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Prevalence of Knee Osteoarthritis in 100 Athletically Active Veteran Soccer Players Compared With a Matched Group of 100 Military Personnel

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Investigation performed at the 251 Hellenic Air Force General Hospital, Athens, Greece

Background: Although knee injuries in professional soccer (football) have been extensively studied, the prevalence of knee osteoarthritis (OA) in veteran players is not well documented.

Purpose: To investigate the prevalence of knee OA in retired professional soccer players in comparison with a group of athletically active military personnel.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A group of 100 veteran Greek soccer players aged 35 to 55 years (mean [±SD] age, 4~~9~~.60 ± 5.9 years [AQ: 1]) were examined for knee OA and were administered the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire. A matched group of 100 athletically active military personnel served as a comparison group.

Results: The sonographic prevalence of OA was significantly higher in the veteran soccer group (52%) than in the military group (33%) (n = 200; *P* = .010). This difference remained significant even after excluding participants with a history of knee surgery (44.1% vs 24.4%, respectively) (n = 150; *P* = .010) [AQ: 2]. Femoral cartilage thickness was similar between the 2 groups (*P* = .473), while altered knee alignment had no effect on the prevalence of OA (*P* = .740). With the exception of perceived pain being more prevalent in the military group, there were no other statistically significant differences between the 2 groups in KOOS values.

Conclusion: Veteran soccer players had a higher sonographic prevalence of knee OA but better pain scores than a matched group of athletically active military personnel.

Keywords: aging athlete; knee; diagnostic ultrasound imaging; football (soccer)

Every year, 25% of adults older than 55 years report an episode of knee pain related to the development of osteoarthritis (OA).[43,58,63,64] Predisposing factors include aging,[63] trauma,[14,55] obesity,[3,63,75] female sex,[18,62] and diabetes.[23] Altered knee alignment and, in particular, knee varus have been shown to increase the predisposition to knee OA.[49,50,68] Soccer (football) is the most popular sport in the world, with over 300 million players.[19] Despite 20 years of medical research sponsored by the Fédération Internationale de Football Association (FIFA) and its Medical Assessment and Research Centre (F-MARC), very little attention has been given to veteran athletes of the sport until recently.[19] Professional soccer has a high prevalence of knee injuries,[21,35,76] and because trauma is considered one of the contributing factors for knee OA,[6,14,41,55,72] there may be a predisposition for the development of knee OA in later age. There is however very limited evidence available on the prevalence of knee OA in retired soccer players.[19] Two recent systematic reviews[24,37] identified few studies that addressed the issue. Despite the growing interest on the subject,[19,24,25,37] the prevalence of knee OA in retired soccer players is still debatable. Early reports of increased OA in the lower leg in soccer players date from the 1960s[33,65] but were investigated again only a few years ago.[15,73] Proposals to consider OA as a soccer-related professional injury were also dismissed.[16] During the past 2 decades, there has been an increased interest in OA, and several questionnaires have been developed to measure symptoms and functional limitations of patients.[13] The Knee injury

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and Osteoarthritis Outcome Score (KOOS), developed by Roos and coworkers,[61] has been proven to have excellent reliability and validity and has now been translated and validated in many languages[51-53,60] including Greek.[48]

The aim of this study was to compare the sonographic prevalence of knee OA and the perceived functional status of retired Greek male professional soccer players with a matched group of male active-duty military personnel, which is a generally healthy population engaged in physical training from early adulthood and continuously involved in various sports in later life.[39,40] We hypothesized that (1) the prevalence of sonographically diagnosed OA would be higher in retired soccer players and (2) the retired soccer players' KOOS values would be worse than the respective values of the military group.

METHODS

A cross-sectional study was designed to investigate the sonographic prevalence of knee OA in 100 male former professional soccer players versus a control group of 100 male active-duty Hellenic Air Force military personnel. The study was granted approval by the Research Department of the 251 Hellenic Air Force General Hospital and the Research and Ethics Approval Committee of the Department for Health at the University of Bath.

Invitation letters and flyers were sent to various soccer clubs and military bases of the Hellenic Air Force, and consenting volunteers were given appointments for a sonographic examination. Inclusion criteria for the group of retired professional soccer players were men aged between 35 and 55 years, participation for at least 5 years in national soccer championships, and no history of recent knee trauma during the previous 6 months. The upper age limit was considered to be a safe distance from the geriatric milestone of 65 years and its associated degenerative lesions. The same criteria without the soccer career requirement applied to the group of active-duty military personnel.

One hundred twenty retired soccer players participated in the study, from which 20 were excluded because of incomplete questionnaires (n = 7), recent knee injuries (n = 4), or being older than 55 years (n = 9). A total of 110 military personnel were examined, of whom 10 did not fulfill the inclusion criteria because of recent knee injuries (n = 6) or being older than 55 years (n = 4). Twenty other military volunteers who were part of the initial pilot study were also excluded because their data were incomplete (missing clinical examinations, trochlea thickness measurements, and KOOS questionnaires).

Participants initially completed a questionnaire focusing on medical and sporting history and the Greek version of the KOOS. A complete clinical examination of the knees, focused on knee alignment, ligamentous instability, effusion, and local tenderness, was then performed. Continuous variables recorded were height, weight, body mass index (BMI), years of sporting or soccer activity, and KOOS values. Knee alignment was clinically measured using a goniometer because this method has good correlation with the radiographic measurement.[36] Alignment was recorded as either normal (178.5°-180.0° [AQ: 3]) or abnormal (varus or valgus) based on published normative values.[47] All other data were recorded as dichotomous categorical variables.

An ultrasound examination of the knee was performed according to published guidelines,[26,45,46] with the participant supine on the examination table with both knees resting in 30° of flexion on a prefabricated foam support using a portable ultrasound unit (Mindray M5; Mindray DS USA Inc) and a linear array transducer (10 M?z). The assessment for osteophytes, defined as cortical protrusions at the joint margins, was performed using medial and lateral middle longitudinal scan positions of the knee compartments (Figure 1). Synovial effusion was defined as a displaceable and compressible anechoic or hypoechoic area with no Doppler signal and more than 4 mm in height in a longitudinal scan of the suprapatellar area of the knee (Figure 2). When significant effusion (>4 mm) and/or osteophytes were found during the ultrasound examination, the participant was considered to have imaging evidence of OA. Cartilage thickness, defined as the distance in millimeters from the hyperechoic soft tissue–cartilage interface to the hyperechoic cartilage-bone interface, was measured in 3 different parts of the femoral trochlea (3 distinct points of the femoral trochlea: the middle third of the lateral part, the middle third of the medial part, and the deepest point of the trochlear groove with the transducer over the patella in a transverse plane and the knee flexed to 120°) (Figure 3). Cartilage thickness was recorded but not used as a criterion of OA because it has moderate validity[1] and there is mixed evidence on the association with pain or functional scores.[7,12] Sonographic findings were recorded either as dichotomous (presence or absence of effusion and osteophytes) or scale (cartilage thickness in millimeters). All data recorded were stored into an Excel file (Microsoft Corp) using a unique participant identifier that related the various data of a participant under complete anonymity.

Statistical analysis was performed using SPSS Statistics for Macintosh (version 22.0; IBM Corp). Preliminary testing for the normality of distribution and multivariate outliers, including the Kolmogorov-Smirnov statistic and Mahalanobis distance for age, BMI, and KOOS values, found violations of assumptions, and a nonparametric Mann-Whitney *U* test was selected to test for differences between the 2 groups [AQ: 5]. Assumption testing found no serious violations for the femoral cartilage thickness data, and multivariate analysis of variance was performed to investigate differences between the 2 groups only for this measurement [AQ: 6]. Dichotomous variables were tested for association using the χ^2 test for independence with Yates continuity correction. The ϕ correlation coefficient was also computed to evaluate the association between the variables. Significance was set at $\alpha = .05$.

RESULTS

Participant Characteristics

The mean ($\pm$SD) age of the soccer player group was 46.90 $\pm$ 5.9 years, with a BMI of 26.72 $\pm$ 4.1 kg/m^2, while the respective values for the military group were 45.26 $\pm$ 5.7

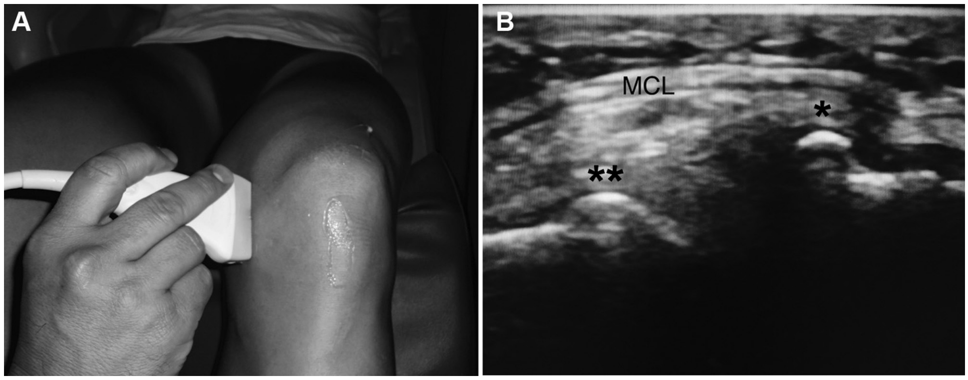

Figure 1. Medial knee sonographic assessment and probe position. (A) Probe position in the medial compartment. The knee rests at 30° of flexion on a prefabricated wedge foam. (B) Ultrasound of the medial compartment in a soccer player with osteoarthritis. Osteophytes of the tibial (*) and femoral (**) sides of the medial compartment, defined as cortical protrusions of the articular margin. [AQ: 4]

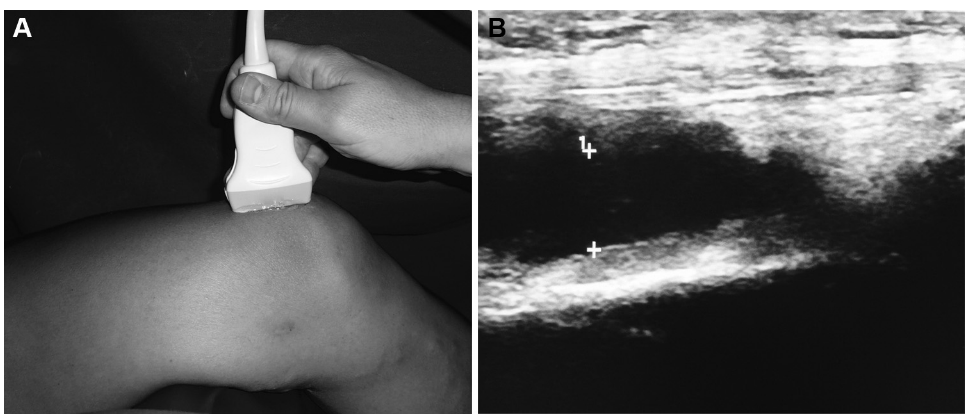

Figure 2. Knee effusion and probe position. (A) Probe position in the suprapatellar compartment. The probe is directly above the patella in the middle line. (B) Ultrasound of knee effusion (measured length: 2.5 cm) in a soccer player with osteoarthritis. Any effusion larger than 4 mm was considered evidence of osteoarthritis.

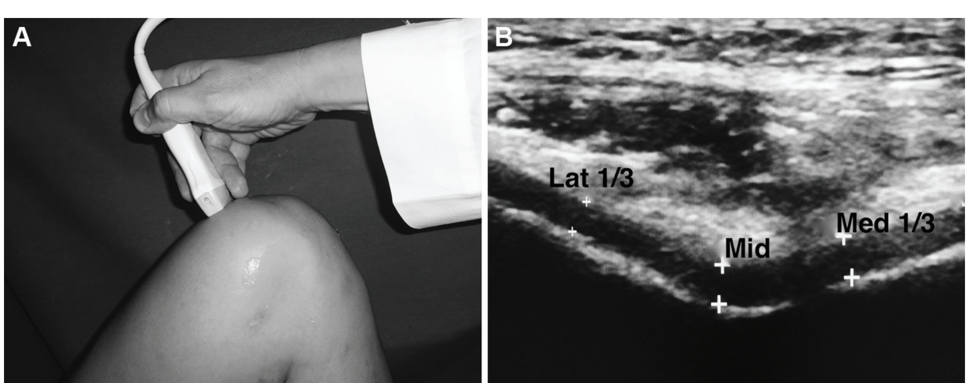

Figure 3. Femoral trochlea cartilage measurements and probe position. (A) Probe position for trochlea measurements. The knee is flexed to 120°, and the probe is directly above the patella in the transverse plane. (B) Ultrasound of the femoral trochlea. Cartilage thickness was measured at 3 distinct points of the femoral trochlea: the middle third of the lateral facet (Lat 1/3), the middle third of the medial facet (Med 1/3), and the deepest point of the trochlear groove (Mid).

TABLE 1
Participant Characteristics[a]

	Soccer Group	Military Group
Age, y	46.90 ± 5.9	45.26 ± 5.7
Body mass index, kg/m^2	26.72 ± 4.1	27.27 ± 3.0
Varus alignment, %	25	22
Exercise, times/wk	2.15 ± 1.9	2.58 ± 1.7
Soccer experience, y	20.52 ± 7.4	4.31 ± 8.6
Surgery, %	32	17

[a]Values are reported as mean ± SD unless otherwise indicated.

years and 27.27 ± 3.0 kg/m^2. The soccer players (median age, 46.5 years) were, on average, a year and a half older than the military service members (median age, 45.0 years), and this was statistically significant (U = 1.890, P = .010). A Mann-Whitney U test for independent samples revealed no significant difference for BMI (26.72 [soccer] vs 27.27 [military] kg/m^2; P = .492). A history of knee surgery was more frequent in the soccer group (32%) compared with the military group (17%). This difference was statistically significant (χ^2(1, n = 200) = 5.298, P = .020, ϕ = .174). Both groups were actively exercising with the same frequency per week (mean, 2.4 times/week; P = .144). Although many military volunteers played soccer as their main sporting activity, there was a clear difference between the 2 groups for years playing soccer (median [AQ: 7], 20.52 [soccer] vs 4.31 [military] years; U = 412.5, P = .000). Table 1 summarizes the characteristics of the participants.

Lower Leg Alignment

Only varus knee deformity (<178.5°) was considered because of its clinical significance[8,62,70] and the rarity of valgus knee or foot pronation in both groups. A varus knee deformity was clinically evident in 25% of soccer players and in 22% of military personnel. This difference was not statistically significant (χ^2(1, n = 200) = 0.111, P = .739, ϕ = .035) even after excluding the 50 participants with a history of knee surgery (χ^2(1, n = 150) = 0.231, P = .631, ϕ = .055) [AQ: 8]. No difference in the prevalence of OA was found between participants with normal or varus knees (χ^2(1, n = 200) = 0.000, P > .999, ϕ = .001) even when the surgically treated participants were excluded (χ^2(1, n = 150) = 0.110, P = .740, ϕ = .043) [AQ: 9].

Femoral Cartilage Thickness

The femoral cartilage thickness in the 3 sites of measurement for each leg is shown in Table 2. Multivariate analysis of variance was performed to investigate differences between the 2 groups. The Levene test was not significant for any of the femoral cartilage measurements, and because the assumption of the equality of variances was not violated, significance was set at α = .05. No statistically significant differences were noted between the 2 groups for any of the 3 cartilage measurement sites (F(6,191) = 0.932, P = .473, Wilks λ = .972, partial η^2 = .028). The same result (no difference) was found even after all the participants who had a history of knee surgery were removed from the analysis (F(6,141) = 0.429, P = .859, Wilks λ = .982, partial η^2 = .018).

TABLE 2
Femoral Cartilage Thickness[a]

	Soccer Group	Military Group
Left knee, mm		
Lat 1/3	2.52 ± 0.51 (2.41-2.62)	2.56 ± 0.46 (2.46-2.65)
Mid	3.07 ± 0.67 (2.94-3.20)	3.29 ± 0.75 (3.13-3.44)
Med 1/3	2.72 ± 0.53 (2.62-2.82)	2.80 ± 0.58 (2.68-2.91)
Right knee, mm		
Lat 1/3	2.57 ± 0.58 (2.45-2.68)	2.63 ± 0.61 (2.50-2.75)
Mid	3.19 ± 0.83 (3.02-3.35)	3.26 ± 0.71 (3.11-3.40)
Med 1/3	2.85 ± 0.75 (2.70-3.00)	2.85 ± 0.61 (2.72-2.97)

[a]Values are reported as mean ± SD (95% CI). Femoral cartilage thickness was measured at 3 distinct points of the femoral trochlea: the middle third of the lateral facet (Lat 1/3), the middle third of the medial facet (Med 1/3), and the deepest point of the trochlear groove (Mid). All measurements were made with the transducer perpendicular over the patella with the knee in 120° of flexion.

KOOS Analysis

The Greek version of the KOOS has been shown to have good internal consistency with Cronbach α for each subscale of the questionnaire: between 0.6 and 0.8.[48] The Cronbach α coefficient for the current study was .955, suggesting excellent internal consistency. Both groups reported a good functional status as reflected in the high values recorded in all the KOOS subscales (Table 3). A Mann-Whitney U test for independent samples revealed no significant difference between the 2 groups for the subscales of symptoms (P = .615), activities of daily living (ADL) (P = .720), sport (P = .245), and quality of life (QoL) (P = .930). There was a statistically significant difference in the pain subscale (U = 4.157, P = .030 [AQ: 10]), with the soccer players having a better value (median, 93.0; n = 100) than the military participants (median, 88.9; n = 100).

Prevalence of OA

The overall prevalence of sonographically diagnosed OA in this study was 42.5%. The group prevalence was 52% for the soccer players and 33% for the military group (Figure 4). A χ^2 test for independence (with Yates continuity correction) indicated a significant association (P = .010) between a professional soccer career and ultrasound findings of OA, although the ϕ correlation coefficient indicated a small effect (χ^2(1, n = 200) = 6.63, P = .010, ϕ = .192). To control for the statistically significant difference in knee surgeries between the 2 groups (32% [soccer] vs 17% [military]; P = .010), a separate χ^2 analysis was performed after excluding the 49 participants with a history of knee surgery in any leg (32 soccer players and 17 military personnel). The ultrasound prevalence of OA remained higher in the soccer group (44.1%) compared with the military

TABLE 3
KOOS Results[a]

KOOS Subscale	Soccer Group	Military Group
Pain[b]	86.03 ± 19.4 (82.17-89.89)	84.79 ± 14.6 (81.88-87.70)
Symptoms	84.28 ± 17.7 (80.76-87.80)	83.29 ± 16.8 (79.93-86.65)
ADL	90.29 ± 15.9 (87.13-93.45)	88.41 ± 14.2 (5.58-91.24)
Sport	75.29 ± 27.5 (69.82-80.76)	71.88 ± 27.0 (66.51-77.25)
QoL	77.57 ± 27.4 (72.12-83.02)	73.69 ± 24.3 (68.84-78.54)

[a]Values are reported as mean ± SD (95% CI). ADL, activities of daily living; KOOS, Knee injury and Osteoarthritis Outcome Score; QoL, quality of life.
[b]A statistically significant difference (P = .010) was only noted for the pain subscale, with the soccer player group reporting less overall pain.

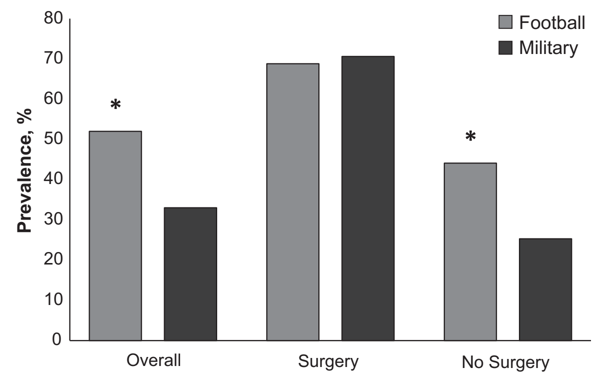

Figure 4. Prevalence of osteoarthritis (OA) in the different groups. There was a statistically significant difference (*) (P = .010) in the overall prevalence of OA between the soccer and military groups even after excluding previously operated participants (P = .010) [AQ: 11]. There was no difference between the 2 groups when only previously operated participants were compared for OA ($P > .999$).

group (25.3%), and this difference was also statistically significant (χ^2(1, n = 151) = 5.917, P = .010, ϕ = .198). When the analysis was performed using only participants with a history of knee surgery, there was no significant difference in the prevalence of OA between the 2 groups (68.8% [soccer] vs 70.6% [military]; $P > .999$). However, the prevalence of OA was significantly higher in the operated compared with the nonoperated participants of the same group (68.8% vs 44.1%, respectively, for soccer players [χ^2(1, n = 100) = 5.290, P = .021, ϕ = .230] and 70.6% vs 25.3%, respectively, for military personnel [χ^2(1, n = 100) = 13.008, P = .000, ϕ = .362]).

DISCUSSION

This study investigated the prevalence of premature knee OA in retired Greek male professional soccer players. A comparison group of active-duty military personnel was used because evidence on the real prevalence of OA in veteran athletes for comparison is still sparse.[17,24,25,28,37,66] Military personnel are engaged in strenuous physical activity from adolescent years and tend to stay athletically active in later stages of life.[39,40,44] The military has been proposed as a good model to study the epidemiology of OA in younger ages[10] because when adjusted for age, it has a similar incidence of OA with that of the general population[34] (incidence of 7.86 per 1000 person-years for the military compared with 7.19 for civilians).[10,34]

There was a statistically significant difference in age (P = .010) between the 2 groups, with the soccer veterans (median, 46.5 years) being one and a half years older than their military counterparts (median, 45.0 years). However, this age difference is considered small in everyday clinical practice, given that an increased prevalence of knee OA (30%) is expected in people over the age of 63 years.[2] Body weight and altered knee alignment are known risk factors for knee OA.[3,52,68] In this study, no statistically significant difference in BMI (P = .492) and knee axis alignment (P = .739) was found between the 2 groups to confound the effect of soccer. Mild physical activity is considered to have a beneficial effect on knee OA,[29,74,76] while strenuous sports are considered possible risk factors.[9,38,42,67] Both groups in the present study devoted the same amount of time per week for exercise and sports, and no statistically significant difference was found in training time (P = .144) to consider current exercise as a separate risk factor. Surgery for knee trauma has been shown to increase the risk of knee OA.[14,55,57,69] Because volunteers with a history of injury or surgery of the knee were not excluded from this study, the possibility for bias in sample selection exists, given that previously injured athletes may be more willing to seek medical attention than healthy persons. However, the exclusion of previously injured athletes would have distorted the real prevalence of OA.

Previous studies have used radiographs for epidemiological studies of arthritis in healthy persons.[20,35,59] However, this methodology has logistic disadvantages such as the availability of imaging facilities and raises ethical concerns such as exposure to clinically unjustified irradiation. The European Society of Radiology[22] strongly advises the reduction of radiographs in clinical practice, and techniques to reduce the radiation dose of a knee radiograph by 37% have been recently reported.[32] Diagnostic ultrasound of the knee is noninvasive, has no radiation hazard, and provides useful information for both the presence of osteophytes and effusion and the condition of soft tissues and cartilage.[7,31,45]

The ultrasound examination in this study focused on the presence of osteophytes and joint effusion because these features were found to have high interrater reliability for use in the community.[1] Ultrasonography has been shown to have moderate to excellent validity for the detection of osteophytes and effusion and moderate validity for femoral cartilage thickness.[1,27] There is mixed evidence in the literature on the association of femoral trochlea cartilage thickness with pain or functional scores, with some studies reporting no association[7] and other studies reporting some association.[12] Although femoral trochlea cartilage erosion is a significant finding in knee OA involving the patellofemoral joint,[46] no statistically significant differences were noted between the 2 groups (P = .473) even after excluding all participants with a history of knee surgery (P = .859). Because no significant differences were noted and the validity of this finding is moderate,[1,27] the cartilage thickness measurements are reported in our results but were not considered for the analysis of OA prevalence.

The overall prevalence of OA in this study was 42.5% (defined as documented effusion >4 mm and/or presence of osteophytes). The group prevalence was 52% for soccer players and 33% for military personnel, and this difference was statistically significant (P = .010). Because previous knee surgery was significantly (P = .020 [AQ: 12]) more common in the soccer group (32%) compared with the military group (17%), a separate analysis of prevalence was performed after the exclusion of surgically treated knees in both groups. The difference in OA prevalence in nonoperated participants remained significant (44.1% [soccer] vs 25.3% [military]; P = .001 [AQ: 13]). No difference was noted when the 2 groups were compared using only previously operated participants (P > .999).

The data available in the literature on the prevalence of OA are limited and variable. In a recent meta-analysis, the authors reported that after adjusting for injuries of the knee, soccer players had only a slightly increased risk of knee OA.[66] Drawer and Fuller[16] have reported a prevalence of self-reported knee OA between 19% and 21.3% in a group of veteran soccer players with a mean age of 47.6 years. Turner and colleagues[73] reported a prevalence of self-reported knee OA between 20% and 26% in a group with a mean age of 49.2 years. However, 3 other studies with the same mean age (49.2 years) that documented the presence of knee OA based on radiographs reported a higher prevalence (60%-80%).[4,20,35] The overall prevalence in soccer players in the current study (52%) falls between the values reported from studies that used only questionnaires (16%-20% [AQ: 14]) and studies that used radiographs (60%-80%). Given that the age range of soccer players in this study is comparable with the age range reported in similar studies, this difference in prevalence may be explained in part by the recording method (self-reported vs objective findings).

The underreporting of OA may suggest that veteran athletes tend to underestimate the significance of osteoarthritic symptoms such as pain or dysfunction. The underestimation of pain in the retired athlete group is evident in the results of the KOOS questionnaire in which the only difference in functional scores between the 2 groups was in the pain subscale. Soccer veterans had significantly better scores than their military counterparts (P = .030 [AQ: 15]), despite the fact that they had more knee surgeries or OA findings and exercised the same amount of time per week during the time period of this study. This finding initially confused us as advanced OA is usually associated with more pain.[56] The only plausible explanation is an increased pain tolerance or altered pain perception in the professional athlete group. Intense athletic activity is considered to lead to behavioral and emotional changes, increasing pain tolerance in athletes compared with population controls.[54,71] Another issue that could possibly contribute to the lower levels of reported pain is the fact that players tend to underestimate and forget previous trauma. A study in soccer players found that they were able to recall at a later time only about one-third of the actual injuries that have been recorded by their physicians.[30]

There are only 2 studies that provide normative data for the KOOS value of the general population: one study with a random selection of a population sample (aged 18-84 years) in Sweden[52] and one with young (mean age, 19 years) American military recruits.[11] In the current study, both groups had lower values compared with the much younger military recruits of the American study. The mean KOOS values of the soccer veterans in the present study were lower in comparison to the published Swedish values for the age range of 35 to 54 years in all subscales: pain (86.03 vs 87.4, respectively), symptoms (84.28 vs 89.1, respectively), ADL (90.29 vs 95.2, respectively), sport (75.29 vs 86.4, respectively), and QoL (77.57 vs 83.6, respectively). The military group also had lower values compared with the published Swedish values in all the subscales: pain (84.79 vs 87.4, respectively), symptoms (83.29 vs 89.1, respectively), ADL (88.41 vs 95.2, respectively), sport (71.88 vs 86.4, respectively), and QoL (73.69 vs 83.6, respectively). In a recent study from Brazil that looked into the prevalence of OA in a similarly aged (30-55 years) group of former professional soccer players, KOOS values were slightly higher for all subscales compared with our study, despite a higher radiographic evidence of OA in that study (66% vs 52%, respectively).[5][AQ: 16]

Strengths and Limitations

To our knowledge, this is the first study to use ultrasound to record the prevalence of OA in veteran soccer players. All clinical and sonographic examinations in this study were performed by an orthopaedic surgeon trained in musculoskeletal ultrasound under the supervision of a specialist radiologist, ensuring high interrater reliability.[1] While ultrasound may detect osteophytes and effusion, the ultrasound evaluation in this study did not detect weightbearing joint space narrowing of the tibiofemoral compartment, subchondral sclerosis, or subchondral cystic changes, which are other common radiographic features of OA. The recruitment process might have been influenced by selection bias because the opportunity for a medical consultation may have attracted more symptomatic patients to participate in this study. The inclusion of participants with a known previous knee injury may also have affected the prevalence, despite that this had no effect on the differences between a group of veteran soccer players compared with a group of athletically active military personnel. This study provides an estimate of KOOS values of these 2 distinctive groups, but a bigger sample size is required to provide normative values for military personnel and retired athletes of this age. This study adds more evidence to the limited literature of possible adverse effects of a professional soccer career on the knee.

CONCLUSION

This is the first study to use ultrasound to investigate the prevalence of knee OA among veteran soccer players. The findings suggest that there is a significantly higher prevalence of knee OA in veteran soccer players compared with athletically active military personnel. Veteran soccer players might have higher pain tolerance thresholds as a result of years of intense training and frequent injuries and may underestimate the development of OA. This study may raise the need for the better education of veteran players by their respective soccer associations on the significance of knee OA for quality of life and for the need for medical advice. Clinicians should use a selection of both objective and subjective methods to detect knee OA in veteran athletes because pain perception may be altered in some people. Diagnostic knee ultrasound is a useful nonionizing modality for this purpose.

REFERENCES

1. Abraham AM, Goff I, Pearce MS, Francis RM, Birrell F. Reliability and validity of ultrasound imaging of features of knee osteoarthritis in the community. *BMC Musculoskelet Disord*. 2011;12:70.
2. Abraham AM, Pearce MS, Mann KD, Francis RM, Birrell F. Population prevalence of ultrasound features of osteoarthritis in the hand, knee and hip at age 63 years: the Newcastle thousand families birth cohort. *BMC Musculoskelet Disord*. 2014;15:162.
3. Apold H, Meyer HE, Nordsletten L, Furnes O, Baste V, Flugsrud GB. Weight gain and the risk of knee replacement due to primary osteoarthritis: a population based, prospective cohort study of 225,908 individuals. *Osteoarthritis Cartilage*. 2014;22(5):652-658.
4. Arliani G, Astur D, Yamada R, et al. Early osteoarthritis and reduced quality of life after retirement in former professional soccer players. *Clinics (Sao Paulo)*. 2014;69(9):589-594.
5. Arliani GG, Astur DC, Yamada RKF, et al. Professional football can be considered a healthy sport [published online May 17, 2015]? *Knee Surg Sport Traumatol Arthrosc*. doi:10.1007/s00167-015-3636-2.
6. Barenius B, Ponzer S, Shalabi A, Bujak R, Norlén L, Eriksson K. Increased risk of osteoarthritis after anterior cruciate ligament reconstruction: a 14-year follow-up study of a randomized controlled trial. *Am J Sports Med*. 2014;42(5):1049-1057.
7. Bevers K, Bijlsma JW, Vriezekolk JE, van den Ende CH, den Broeder AA. Ultrasonographic features in symptomatic osteoarthritis of the knee and relation with pain. *Rheumatology*. 2014;53(9):1625-1629.
8. Brouwer GM, Van Tol AW, Bergink AP, et al. Association between valgus and varus alignment and the development and progression of radiographic osteoarthritis of the knee. *Arthritis Rheum*. 2007;56(4):1204-1211.
9. Caine DJ, Golightly YM. Osteoarthritis as an outcome of paediatric sport: an epidemiological perspective. *Br J Sports Med*. 2011; 45(4):298-303.
10. Cameron KL, Hsiao MS, Owens BD, Burks R, Svoboda SJ. Incidence of physician-diagnosed osteoarthritis among active duty United States military service members. *Arthritis Rheum*. 2011;63(10):2974-2982.
11. Cameron KL, Thompson BS, Peck KY, Owens BD, Marshall SW, Svoboda SJ. Normative values for the KOOS and WOMAC in a young athletic population: history of knee ligament injury is associated with lower scores. *Am J Sports Med*. 2013;41(3):582-589.
12. Chen Y-J, Chen C-H, Wang C-L, Huang M-H, Chen T-W, Lee C-L. Association between the severity of femoral condylar cartilage erosion related to knee osteoarthritis by ultrasonographic evaluation and the clinical symptoms and functions. *Arch Phys Med Rehabil*. 2015;96(5):837-844.
13. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). *Arthritis Care Res*. 2011;63(Suppl 11):208-228.
14. Dare D, Rodeo S. Mechanisms of post-traumatic osteoarthritis after ACL injury. *Curr Rheumatol Rep*. 2014;16(10):448.
15. Drawer S, Fuller CW. Perceptions of retired professional soccer players about the provision of support services before and after retirement. *Br J Sports Med*. 2002;36(1):33-38.
16. Drawer S, Fuller CW. Propensity for osteoarthritis and lower limb joint pain in retired professional soccer players. *Br J Sports Med*. 2001;35(6):402-408.
17. Driban JB, Hootman JM, Sitler MR, Harris K, Cattano NM. Is participation in certain sports associated with knee osteoarthritis? A systematic review [published online January 9, 2015]. *J Athl Train*. doi:10.4085/1062-6050-50.2.08.
18. Dugan SA. Sports-related knee injuries in female athletes: what gives? *Am J Phys Med Rehabil*. 2005;84(2):122-130.
19. Dvorak J. Osteoarthritis in football: FIFA/F-MARC approach. *Br J Sports Med*. 2011;45(8):673-676.
20. Elleuch MH, Guermazi M, Mezghanni M, et al. Knee osteoarthritis in 50 former top-level soccer players: a comparative study. *Ann Readapt Med Phys*. 2008;51(3):174-178.
21. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic risk factors for acute knee injuries among male football players: a prospective cohort study. *Scand J Med Sci Sports*. 2011;21(5):645-652.
22. European Society of Radiology. White paper on radiation protection by the European Society of Radiology. *Insights Imaging*. 2011; 2(4):357-362.
23. Eymard F, Parsons C, Edwards MH, et al. Diabetes is a risk factor for knee osteoarthritis progression. *Osteoarthritis Cartilage*. 2015;23(6):851-859.
24. Gouttebarge V, Inklaar H, Backx F, Kerkhoffs G. Prevalence of osteoarthritis in former elite athletes: a systematic overview of the recent literature. *Rheumatol Int*. 2015;35(3):405-418.
25. Gouttebarge V, Inklaar H, Frings-Dresen MH. Risk and consequences of osteoarthritis after a professional football career: a systematic review of the recent literature. *J Sports Med Phys Fitness*. 2014;54(4):494-504.
26. Iagnocco A, Meenagh G, Riente L, et al. Ultrasound imaging for the rheumatologist XXIX: sonographic assessment of the knee in patients with osteoarthritis. *Clin Exp Rheumatol*. 2010;28(5):643-646.
27. Iagnocco A, Perricone C, Scirocco C, et al. The interobserver reliability of ultrasound in knee osteoarthritis. *Rheumatology (Oxford)*. 2012;51(11):2013-2019.
28. Iosifidis MI, Tsarouhas A, Fylaktou A. Lower limb clinical and radiographic osteoarthritis in former elite male athletes. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(9):2528-2535.
29. Juhl C, Christensen R, Roos EM, Zhang W, Lund H. Impact of exercise type and dose on pain and disability in knee osteoarthritis: a systematic review and meta-regression analysis of randomized controlled trials. *Arthritis Rheumatol*. 2014;66(3):622-636.
30. Junge A, Dvorak J. Influence of definition and data collection on the incidence of injuries in football. *Am J Sports Med*. 2000;28(5 Suppl):S40-S46.
31. Kawaguchi K, Enokida M, Otsuki R, Teshima R. Ultrasonographic evaluation of medial radial displacement of the medial meniscus in knee osteoarthritis. *Arthritis Rheum*. 2012;64(1):173-180.
32. Kloth JK, Tanner M, Stiller W, et al. Radiation dose reduction in digital plain radiography of the knee after total knee arthroplasty. *Rofo*. 2015;187(8):685-690.
33. Klünder KB, Rud B, Hansen J. Osteoarthritis of the hip and knee joint in retired football players. *Acta Orthop Scand*. 1980;51(6):925-927.
34. Kopec JA, Rahman MM, Berthelot J-M, et al. Descriptive epidemiology of osteoarthritis in British Columbia, Canada. *J Rheumatol*. 2007;34(2):386-393.
35. Krajnc Z, Vogrin M, Rečnik G, Crnjac A, Drobnič M, Antolič V. Increased risk of knee injuries and osteoarthritis in the non-dominant leg of former professional football players. *Wien Klin Wochenschr*. 2010;122(Suppl 2):40-43.
36. Kraus VB, Vail TP, Worrell T, McDaniel G. A comparative assessment of alignment angle of the knee by radiographic and physical examination methods. *Arthritis Rheum*. 2005;52(6):1730-1735.

37. Kuijt M-TK, Inklaar H, Gouttebarge V, Frings-Dresen MHW. Knee and ankle osteoarthritis in former elite soccer players: a systematic review of the recent literature. *J Sci Med Sport*. 2012;15(6):480-487.
38. Kujala UM, Kettunen J, Paananen H, et al. Knee osteoarthritis in former runners, soccer players, weight lifters, and shooters. *Arthritis Rheum*. 1995;38(4):539-546.
39. Lindquist CH, Bray RM. Trends in overweight and physical activity among U.S. military personnel, 1995–1998. *Prev Med (Baltim)*. 2001;32(1):57-65.
40. Littman AJ, Forsberg CW, Boyko EJ. Associations between compulsory physical activity during military service and activity in later adulthood among male veterans compared with nonveterans. *J Phys Act Health*. 2013;10(6):784-791.
41. Louboutin H, Debarge R, Richou J, et al. Osteoarthritis in patients with anterior cruciate ligament rupture: a review of risk factors. *Knee*. 2009;16(4):239-244.
42. Maffulli N, Longo UG, Gougoulias N, Caine D, Denaro V. Sport injuries: a review of outcomes. *Br Med Bull*. 2011;97(1):47-80.
43. March L, Smith EUR, Hoy DG, et al. Burden of disability due to musculoskeletal (MSK) disorders. *Best Pract Res Clin Rheumatol*. 2014;28(3):353-366.
44. Martins LCX, Lopes CS. Rank, job stress, psychological distress and physical activity among military personnel. *BMC Public Health*. 2013;13:716.
45. Mermerci BB, Garip Y, Uysal RS, et al. Clinic and ultrasound findings related to pain in patients with knee osteoarthritis. *Clin Rheumatol*. 2011;30(8):1055-1062.
46. Möller I, Möller I, Bong D, et al. Ultrasound in the study and monitoring of osteoarthritis. *Osteoarthritis Cartilage*. 2008;16(Suppl 3):S4-S7.
47. Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower extremity. *J Bone Joint Surg Am*. 1987;69(5):745-749.
48. Moutzouri M, Tsoumpos P, Billis E, Papoutsidakis A, Gliatis J. Cross-cultural translation and validation of the Greek version of the Knee Injury and Osteoarthritis Outcome Score (KOOS) in patients with total knee replacement. *Disabil Rehabil*. 2015;37(16):1477-1483.
49. Moyer RF, Birmingham TB, Bryant DM, Giffin JR, Marriott KA, Leitch KM. Biomechanical effects of valgus knee bracing: a systematic review and meta-analysis. *Osteoarthritis Cartilage*. 2015;23(2):178-188.
50. Moyer RF, Ratneswaran A, Beier F, Birmingham TB. Osteoarthritis year in review 2014: mechanics. Basic and clinical studies in osteoarthritis. *Osteoarthritis Cartilage*. 2014;22(12):1989-2002.
51. Ornetti P, Parratte S, Gossec L, et al. Cross-cultural adaptation and validation of the French version of the Knee injury and Osteoarthritis Outcome Score (KOOS) in knee osteoarthritis patients. *Osteoarthritis Cartilage*. 2008;16(4):423-428.
52. Paradowski PT, Bergman S, Sundén-Lundius A, Lohmander LS, Roos EM. Knee complaints vary with age and gender in the adult population: population-based reference data for the Knee injury and Osteoarthritis Outcome Score (KOOS). *BMC Musculoskelet Disord*. 2006;7:38.
53. Paradowski PT, Witoński D, Kęska R, Roos EM. Cross-cultural translation and measurement properties of the Polish version of the Knee injury and Osteoarthritis Outcome Score (KOOS) following anterior cruciate ligament reconstruction. *Health Qual Life Outcomes*. 2013;11:107.
54. Pen LJ, Fisher CA. Athletes and pain tolerance. *Sports Med*. 1994;18(5):319-329.
55. Racine J, Aaron RK. Post-traumatic osteoarthritis after ACL injury. *R I Med J*. 2014;97(11):25-28.
56. Riddle DL, Jiranek WA. Knee osteoarthritis radiographic progression and associations with pain and function prior to knee arthroplasty: a multicenter comparative cohort study. *Osteoarthritis Cartilage*. 2015;23(3):391-396.
57. Riordan EA, Little C, Hunter D. Pathogenesis of post-traumatic OA with a view to intervention. *Best Pract Res Clin Rheumatol*. 2014;28(1):17-30.
58. Roemer FW, Eckstein F, Hayashi D, Guermazi A. The role of imaging in osteoarthritis. *Best Pract Res Clin Rheumatol*. 2014;28(1):31-60.
59. Roemer FW, Jarraya M, Niu J, Silva J-R, Frobell R, Guermazi A. Increased risk for radiographic osteoarthritis features in young active athletes: a cross-sectional matched case-control study. *Osteoarthritis Cartilage*. 2015;23(2):239-243.
60. Roos EM, Roos HP, Ekdahl C, Lohmander LS. Knee injury and Osteoarthritis Outcome Score (KOOS): validation of a Swedish version. *Scand J Med Sci Sports*. 1998;8(6):439-448.
61. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS): development of a self-administered outcome measure. *J Orthop Sports Phys Ther*. 1998;28(2):88-96.
62. Runhaar J, van Middelkoop M, Reijman M, Vroegindeweij D, Oei EHG, Bierma-Zeinstra SMA. Malalignment: a possible target for prevention of incident knee osteoarthritis in overweight and obese women. *Rheumatology (Oxford)*. 2014;53(9):1618-1624.
63. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage*. 2014;23(4):507-515.
64. Smith E, Hoy DG, Cross M, et al. The global burden of other musculoskeletal disorders: estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis*. 2014;73(8):1462-1469.
65. Solonen KA. The joints of the lower extremities of football players. *Ann Chir Gynaecol Fenn*. 1966;55(3):176-180.
66. Spahn G, Grosser V, Schiltenwolf M, Schröter F, Grifka J. [Football as risk factor for a non-injury-related knee osteoarthritis: results from a systematic review and metaanalysis]. *Sportverletz Sportschaden*. 2015;29(1):27-39.
67. Spector TD, Harris PA, Hart DJ, et al. Risk of osteoarthritis associated with long-term weight-bearing sports: a radiologic survey of the hips and knees in female ex-athletes and population controls. *Arthritis Rheum*. 1996;39(6):988-995.
68. Stief F, Böhm H, Dussa CU, et al. Effect of lower limb malalignment in the frontal plane on transverse plane mechanics during gait in young individuals with varus knee alignment. *Knee*. 2014;21(3):688-693.
69. Takeda H, Nakagawa T, Nakamura K, Engebretsen L. Prevention and management of knee osteoarthritis and knee cartilage injury in sports. *Br J Sports Med*. 2011;45(4):304-309.
70. Teichtahl AJ, Cicuttini FM, Janakiramanan N, Davis SR, Wluka AE. Static knee alignment and its association with radiographic knee osteoarthritis. *Osteoarthritis Cartilage*. 2006;14(9):958-962.
71. Tesarz J, Schuster AK, Hartmann M, Gerhardt A, Eich W. Pain perception in athletes compared to normally active controls: a systematic review with meta-analysis. *Pain*. 2012;153(6):1253-1262.
72. Thelin N, Holmberg S, Thelin A. Knee injuries account for the sports-related increased risk of knee osteoarthritis. *Scand J Med Sci Sports*. 2006;16(5):329-333.
73. Turner AP, Barlow JH, Heathcote-Elliott C. Long term health impact of playing professional football in the United Kingdom. *Br J Sports Med*. 2000;34(5):332-336.
74. Vad V, Hong HM, Zazzali M, Agi N, Basrai D. Exercise recommendations in athletes with early osteoarthritis of the knee. *Sports Med*. 2002;32(11):729-739.
75. Visser AW, de Mutsert R, Bloem JL, et al. Knee osteoarthritis and fat free mass interact in their impact on health-related quality of life in men: the Netherlands Epidemiology of Obesity study [published online January 2015]. *Arthritis Care Res (Hoboken)*. doi:10.1002/acr.22550.[AQ: 17]
76. Waldén M, Hägglund M, Magnusson H, Ekstrand J. Anterior cruciate ligament injury in elite football: a prospective three-cohort study. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(1):11-19.