) reported that they had been diagnosed with OA in at least one lower limb joint. The prevalence of self-reported knee OA diagnosis was 40.3%, whereof the right knee accounted for 19.0% and the left knee for 21.3% of diagnoses. The mean age (SD) at diagnosis was 36.1 (12.8) years for the right knee and 35.2 (11.5) years for the left knee. Of all respondents diagnosed with OA, 12% were affected in the ankles, whereof 5.7% in the right ankle and 6.3% in the left ankle. The mean age (SD) at diagnosis was 29.5 (4.2) years for the right ankle and 31.6 (5.8) years for the left ankle. Turner et al. (2000) conducted a cross-sectional survey in the United Kingdom (UK).[28] They distributed 515 questionnaires through the Former Player Associations (FPAs), whereof 284 were returned. The mean age (SD) of the participants was 56.1 (11.8) years, and the mean length (SD) of their professional career was 13.5 (5.3) years. Besides the response rate, no additional information was presented about non-responders. Furthermore, OA was not specifically defined, and it was unclear if the measurement instrument for OA was valid. They used a questionnaire wherein respondents were asked if they had been diagnosed with OA and at what age they had been diagnosed. However, it was obscure how and by whom this diagnosis was made, as this was not specifically questioned. Forty-nine percent of respondents indicated that they had been diagnosed with OA on at least one anatomical site. Sixty percent had been diagnosed with OA in two or more joints, and 30% had been diagnosed with OA in three or more joints. The mean age (SD) at diagnosis of OA was 40.4 (12.5) years. Of all OA diagnoses ($n = 314$), the knees were most commonly affected by OA: 46%, whereof 26% ($n = 82$) in the right knee and 20% ($n = 62$) in the left knee. The ankles accounted for 17% of all 314 OA diagnoses, whereof 11% ($n = 33$) in the right ankle and 6% ($n = 20$) in the left ankle.

## 4. Discussion

The aim of this study was to systematically review the recent literature regarding the prevalence of knee and ankle OA in former elite soccer players. Our search strategy and study selection resulted in the analysis of four studies. The studies by Elleuch et al. (2008) and Krajnc et al. (2010), which were evaluated as having a high methodological quality, found a prevalence rate of knee OA between 60 and 80%.[29,30] The studies by Drawer et al. (2001) and Turner et al. (2000), both evaluated as having a moderate methodological quality, found a prevalence rate of knee OA between 40 and 46%.[26,28] These last two studies also investigated the prevalence of ankle OA, which appeared to be between 12 and 17%.

There is a significant difference in the prevalence rates of knee OA (from 40% to 80%) between the included studies. This difference could be explained by possible differences in the mean age of the studied populations, differences in the amount of exposure to professional soccer (length of professional career), or by differences in the measurement instrument to determine OA.

Because age is a risk factor for OA, a higher mean age of the studied population could result in a higher prevalence rate of OA. However, because the mean ages of the studied populations in the included studies are comparable, this factor is not likely to be an explanation for the differences in the prevalence rates. In fact, the population in the study by Turner et al. (2000) had a higher mean age (56.1 years) than the populations in the studies by Elleuch et al. (2008) and Krajnc et al. (2010) (both 49.2 years) whereas the prevalence of knee OA in Turner's study was 46% compared to 80% in Elleuch's and more than 60% in Krajnc's study.[28–30]

Because exposure to high intensity and extensive sports is a risk factor for OA, it could be assumed that a longer professional career would result in a higher chance to develop OA. In addition, a longer professional career would probably result in more joint injuries, which is also a risk factor for OA. However, the studies with a longer mean duration of professional career, ranging from 13.5 to 14.3 years, found a lower prevalence rate of knee OA (between 40 and 46%) than the studies with a shorter mean duration of professional career, ranging from 10.7 to 11.3 years (between 60 and 80%). Then, the assumption could be made that the fittest professional players are likely to have a long soccer career and have a lower at risk for long term knee OA.

The use of distinct measurement instruments could also explain the differences in OA prevalence rates. The studies that found a prevalence rate between 40 and 46% used a questionnaire with self-reported diagnosis of OA to determine knee OA.[26,28] On the other hand, the studies that found a rate between 60 and 80% used radiographic examination to determine the prevalence of knee OA.[29,30] Apparently, radiographic examination finds a higher rate of knee OA compared to self-reported knee OA diagnosis. This difference could be due to the discordance between clinically and radiographically established knee OA as not all individuals with radiographic OA have symptomatic disease.[31–33] Moreover, the prevalence rates in the studies that determined OA by self-reported diagnosis could be affected by recall bias. Considering that the time between OA diagnosis and participation in these studies was often more than 15 years, players might have forgotten if and at what specific age they had been diagnosed with OA.

Taken together, the overall lower prevalence rates found in the studies by Drawer et al. (2001) and Turner et al. (2000) compared to the prevalence rates found in the

studies by Elleuch et al. (2008) and Krajnc et al. (2010) could be explained by the use of distinct measurement instruments.[26,28–30] However, there is still a difference in the prevalence rates between the two studies using radiographic examination as their measurement instrument: 60% in the study by Krajnc et al. (2010) vs. 80% in the study by Elleuch et al. (2008). The detection rate of knee OA by radiography is very dependent on the amount and types of views used in the radiographic examination of the knee.[34] As these views vary among studies, one must keep this methodological discrepancy in mind when comparing the prevalence rates of radiographic diagnosed knee OA between different studies. In conclusion, the use of distinct measurements instruments to establish knee OA may likely explain the differences in the prevalence rates between the four studies.

No large difference was observed in the prevalence rates of ankle OA, which was determined by Drawer et al. (2001) and Turner et al. (2000). The prevalence rates of ankle OA were 12% in Drawer's study and 17% in Turner's study.[26,27] In both studies, OA was determined by self-reported diagnosis.

The prevalence of knee and/or ankle OA in former elite soccer players can be considered as high. For comparison, radiographic osteoarthritis, which has a prevalence rate of between 60 and 80% in former elite soccer players, has a prevalence of 25% in the general population aged 50 and over in the United Kingdom (UK) whereas a prevalence of 18% is found in non-elite sport participants.[35,36] In other occupational groups with knee-straining work such as floor layers, the prevalence of radiographic knee OA has been found to be 34% in individuals 50 years or older.[37] Furthermore, Kellgren and Lawrence studied the prevalence of OA in miners, manual workers and office workers aged 40–50 years and found prevalence rates of radiographic knee OA of 6%, 2% and 0%, respectively.[38] Self-reported knee OA diagnosis by a medical specialist had a prevalence between 40 and 46% in former elite soccer players whereas the prevalence of general practice diagnosed knee OA in the general population aged 45 years or older in the UK has been reported to be 12.5%.[39] Whether this substantial difference could rely on the clinical criteria used for diagnostic remains unknown as information about it is lacking.

Because symptomatic OA of the ankle joint is relatively rare (less than 1% in the general adult population), the prevalence of ankle OA in different populations and/or occupations has not been as extensively studied as OA of the knee joint.[40] For this reason, we could not find any suitable studies in which the prevalence of ankle OA was determined in a similar age group to the populations in our studies. Based on the prevalence of self-reported diagnosed ankle OA in the studies by Drawer et al. (2001) and Turner et al. (2000) (between 12 and 17%), it can be assumed that, along with knee OA, ankle OA occurs more often in former elite soccer players than in the general population.[26,28]

Our study shows that the prevalence of knee and ankle OA can be acknowledged as high. However, we do not know whether this high prevalence of knee and ankle OA is a reason for concern as the related consequences in terms of quality of life, activities and (work) participation were not extensively described in the included studies. Several studies have shown that patients diagnosed with hip or knee OA have relevant limitations in activities such as walking, a decreased work-related functional capacity compared to healthy ageing workers, and report a lower quality of life.[27,41,42] However, to our knowledge, there is lacking evidence indicating whether or not the consequences of knee and ankle OA also affect former elite soccer players.

Considering the high rate of OA in former elite soccer players compared to the general population and to other occupations and that OA is an irreversible disease with notable consequences, more action should be taken to prevent the development of OA in elite soccer players. It has been suggested to implement a health surveillance program for elite soccer players.[43] Such a health surveillance program could be developed to identify players or subgroups of players at risk for OA. For example, physical examinations or stability and muscle strength tests of the knee and ankle could indicate the potential for injuries.[43] Subsequently, adequate preventive measures, as suggested by the FIFA, could be implemented in players or subgroups of players at risk.[44] Although no study has been exploring whether soccer exposure (in terms of training, competition or activities) is a risk factor for knee or ankle OA, preventing measures focusing on the reduction of the exposure to soccer-related activities would be obviously unfeasible in elite soccer. On the other hand, as joint injuries have been described to be one of the strongest risk factors for developing OA, the attention could be focused on the prevention of these joint injuries.[45] According to a review by Gillquist et al. (1999), isolated meniscus rupture or ruptures of the anterior cruciate ligament (ACL) of the knee are associated with a 10-fold increase in OA compared to age-matched uninjured controls.[46] In addition, a study by Valderrabano et al. (2006) revealed that lateral ankle sprains in sports are the main cause of ligamentous posttraumatic ankle OA.[47] Consequently, specific training programmes and/or preventive strategies could be implemented to reduce the chance of injuries.[43] Regarding the ankle, there is evidence that the use of external ankle supports, such as ankle taping or ankle braces, prevent ankle sprains.[48] Furthermore, a combination of external ankle supports with neuromuscular training has been shown to prevent the recurrence of ankle sprains.[49] For the knee, several training components have been reported to prevent ACL injuries such as stretching, plyometrics, dynamic balance and strength, body awareness and proprioceptive/neuromuscular training.[50] In addition, core and trunk control has been described as an effective training component to reduce ACL injuries as athletes with decreased neuromuscular control of the core are at increased risk of knee injury.[50]

## 5. Conclusion

In conclusion, the present review has shown that the prevalence of knee and/or ankle OA in former elite soccer players is high compared to the general population and to other occupations. To identify players at risk for OA, a health surveillance program could be implemented in elite soccer, and preventive measures for injuries should be made. Additionally, whether the risk of developing OA varies among different subgroups of elite soccer players, for example among different positions or age groups, remains to be explored. In this way, adequate prevention can focus on these high-risk subgroups. Furthermore, it should be determined what the consequences of knee and/or ankle OA in former elite soccer players are. It could be determined if retired players diagnosed with OA encounter any limitations in their activities and daily function and if OA affected the quality and length of their professional careers.

## Practical implications

- As the prevalence of knee and/or ankle OA in former elite soccer players is high, health surveillance program should be implemented in elite soccer, and preventive measures for injuries should be made to identify players at risk for OA.
- Whether the risk of developing OA varies among different subgroups of elite soccer players, for example among different positions or age groups, should be explored in order to develop and implement adequate prevention programs.
- With regard to the high prevalence of knee and/or ankle OA in former elite soccer players, it should be determined if retired players diagnosed with OA encounter any limitations in their activities and daily function and if OA affected the quality and length of their professional careers.

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