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Ankle osteoarthritis and its association with severe ankle injuries, ankle surgeries and health-related quality of life in recently retired professional male football and rugby players

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3 **1 Ankle osteoarthritis and its association with severe ankle injuries, ankle surgeries and health-related**
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5 **2 quality of life in recently retired professional male football and rugby players**
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3 24 **Abstract**
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5 25 **Objectives**
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7 26 To determine (i) the prevalence of ankle osteoarthritis (OA) among former professional football and
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10 27 rugby players, (ii) assess the association between ankle injuries or ankle surgeries with ankle OA, and (iii)
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12 28 compare the mental and physical quality of life (QoL) between former professional football and rugby
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14 29 players with and without OA.
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18 31 **Methods**
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21 32 We conducted a questionnaire based observational study with a cross-sectional design. Former
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23 33 professional football and rugby players were recruited by the football players worldwide (FIFPRO) and
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25 34 the International Rugby Players (IRP). Information concerning ankle OA, sustained ankle injuries and
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27 35 ankle surgeries was gathered (medical record or team doctor). Health related QoL was assessed using
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29 36 the PROMIS physical and mental health scores.
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34 38 **Results**
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37 39 Overall, 553 former professional football (n = 401) and rugby players (n = 152) were enrolled in the
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39 40 study (response rate of 56%). Ankle OA prevalence among former professional football and rugby
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41 41 players was 9.2% and 4.6%, respectively. Football players were more likely to suffer from ankle OA
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43 42 following every ankle injury and/or surgery. Football and rugby players with ankle OA had similar
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45 43 PROMIS physical and mental health scores to the norm for the general population.
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50 45 **Conclusion**
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52 46 Former professional football and rugby players had a higher ankle OA prevalence than the general
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54 47 population (3.4%). Football players are more likely to suffer from ankle OA following every ankle injury
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3 48 and/or surgery. No clinical relevant difference was seen for physical or mental health related QoL among
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5 49 football and rugby players. Preventive measures for ankle injuries are recommended.
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9 51 ***Strengths and limitations***

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11 52 - Overall good response rate (56%) and a large group of participating football players (401)
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14 53 - This study had a cross-sectional design, therefore no causal-association can be determined
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17 54 - There were only 7 rugby players with OA, implying a potential serious type II error.
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20 55 - Research based (retrospective) questionnaires are dependent on the accuracy and
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22 56 understanding of the participant. Professional athletes might generally remember the number
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24 57 of severe ankle injuries or surgeries resulting in a training or match absence of ≥ 4 weeks.
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27 58 However, we cannot exclude that participants were not able to precisely recall all their
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29 59 sustained severe ankle injuries and ankle surgeries or that they did not consult their last (team)
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31 60 doctor
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34 61 - Our OA definition did not include a clinical and radiological evaluation.
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63 **Background**

64 Football and Rugby Union (hereafter 'rugby') are among the most popular team sports worldwide. In
65 both sports, ankle injuries represent a significant proportion of the total injuries sustained.¹⁻⁵ Previous
66 ankle injuries are an important risk factor for ankle osteoarthritis (OA).^{6,7}
67
68 Drawer et al. (2002) estimates the overall risk of injury in professional football to be 1,000 times higher
69 than in high-risk industrial occupations, with ankle injuries contributing 10-18% of all injuries.^{2,8} The
70 Union of European Football Associations (UEFA) Champions League Injury Study reported an overall
71 ankle injury rate of 1 injury per 1000 hours.² Lateral ankle sprains (51%) were the most prevalent sub-
72 type of ankle injuries.² In professional rugby, epidemiological studies show that ankle injuries contribute
73 5-20% of all injuries.^{1,3,9,10} Similar to professional football, lateral ankle sprains are the most common
74 ankle injuries with an injury rate of 3.8 - 4.5 injuries per 1,000 player hours depending on the position on
75 the field.¹¹

76
77 Two retrospective cohort studies from the general population (n = 390 and n = 639 patients
78 respectively), reported that 70-78% of ankle OA cases were associated with a previously sustained ankle
79 injury. These previous injuries included fractures, isolated osteochondral defects of the talus and ankle
80 ligament injuries.^{6,7} Among these post-traumatic ankle OA cases, 28% were associated with a previously
81 sustained ligamentous injury.⁷ To our knowledge, there are no prospective studies on the association of
82 ankle injuries and ankle OA.

83
84 In the general population the prevalence of ankle OA is estimated to be 3.4% in people over 50 years of
85 age.¹² The reported prevalence of ankle OA 16 to 22 years after a professional football career is 12-
86 19%.¹³⁻¹⁵ No data are available for ankle OA among former professional rugby players. In comparison to

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3 87 a general population control group, the prevalence of OA in any joint and the incidence of joint
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5 88 replacement for any joint was estimated to be 4 and 6 times higher, respectively, among former elite
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7 89 rugby players.¹⁶ This has been associated with a significantly poorer mental and physical health-related
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10 90 quality of life (QoL).¹⁶
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14 92 Several other studies report the association of general OA with mental health symptoms and physical
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16 93 health-related QoL among former elite athletes across professional team sports including football and
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18 94 rugby.^{17,18} Therefore, the impact of OA on retired players must be considered. To date, the
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21 95 epidemiological evidence concerning the prevalence of ankle OA in professional football is either
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23 96 outdated or limited, and in the case of rugby non-existent, while data on the association between
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25 97 previous ankle injury and ankle OA is scarce in both sports.
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30 99 The objective of this study was threefold. Firstly, to evaluate the prevalence of ankle OA in recently
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32 100 retired professional football and rugby players. Secondly, to determine the association between ankle
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34 101 injury and/or ankle surgery and ankle OA. Thirdly, to compare the mental and physical QoL in players
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36 102 with and without ankle OA. Our hypotheses were that (i) recently retired professional football and rugby
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38 103 players have a higher ankle OA prevalence than the general population (as found in the literature), (ii)
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40 104 ankle injuries and/or ankle surgeries are associated with ankle OA, and (iii) the mental and physical QoL
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43 105 of recently retired professional football and rugby players with OA is lower compared to those players
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45 106 without OA.
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3 109 **Methods**

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5 110 **Design**

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8 111 We conducted a questionnaire based observational study with a cross-sectional design. Ethical approval
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10 112 for the study was provided by the Ethical Committee of the Yokohama City Sports Medical Center (17.003;
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12 113 Yokohama, Japan) and the Medical Ethics Review Committee of the Academic Medical Center
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14 114 (W16_366#16.431; Amsterdam, The Netherlands). The study was reported according to the
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16 115 'Strengthening the Reporting of Observational Studies in Epidemiology' statement and conducted in
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18 116 accordance with the Declaration of Helsinki (2013).¹⁹

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23 118 **Participants**

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25 119 Retired professional football and rugby players were randomly recruited to reduce recruitment bias, by
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27 120 the Football Players Worldwide (FIFPRO) and the International Rugby Players (IRP). Inclusion criteria were:
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29 121 (a) being a retired male professional football or rugby player; (b) being younger than 50 years of age; (c)
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31 122 being able to read and comprehend texts in English, French or Spanish.

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36 124 The definition of a retired professional football or rugby player was that he (i) has trained to improve
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38 125 performances, (ii) has competed in the highest or second highest national league, and (iii), has had training
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40 126 and competition as a major activity (way of living) or focus of personal interest, devoting several hours in
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42 127 all or most of the days for these activities, and exceeding the time allocated to other types of professional
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44 128 or leisure activities. If interested, players received information about the study, gave their informed
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46 129 consent and completed an electronic questionnaire. Once completed, the electronic questionnaires were
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48 130 saved automatically on a secured electronic server that only the principal investigator could access.

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54 132 Sample size calculation for ankle OA prevalence indicated that 138 participants per sport were needed
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3 133 (power of 80%, confidence interval of 95%; absolute precision of 5%) under the assumption of an
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5 134 anticipated population proportion of 10%.²⁰ Expecting a response rate of approximately 50%, we intended
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7 135 to reach at least 300 participants per sport.
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12 137 ***Dependent variable: Ankle osteoarthritis***
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14 138 The clinical diagnosis of ankle OA by a medical professional was retrospectively determined using a single
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16 139 question ('Have you been diagnosed with ankle osteoarthritis by a medical professional?'). Participants
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18 140 were given the definition of ankle OA (based on the NICE criteria; adapted for age), determined as the
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20 141 damage of the ankle joint's cartilage that leads to activity-related joint pain with either no morning joint-
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22 142 related stiffness or morning stiffness that lasts no longer than 30 minutes.²¹ For this question, participants
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24 143 were requested to consult either their medical record or their most recent medical professional.
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30 145 ***Independent variable: Severe ankle injury and related surgery***
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32 146 History of a severe ankle injury during their professional football or rugby career was examined through
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34 147 a single question for the sequential recording of single or multiple injury events over time. Similarly,
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36 148 history of an ankle related surgery was recorded through a single question for the sequential recording of
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38 149 a single or multiple ankle surgeries over time. In our study, a severe ankle injury was defined as an injury
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40 150 that involved the ankle joint, occurred during team activities (training or match), and led to absence from
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42 151 either training or a match for more than 28 days^{18,19}. For this question, participants were requested to
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44 152 consult either their medical records or their most recent medical doctor.
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50 154 ***Health-related quality of life***
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52 155 The Patient-Reported Outcomes Measurement Information System Global Health short form (PROMIS-
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54 156 GH) assesses multiple domains related to health-related quality of life such as health, functioning, pain,
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3 157 social activities and fatigue.²⁰ The PROMIS-GH has been validated in several populations and languages
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5 158 among which are English, French and Spanish (for detailed information, see www.nihpromis.org).²⁰ The
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7 159 Global Mental Health and Global Physical Health scores were calculated based on 10 items each measured
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10 160 on a 5-point scale (from 1 to 5) and subsequently converted.²⁰ These subscale scores ranged from 0 to
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12 161 100, with a higher score indicating better quality of life and a mean score of 50 indicating the norm for
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14 162 the general population.²²

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164 **Procedures**

165 An anonymous questionnaire (electronic and/or paper) available in English, French and Spanish was
166 compiled (LimeSurvey Professional). It included the following descriptive variables: age, body-height,
167 body-weight, duration of professional football or rugby career, level of play, duration and nature of
168 retirement, and current employment status (employed or not employed). Additionally, this questionnaire
169 included questions for the outcomes previously elaborated on (ankle OA, ankle injury, ankle surgery, QoL).
170 Information about the study was sent per email to potential participants by FIFPRO and IRP. Participants
171 interested in the study, gave their informed consent and completed the electronic questionnaire.
172 Participants were asked to complete the questionnaire within 2 weeks, reminders being sent after 2 and
173 4 weeks. For privacy reasons, the responses to the questionnaires were coded and anonymized. Once
174 completed, the electronic questionnaires were automatically saved on a secured electronic server that
175 only the principal investigator could access. Players participated voluntarily and did not receive any
176 reward for their participation.

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178 **Statistical analyses**

179 Data analysis was performed using the statistical software IBM SPSS 24.0 for Windows. Analyses were
180 conducted separately for retired professional football and rugby players. Data were assessed (visually) for

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3 181 normality and presented as mean \pm standard deviation (SD), median (interquartile range [IQR]), or
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5 182 frequency (proportion in %) as appropriate. Body mass index (BMI) was calculated using the provided
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7 183 weight and height of participants (kg/m^2). Prevalence of ankle OA, overall and within the age categories
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9 184 of ≤ 40 years and >40 years, was calculated as the proportion of the number of participants with ankle OA
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11 185 relative to the total number of participants in each category.²⁰ A logistic regression analysis was performed
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13 186 to determine the association of the number of severe ankle injuries and/or ankle surgeries (continuous
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15 187 independent variable) with ankle OA (dichotomous dependent variable). Severe ankle injuries and or
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17 188 ankle-related surgeries were also expressed using 3 pre-determined categories (0, 1 and >1). This was
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19 189 adjusted for age and BMI, both having been identified as risk factors for OA.^{23,24} Descriptive analyses of
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21 190 health-related quality of life (Global Physical Health and Global Mental Health) were conducted, while
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23 191 comparisons between groups (retired players with ankle OA vs. retired players without ankle OA) were
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27 192 made using a Mann-Whitney U test for independent samples.²⁰

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3 195 **Results**

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5 196 ***Participants***

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7 197 From a total of 750 football and 326 rugby players contacted, respectively 401 and 152 gave their

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9 198 written informed consent and completed the questionnaire (overall response rate of 56%).

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11 199 Characteristics of the two groups including the pre-determined sub-categories for severe ankle injuries

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13 200 and ankle surgeries (0, 1 and >1) are illustrated in Table 1.

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17 202 ***Prevalence of ankle osteoarthritis, severe injury and surgery***

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19 203 The prevalence of patient reported ankle OA (including the pre-determined categories of ≤ 40 years

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21 204 and > 40 years) among recently retired professional football and rugby players, is presented in Table 2.

22
23 205 The prevalence of ankle OA in former professional football players was 9.2% (n = 37). Overall, 94% of

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25 206 players with ankle OA were documented to have sustained ≥1 ankle injury and 62% had undergone ≥1

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27 207 ankle surgery. In the non-OA group (n = 364), 54% had sustained ≥1 ankle injury and 14% had

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29 208 undergone ≥1 ankle surgery. Logistic regression analysis (Table 3) showed that football players who

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31 209 had sustained a severe ankle injury were 1.3 (95%CI: 1.1 - 1.6) times more likely to report ankle OA (p <

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33 210 0.001). Football players who had undergone ankle surgery were 2.1 (95%CI: 1.4 – 3.1) times more likely

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35 211 to report ankle OA (p < 0.001).

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39 213 The prevalence of ankle OA in former professional rugby players was 4.6% (n = 7). Overall, six out of

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41 214 seven (86%) rugby players with ankle OA reported to have sustained ≥1 ankle injury and four out of

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43 215 seven (57.1%) had undergone ≥1 ankle surgery. In the non-OA group (n = 145), 58.2% had sustained ≥1

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45 216 ankle injury and 18.4% had undergone ≥1 ankle surgery. Logistic regression analysis (Table 3) showed no

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47 217 significant association between either severe ankle injuries (OR = 1.1 95%CI: 0.8 – 1.5) or ankle surgeries

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49 218 (OR = 2.0 95%CI: 0.8 – 4.7) and ankle OA among former professional rugby players.

Table 1: Descriptive characteristics of recently retired professional football players and rugby players

	Football			Rugby		
	Total (n = 401)	Ankle OA (n = 37)	No ankle OA (n = 364)	Total (n = 152)	Ankle OA (n = 7)	No ankle OA (n = 145)
Age in years * (median; IQR; min-max / mean ± SD)	36 (32-40; 25-50)	39 (36-42; 27-49)*	36 (32-40; 25-50)*	40 ± 6	41 ± 7	40 ± 6
Height in cm (mean ± SD / median; IQR; min-max)	181 ± 7	180 ± 7	182 ± 7	186 (180-191; 166-203)	191 (173-192; 172-192)	186 (180-191; 166-203)
Weight in kg (in kg (mean ± SD))	82 ± 9	82 ± 13	82 ± 9	100 (91-114; 59-170)	108 (89-123; 82-130)	100 (91-113; 59-170)
BMI in kg/m ² (median; IQR; min-max))	24.8 (23.5-26.2; 20.1-32.7)	24.8 (22.9-26.6; 20.3-29)	24.7 (23.5-26.1; 20.1-32.7)	29.0 (27.1-31.4; 20.4-52.5)	32.2 (28.5-33.7; 27.4-35.3)*	28.9 (27.0-31.2; 20.4-52.5)*
Employed in % (n)	89% (350)	92% (33)	89% (317)	91% (139)	86% (6)	92% (133)
Professional career duration in years (median; IQR; min- max)	13 (10-15; 2-19)	13 (12-16; 5-18)	13 (9-15; 2-19)	10 (7-15; 2-20)	10 (8-12.5; 8-13)	10 (7-15; 2-20)
Retirement duration in years (median; IQR; min-max)	4 (2-7; 1-17)	5 (3-9; 1-12)	4 (2-7; 1-17)	8 (3-12; 0-22)	12 (2-16; 1-19)	8 (4-11; 0-22)
Level of play top league; % (n)	81% (314)	92% (34)	80% (280)	80% (106)	86% (6)	80% (100)
Forced retirement % (n)	29% (113)	27% (10)	30% (103)	36% (55)	57% (4)	35% (51)
Severe ankle injuries (median; IQR; min-max)	1 (0-2; 0-10)	2 (1-3; 0-10)	1 (0-2; 0-10)	1 (0-2; 0-20)	1 (1-2; 0-3)	1 (0-2; 0-20)
Ankle surgeries (median; IQR; min-max)	0 (0-0; 0-5)	1 (0-2; 0-5)	0 (0-0; 0-5)	0 (0-0; 0-4)	1 (0-1; 0-2)	0 (0-0; 0-4)

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* Statistically significant difference between ankle OA and no ankle OA. Abbreviations: OA = Osteoarthritis; IQR = interquartile range; n = number

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Table 2: Subcategories for prevalence of reported ankle OA, severe injuries and ankle surgeries in retired football and rugby players

	Football			Rugby		
	Total (n = 401)*	≤ 40 years (n = 271)	> 40 years (n = 83)	Total (n = 152)	≤ 40 years (n = 82)	> 40 years (n = 66)
Prevalence ankle OA in % (95%CI)	9.2% (6.4 – 12.1)	8.5% (5.2 – 11.8)	12.0% (5.0 – 19.1)	4.6% (1.2 – 8.0)	2.4% (0.9 – 5.8)	4.5% (0.5 – 9.6)
	0 ankle injuries	1 ankle injury	> 1 ankle injury	0 ankle injuries	1 ankle injury	> 1 ankle injury
Severe ankle injuries total (% (n))	42.5% (156)	25.3% (93)	32.2% (118)	40.5% (60)	27.7% (41)	31.8% (47)
- With ankle OA (% (n))	5.7% (2)	28.6% (10)	65.7% (23)	14.3% (1)	42.9% (3)	42.9% (3)
- Without ankle OA (% (n))	46.4% (154)	25.0% (83)	28.6% (95)	41.8% (59)	27.0% (38)	31.2% (44)
	No ankle surgeries	1 ankle surgery	> 1 ankle surgery	No ankle surgeries	1 ankle surgery	> 1 ankle surgery
Ankle surgeries total in % (n)	81.5% (299)	10.9% (40)	7.6% (28)	79.7% (118)	15.5% (23)	4.7% (7)
- With ankle OA % (n)	38.2% (13)	29.4% (10)	32.4% (11)	42.9% (3)	42.9% (3)	14.3% (1)
- Without ankle OA % (n)	85.9% (286)	9% (30)	5.1% (17)	81.6% (115)	14.2% (20)	4.3% (6)

*The sum of patients in the subcategories ≤ 40 years and > 40 years does not equal the "Total number of participants" due to missing data (regarding age).

Abbreviations: OA = Osteoarthritis; n = number; CI = confidence interval;

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Table 3: Association (odds ratio and 95% CI) of severe ankle injury and ankle surgery with ankle osteoarthritis among recently retired professional football and rugby players

	Football (n = 401)		Rugby (n = 152)	
	Unadjusted	Adjusted ^ψ	Unadjusted	Adjusted ^ψ
Severe ankle injury (OR, 95%CI)	1.34 (1.17-1.53)	1.33 (1.14-1.55)	1.01 (0.74-1.38)	1.05 (0.75-1.47)
Ankle surgery (OR, 95%CI)	2.20 (1.61-3.00)	2.09 (1.41-3.08)	1.99 (0.92-4.3)	1.96 (0.81-4.71)

^ψAdjusted for age and body mass index (BMI); Abbreviations: OR = Odds Ratio; n = number; CI = confidence interval

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221 **Mental and physical QoL**

222

223 For the PROMIS physical health score a statistically significant lower outcome was found for football ($p = 0.01$) and rugby players ($p = 0.009$) with

224 OA (48 and 45 points respectively) compared to players without OA (51 and 51 points respectively). The PROMIS mental health score was not

225 significantly different between players with OA vs players without OA. Data is presented in Table 4.

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219 *Table 4: Mental and physical quality of life (0-100) of recently retired football and rugby players with ankle OA compared to players without ankle OA*

	Football				Rugby			
	Total (n = 401)	With ankle OA (n = 37)	Without ankle OA (n = 364)	p-value	Total (n = 152)	With ankle OA (n = 7)	Without ankle OA (n = 145)	p-value
<i>PROMIS mental health (median; IQR; min-max)</i>	51; 46-56; 31-68	51; 46-53; 31-63	53; 46-56; 31-68	0.251	52; 46-56; 28-68	48; 48-53; 46-56	53; 46-56; 28-68	0.567
<i>PROMIS Physical health* (median; IQR; min-max)</i>	51; 46-56; 27-68	48; 42-54; 35-62*	51; 48-58; 27-68*	0.010	51; 45-54; 30-68	45; 37-48; 37-51*	51; 37-56; 30-68*	0.009

31 **Statistically significant difference; Abbreviations: OA = Osteoarthritis; IQR = Interquartile range; n = number*

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Table 5: Post-Hoc analysis regarding mental and physical quality of life of recently retired football and rugby players who reported to have been forced to retire, and quality of life of players who reported to have been forced to retire with ankle OA compared to players without ankle OA

	PROMIS mental health (median; IQR; min-max)	p-value	PROMIS physical health (median; IQR; min-max)	p-value
<i>Total</i>				
<i>Voluntarily retired*</i> (n = 369)	53; 48-56; 31-68*	p < 0.001	54; 48-58; 30-68*	p < 0.001
<i>Forced to retire*</i> (n = 168)	48; 44-53; 28-68*		48; 42-51; 27-68*	
<i>Voluntarily retired with OA*</i> (n = 30)	51; 46-53; 36-63	p = 0.074	51; 45-54; 35-62*	p = 0.001
<i>Voluntarily retired without OA*</i> (n = 339)	53; 48-59; 31-68		54; 48-58; 30-68*	
<i>Forced to retire with OA</i> (n = 14)	48; 46-55; 31-63	p = 0.841	42; 40-46; 37-58	p = 0.159

231 Post-hoc analysis

232 In the literature, forced retirement is a risk factor for post-career mental health symptoms.²⁵ Following
 233 data analysis, we were concerned by the seemingly high percentage of football and rugby players who
 234 stopped due to a career ending injury. As we were analysing the impact ankle OA had on QoL, we felt
 235 the effect of a career ending injury on QoL to be in line with our initial objectives. Consequently we
 236 performed a post-hoc analysis to determine any associations between reported forced retirement and
 237 mental and physical PROMIS health scores. In this study, 31% of players reported to have been forced to
 238 retire, specifically: 29% of football players and 36% of rugby players.

240 The post-hoc sub-analysis of all players regarding mental and physical health scores associated with
 241 voluntary retirement and in conjunction with ankle OA is presented in Table 5. No post-hoc sub-analysis
 242 was done for football and rugby players separately, regarding voluntary retirement in conjunction with
 243 ankle OA, due to the low number of ankle OA cases among rugby players. However mental and physical
 244 health scores in football and rugby due to forced retirement is presented separately in Table 5.

245

1 2 3 4 5 6 7	<i>Forced to retire without OA (n = 154)</i>	48; 44-53; 28-68		48; 42-52; 27-68	
8	<i>Football*</i>				
9	<i>Voluntarily retired* (n = 272)</i>	53; 48-56; 31-68*		54; 48-58; 30-68*	
10	<i>Forced to retire* (n = 113)</i>	48; 44-53; 31-63*	p < 0.001	48; 42-51; 27-62*	p < 0.001
11	<i>Rugby*</i>				
12	<i>Voluntarily retired* (n = 97)</i>	53; 48-56; 31-68*		54; 48-58; 35-68*	
13	<i>Forced to retire* (n = 55)</i>	48; 44-56; 28-68*	p = 0.018	48; 37-54; 30-68*	p < 0.001

*Statistically significant difference; Abbreviations: IQR = Interquartile range; OA = Osteoarthritis; n = number

246

248 **Discussion**

249 Our most important findings were that (i) the prevalence of ankle OA among former professional
250 football and rugby players was, 9.2% (95%CI 6.4 –12.1) and 4.6% (95%CI (1.2 – 8.0), respectively; (ii)
251 previous severe ankle injuries and ankle surgeries are associated with ankle OA among former
252 professional football players; and (iii) ankle OA does not lead to reduced mental or physical QoL in
253 former professional football and rugby players.

254

255 **Ankle OA in football and rugby compared to other sports and the general population**

256 Several studies have reported symptomatic ankle OA prevalence among a variety of former elite
257 athletes, ranging from 0% in volleyball (n = 22), long distance running (n = 30), elite high-jump (n = 30)
258 and ballet (n = 27) to 10% among former military parachutists (n = 40).^{26–30} In our study, the prevalence
259 of ankle OA among former professional football (9.2%) and rugby players (4.6%) was higher than the
260 estimated prevalence among the general population (3.4 %).¹² Murray et al. (2018) invited participants
261 with self-reported ankle pain (11.7%) from the general population for a radiograph (radiological atlas of
262 Foot OA).^{12,31}

263

264 Our study reports a lower ankle OA prevalence compared to previous studies among former
265 professional football players (12-19%).^{13–15} In these studies, data was similarly collected using cross-
266 sectional retrospective self-reported questionnaires.^{13,14} No previous data is available concerning ankle
267 OA among former professional rugby players. The low ankle OA prevalence among rugby players in this
268 study is likely due to either an under reporting of ankle OA among rugby players or a type II error.

269

270 ***Association of severe ankle injuries and ankle surgeries with ankle OA***

271 In our study, football players were 1.3 (95%CI: 1.1 - 1.6) and 2.1 (95%CI: 1.4 – 3.1) times more likely to
272 develop ankle OA for every ankle injury and ankle surgery, respectively. This is in line with previous

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3 273 studies that showed an association between ankle OA and ankle injuries, stating traumatic ankle injuries
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5 274 to be the main cause of ankle OA (70-78%).^{6,7} Consequences of ankle injuries are thought to be due to
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7 275 either direct damage the articular surfaces or change in ankle joint biomechanics (e.g. through chronic
8
9 276 ankle instability due to ankle ligament damage).³² No association was seen for severe ankle injuries or
10
11 277 ankle surgeries and ankle OA among rugby players. Although the best estimate for the association of
12
13 278 ankle surgeries and OA is similar to football (OR = 2), the 95%CI includes 1 (0.8 – 4.7). This may be due
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15 279 to insufficient power among rugby players, as only 7 reported ankle OA.
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21 281 ***Health-related quality of life***

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23 282 Filbay et al. (2019) reported factors such as age, type of sport (contact/collision sports), OA and
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25 283 involuntary retirement from sport to possibly negatively impact QoL.^{25,33–35} However the positive
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27 284 impacts associated with elite sport participation, such as pride of accomplishments, social network
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29 285 (through sport participation) and coping and adjustment to musculoskeletal pain (due to resilience and
30
31 286 determination), may persist and even compensate reduced physical QOL beyond retirement of the
32
33 287 player's athletic career.³³
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39 289 Our post-hoc sub-analysis revealed 29% of football players and 36% of rugby players were forced to
40
41 290 retire. Although we reported several instances of statistically significant differences in our study for both
42
43 291 physical and mental PROMIS health scores, all were similar to the estimated norm for the general
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45 292 population (50 points). Unfortunately, there is no robust minimally clinically important difference
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47 293 (MCID) threshold for the PROMIS-10 global short form applicable for this population. Consequently, it is
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49 294 difficult to interpret the results. Nevertheless, although statistically significant, the PROMIS mental and
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51 295 physical health scores observed, for both football and rugby players, are unlikely clinically significant.
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3 296 Based on our data, ankle OA does not lead to reduced mental or physical QoL in former professional
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5 297 football and rugby players.
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10 299 ***Strengths and limitations***

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12 300 We had an overall good response rate (56%) and a large group of participating football players (401).

13
14 301 However, several limitations should be mentioned. Firstly, this study had a cross-sectional design,

15
16 302 therefore no causal-association can be determined. Secondly, there were only 7 rugby players with OA,

17
18 303 implying a potential serious type II error. Thirdly, recruitment procedures were blinded to the research

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20 304 team, a non-response analysis could not be performed. Fourthly, research based (retrospective)

21
22 305 questionnaires are dependent on the accuracy and understanding of the participant. Professional

23
24 306 athletes might generally remember the number of severe ankle injuries or surgeries resulting in a

25
26 307 training or match absence of ≥ 4 weeks. However, we cannot exclude that participants were not able to

27
28 308 precisely recall all their sustained severe ankle injuries and ankle surgeries or that they did not consult

29
30 309 their last (team) doctor. Finally, our OA definition did not include a clinical and radiological evaluation.

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36 311 ***Implications for practice***

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38 312 The epidemiological data from this study regarding ankle OA prevalence among former professional

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40 313 football and rugby players, and its association with both severe ankle injuries and ankle surgeries, is an

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42 314 essential part of protecting the athlete's health. In both professional football and rugby, a higher

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44 315 prevalence of ankle OA can be expected compared to the general population. Furthermore, As the

45
46 316 majority are post-traumatic, preventive measures and adequate rehabilitation are recommended.

47
48 317 Awareness should be raised, regarding the increased risk of developing ankle OA following each ankle

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50 318 injury and surgery. Additionally primary and secondary prevention programmes should be implemented.

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52 319 Exercise based prevention intervention programs, such as the FIFA11+ in football and the movement

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3 320 control injury prevention programme in rugby, have found reduced ankle injury incidence and
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5 321 burden.^{36,37} Finally, management of ankle OA is key for retired players, focusing on healthy lifestyle
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7 322 including physical activity, pain alleviation, function and minimising disability.³⁸⁻⁴⁰ With this intention,
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9
10 323 FIFPRO has developed an “After Career Consultation”.⁴¹ Future studies will evaluate its relevance.
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14 325

New findings and impact on clinical practice in the future

- The prevalence of ankle OA in both professional football (9.2%) and rugby (4.6%), is higher than the estimated prevalence in the general population (3.4%).
- Awareness should be raised among football and rugby players, regarding the increased risk of developing ankle OA following each ankle injury and ankle surgery.
- Primary and secondary prevention programmes should be implemented, as these might help in reducing the risk of developing ankle OA.
- Management of ankle OA is key for retired players. With this intention, FIFPRO has developed an “After Career Consultation”. Future studies will evaluate its relevance.

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Conclusion

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46 329 This cross-sectional study found an athlete reported ankle OA prevalence of 9.2% and 4.6% among
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48 330 recently retired professional football and rugby players, respectively. Severe ankle injuries and ankle
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50 331 surgeries were associated with a higher prevalence of ankle OA in former professional football players.
51
52 332 No clinically relevant differences in QoL were reported in players with OA compared to players without
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54
55 333 OA. As a higher prevalence of ankle OA can be expected in both professional football and rugby
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3 334 compared to the general population, and the majority are post-traumatic, primary and secondary
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5 335 preventive measures for ankle injuries and an optimal diagnosis and treatment plan are recommended.
6
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9
10 337 **Acknowledgements**

11
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13
14 339 grateful to all retired professional football and rugby players who participated in the study.
15
16
17 340

18
19 341 **Contributorship statement**

20
21 342 Authorship was determined according to the ICMJE authorship recommendations. All authors were
22
23 343 involved in the design of the study, data analysis and data interpretation. VG and GMMJK were
24
25 344 responsible for data collection. LP drafted the manuscript, with critical review provided by all authors.
26
27
28 345 All authors approved the final version of the manuscript.
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31 346

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33
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35
36 349 sectors.
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40
41 351 **Competing interests**

42
43 352 None declared.
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47
48 354 **Ethics approval**

49
50 355 Ethical approval for the study was provided by the Ethical Committee of the Yokohama City Sports
51
52 356 Medical Center (17.003; Yokohama, Japan) and the Medical Ethics Review Committee of the Academic
53
54 357 Medical Center (W16_366#16.431; Amsterdam, The Netherlands)
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5 359 **Patient and public involvement**
6

7 360 This research was done without patient involvement. Patients were not invited to comment on the
8

9
10 361 study design and were not consulted to develop patient relevant outcomes or interpret the results.
11

12 362 Patients were not invited to contribute to the writing or editing of this document for readability or
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14 363 accuracy.
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21 366 **Data sharing statement**
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23 367 No additional data available
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract – ✓ (b) Provide in the abstract an informative and balanced summary of what was done and what was found – ✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported – ✓: p. 4 line 64 – 96
Objectives	3	State specific objectives, including any prespecified hypotheses – ✓: p. 4 line 98 – 104
Methods		
Study design	4	Present key elements of study design early in the paper – ✓: p. 6 line 108 – 114
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection – ✓: p. 6 line 116 – 133
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants – ✓: p. 6 line 116 – 133
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – ✓: p. 6 line 135 – 159
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group – ✓: p. 6 line 161 – 172
Bias	9	Describe any efforts to address potential sources of bias – ✓: p. 6 line 117
Study size	10	Explain how the study size was arrived at – ✓: p. 6 – 7 line 130 – 133
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why – ✓: p. 8-9 line 175 – 188
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses – ✓: p. 8-9 line 175 – 188
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed – ✓: p. 10 line 192 – 196 (b) Give reasons for non-participation at each stage – ✓: p. 10 line 192 – 196 (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders – ✓: p 11 table 1 (b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures – ✓: p 11 – 14, table 2 -4
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included – ✓: p 11 – 14, table 2 -4 (b) Report category boundaries when continuous variables were categorized

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(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses – √: p 15, line 227 – 237 + p 16 table 5
Discussion		
Key results	18	Summarise key results with reference to study objectives – √: p 17, line 242 - 245
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias – √: p 3, line 53 - 62
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence – √: p 19 - 20, line 293 - 317
Generalisability	21	Discuss the generalisability (external validity) of the study results p 19 - 20, line 293 - 305
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based p 21, line 339 - 340

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Ankle osteoarthritis and its association with severe ankle injuries, ankle surgeries and health-related quality of life in recently retired professional male football and rugby players: A Cross-sectional observational study

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1
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3 **1 Ankle osteoarthritis and its association with severe ankle injuries, ankle surgeries and health-related**
4
5 **2 quality of life in recently retired professional male football and rugby players: A Cross-sectional**
6
7 **3 observational study**
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9

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2
3 **28 Abstract**

4
5 **29 Objectives**

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8 To determine (i) the prevalence of ankle osteoarthritis (OA) among former professional football and
9
10 31 rugby players, (ii) assess the association between ankle injuries or ankle surgeries with ankle OA, and (iii)
11
12 32 compare the mental and physical quality of life (QoL) between former professional football and rugby
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14 33 players with and without OA.
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19 **35 Methods**

20
21 36 We conducted a questionnaire based observational study with a cross-sectional design. Former
22
23 37 professional football and rugby players were recruited by the football players worldwide (FIFPRO) and
24
25 38 the International Rugby Players (IRP). Information concerning ankle OA, sustained ankle injuries and
26
27 39 ankle surgeries was gathered (medical record or most recent medical professional). Health related
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30 40 QoL was assessed using the PROMIS physical and mental health scores.
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35 **42 Results**

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37 43 Overall, 553 former professional football (n = 401) and rugby players (n = 152) were enrolled in the
38
39 44 study (response rate of 56%). Ankle OA prevalence among former professional football and rugby
40
41 45 players was 9.2% and 4.6%, respectively. Football players were more likely to suffer from ankle OA
42
43 46 following every ankle injury and/or surgery. Football and rugby players with ankle OA had similar
44
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46 47 PROMIS physical and mental health scores to the norm for the general population.
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51 **49 Conclusion**

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53 50 Former professional football and rugby players had a higher ankle OA prevalence than the general
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55 51 population (3.4%). Football players are more likely to suffer from ankle OA following every ankle injury
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3 52 and/or surgery. No clinical relevant difference was seen for physical or mental health related QoL among
4
5 53 football and rugby players. Preventive measures for ankle injuries are recommended.
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10 55 ***Strengths and limitations***

- 11
12 56 - Overall good response rate (56%) and a large group of participating football players (401)
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15 57 - This study had a cross-sectional design, therefore no causal-association can be determined
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18 58 - This study contributes to the literature, where the current available data concerning ankle OA in
19
20 59 professional football and rugby players is outdated or non-existent.
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23 60 - The data is based on (retrospective) questionnaires and is therefore dependent on the accuracy
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25 61 and understanding of the participant. Our OA definition did not include a clinical and
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28 62 radiological evaluation.
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64 Background

65 Football and Rugby Union (hereafter 'rugby') are among the most popular team sports worldwide. In
66 both sports, ankle injuries represent a significant proportion of the total injuries sustained.¹⁻⁵ Previous
67 ankle injuries are an important risk factor for ankle osteoarthritis (OA).^{6,7}
68
69 Drawer et al. (2002) estimates the overall risk of injury in professional football to be 1,000 times higher
70 than in high-risk industrial occupations, with ankle injuries contributing 10-18% of all injuries.^{2,8} The
71 Union of European Football Associations (UEFA) Champions League Injury Study reported an overall
72 ankle injury rate of 1 injury per 1000 hours.² Lateral ankle sprains (51%) were the most prevalent sub-
73 type of ankle injuries.² In professional rugby, epidemiological studies show that ankle injuries contribute
74 5-20% of all injuries.^{1,3,9,10} Similar to professional football, lateral ankle sprains are the most common
75 ankle injuries with an injury rate of 3.8 - 4.5 injuries per 1,000 player hours depending on the position on
76 the field.¹¹

77
78 Two retrospective cohort studies from the general population (n = 390 and n = 639 patients
79 respectively), reported that 70-78% of ankle OA cases were associated with a previously sustained ankle
80 injury. These previous injuries included fractures, isolated osteochondral defects of the talus and ankle
81 ligament injuries.^{6,7} Among these post-traumatic ankle OA cases, 28% were associated with a previously
82 sustained ligamentous injury.⁷ To our knowledge, there are no prospective studies on the association of
83 ankle injuries and ankle OA.

84
85 In the general population the prevalence of ankle OA is estimated to be 3.4% in people over 50 years of
86 age.¹² The reported prevalence of ankle OA 16 to 22 years after a professional football career is 12-
87 19%.¹³⁻¹⁵ No data are available for ankle OA among former professional rugby players. In comparison to

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3 88 a general population control group, the prevalence of OA in any joint and the incidence of joint
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5 89 replacement for any joint was estimated to be 4 and 6 times higher, respectively, among former elite
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7 90 rugby players.¹⁶ This has been associated with a significantly poorer mental and physical health-related
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10 91 quality of life (QoL).¹⁶
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14 93 Several other studies report the association of general OA with mental health symptoms and physical
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16 94 health-related QoL among former elite athletes across professional team sports including football and
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18 95 rugby.^{17,18} Therefore, the impact of OA on retired players must be considered. To date, the
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21 96 epidemiological evidence concerning the prevalence of ankle OA in professional football is either
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23 97 outdated or limited, and in the case of rugby non-existent, while data on the association between
24
25 98 previous ankle injury and ankle OA is scarce in both sports.
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30 100 The objective of this study was threefold. Firstly, to evaluate the prevalence of ankle OA in recently
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32 101 retired professional football and rugby players. Secondly, to determine the association between ankle
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34 102 injury and/or ankle surgery and ankle OA. Thirdly, to compare the mental and physical QoL in players
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36 103 with and without ankle OA. Our hypotheses were that (i) recently retired professional football and rugby
37
38 104 players have a higher ankle OA prevalence than the general population (as found in the literature), (ii)
39
40 105 ankle injuries and/or ankle surgeries are associated with ankle OA, and (iii) the mental and physical QoL
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42 106 of recently retired professional football and rugby players with OA is lower compared to those players
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45 107 without OA.
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3 110 **Methods**
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5 111 **Design**
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7 112 We conducted a questionnaire based observational study with a cross-sectional design. Ethical approval
8 113 for the study was provided by the Ethical Committee of the Yokohama City Sports Medical Center (17.003;
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10 114 Yokohama, Japan) and the Medical Ethics Review Committee of the Academic Medical Center
11
12 115 (W16_366#16.431; Amsterdam, The Netherlands). The study was reported according to the
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14 116 'Strengthening the Reporting of Observational Studies in Epidemiology' statement and conducted in
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16 117 accordance with the Declaration of Helsinki (2013).¹⁹
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22
23 119 **Participants**
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25 120 Retired professional football and rugby players were randomly recruited to reduce recruitment bias, by
26
27 121 the Football Players Worldwide (FIFPRO) and the International Rugby Players (IRP). Inclusion criteria were:
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29 122 (a) being a retired male professional football or rugby player; (b) being younger than 50 years of age; (c)
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31 123 being able to read and comprehend texts in English, French or Spanish.
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35
36 125 The definition of a retired professional football or rugby player was that he (i) has trained to improve
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38 126 performances, (ii) has competed in the highest or second highest national league, and (iii), has had training
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40 127 and competition as a major activity (way of living) or focus of personal interest, devoting several hours in
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42 128 all or most of the days for these activities, and exceeding the time allocated to other types of professional
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44 129 or leisure activities. If interested, players received information about the study, gave their informed
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46 130 consent and completed an electronic questionnaire. Once completed, the electronic questionnaires were
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48 131 saved automatically on a secured electronic server that only the principal investigator could access.
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54 133 Sample size calculation for ankle OA prevalence indicated that 138 participants per sport were needed
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3 134 (power of 80%, confidence interval of 95%; absolute precision of 5%) under the assumption of an
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5 135 anticipated population proportion of 10%.²⁰ Expecting a response rate of approximately 50%, we intended
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7 136 to reach at least 300 participants per sport.
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12 138 ***Dependent variable: Ankle osteoarthritis***
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14 139 The clinical diagnosis of ankle OA by a medical professional was retrospectively determined using a single
15
16 140 question ('Have you been diagnosed with ankle osteoarthritis by a medical professional?'). Participants
17
18 141 were given the definition of ankle OA (based on the NICE criteria; adapted for age), determined as the
19
20 142 damage of the ankle joint's cartilage that leads to activity-related joint pain with either no morning joint-
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22 143 related stiffness or morning stiffness that lasts no longer than 30 minutes.²¹ For this question, participants
23
24 144 were requested to consult either their medical record or their most recent medical professional.
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30 146 ***Independent variable: Severe ankle injury and related surgery***
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32 147 History of a severe ankle injury during their professional football or rugby career was examined through
33
34 148 a single question for the sequential recording of single or multiple injury events over time. Similarly,
35
36 149 history of an ankle related surgery was recorded through a single question for the sequential recording of
37
38 150 a single or multiple ankle surgeries over time. In our study, a severe ankle injury was defined as an injury
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40 151 that involved the ankle joint, occurred during team activities (training or match), and led to absence from
41
42 152 either training or a match for more than 28 days^{18,19}. For this question, participants were requested to
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44 153 consult either their medical records or their most recent medical professional.
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50 155 ***Health-related quality of life***
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52 156 The Patient-Reported Outcomes Measurement Information System Global Health short form (PROMIS-
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54 157 GH) assesses multiple domains related to health-related quality of life such as health, functioning, pain,
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3 158 social activities and fatigue.²⁰ The PROMIS-GH has been validated in several populations and languages
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5 159 among which are English, French and Spanish (for detailed information, see www.nihpromis.org).²⁰ The
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7 160 Global Mental Health and Global Physical Health scores were calculated based on 10 items each measured
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10 161 on a 5-point scale (from 1 to 5) and subsequently converted.²⁰ These subscale scores ranged from 0 to
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12 162 100, with a higher score indicating better quality of life and a mean score of 50 indicating the norm for
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14 163 the general population.²²

164

165 ***Procedures***

166 An anonymous questionnaire (electronic and/or paper) available in English, French and Spanish was
167 compiled (LimeSurvey Professional). It included the following descriptive variables: age, body-height,
168 body-weight, duration of professional football or rugby career, level of play, duration and nature of
169 retirement, and current employment status (employed or not employed). Additionally, this questionnaire
170 included questions for the outcomes previously elaborated on (ankle OA, ankle injury, ankle surgery, QoL).
171 Information about the study was sent per email to potential participants by FIFPRO and IRP. Participants
172 interested in the study, gave their informed consent and completed the electronic questionnaire.
173 Participants were asked to complete the questionnaire within 2 weeks, reminders being sent after 2 and
174 4 weeks. For privacy reasons, the responses to the questionnaires were coded and anonymized. Once
175 completed, the electronic questionnaires were automatically saved on a secured electronic server that
176 only the principal investigator could access. Players participated voluntarily and did not receive any
177 reward for their participation.

178

179 ***Statistical analyses***

180 Data analysis was performed using the statistical software IBM SPSS 24.0 for Windows. Analyses were
181 conducted separately for retired professional football and rugby players. Data were assessed (visually) for

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3 182 normality and presented as mean \pm standard deviation (SD), median (interquartile range [IQR]), or
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5 183 frequency (proportion in %) as appropriate. Body mass index (BMI) was calculated using the provided
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7 184 weight and height of participants (kg/m²). Prevalence of ankle OA, overall and within the age categories
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9 185 of ≤ 40 years and >40 years, was calculated as the proportion of the number of participants with ankle OA
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11 186 relative to the total number of participants in each category.²⁰ *We chose to dichotomize age at 40 years,*
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13 187 *as our population included former professional athletes. This is opposed to Murray et al. (2018)*
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15 188 *concerning the general population (dichotomized at 50 years of age), and in line with Song et al. (2019)*
16
17 189 *studying former professional American Football players. We made the assumption that although no-*
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19 190 *longer professionals, these former professional athletes would no longer be competing at a decent level*
20
21 191 *at the age of 40. We therefore found 40 years to be a more relevant age to dichotomise than 50 years.*^{12,23}
22
23 192 A logistic regression analysis was performed to determine the association of the number of severe ankle
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25 193 injuries and/or ankle surgeries (continuous independent variable) with ankle OA (dichotomous dependent
26
27 194 variable). Severe ankle injuries and or ankle-related surgeries were also expressed using 3 pre-determined
28
29 195 categories (0, 1 and >1). This was adjusted for age and BMI, both having been identified as risk factors for
30
31 196 OA.^{24,25} Descriptive analyses of health-related quality of life (Global Physical Health and Global Mental
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33 197 Health) were conducted, while comparisons between groups (retired players with ankle OA vs. retired
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35 198 players without ankle OA) were made using a Mann-Whitney U test for independent samples.²⁰
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43 200 **Patient and public involvement**

44
45 201 This research was done without patient involvement. Patients were not invited to comment on the
46
47 202 study design and were not consulted to develop patient relevant outcomes or interpret the results.
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49 203 Patients were not invited to contribute to the writing or editing of this document for readability or
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51 204 accuracy.
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3 205 **Results**

4
5 206 ***Participants***

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7 207 From a total of 750 football and 326 rugby players contacted, respectively 401 and 152 gave their

8
9 208 written informed consent and completed the questionnaire (overall response rate of 56%).

10
11 209 Characteristics of the two groups including the pre-determined sub-categories for severe ankle injuries

12
13 210 and ankle surgeries (0, 1 and >1) are illustrated in Table 1.

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15 211

16
17 212 ***Prevalence of ankle osteoarthritis, severe injury and surgery***

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19 213 The prevalence of patient reported ankle OA (including the pre-determined categories of ≤ 40 years

20
21 214 and > 40 years) among recently retired professional football and rugby players, is presented in Table 2.

22
23 215 The prevalence of ankle OA in former professional football players was 9.2% (n = 37). Overall, 94% of

24
25 216 players with ankle OA were documented to have sustained ≥1 ankle injury and 62% had undergone ≥1

26
27 217 ankle surgery. In the non-OA group (n = 364), 54% had sustained ≥1 ankle injury and 14% had

28
29 218 undergone ≥1 ankle surgery. Logistic regression analysis (Table 3) showed that football players who

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31 219 had sustained a severe ankle injury were 1.3 (95%CI: 1.1 - 1.6) times more likely to report ankle OA (p <

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33 220 0.001). Football players who had undergone ankle surgery were 2.1 (95%CI: 1.4 – 3.1) times more likely

34
35 221 to report ankle OA (p < 0.001).

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37 222

38
39 223 The prevalence of ankle OA in former professional rugby players was 4.6% (n = 7). Overall, six out of

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41 224 seven (86%) rugby players with ankle OA reported to have sustained ≥1 ankle injury and four out of

42
43 225 seven (57.1%) had undergone ≥1 ankle surgery. In the non-OA group (n = 145), 58.2% had sustained ≥1

44
45 226 ankle injury and 18.4% had undergone ≥1 ankle surgery. Logistic regression analysis (Table 3) showed no

46
47 227 significant association between either severe ankle injuries (OR = 1.1 95%CI: 0.8 – 1.5) or ankle surgeries

48
49 228 (OR = 2.0 95%CI: 0.8 – 4.7) and ankle OA among former professional rugby players.

Table 1: Descriptive characteristics of recently retired professional football players and rugby players

	Football			Rugby		
	Total (n = 401)	Ankle OA (n = 37)	No ankle OA (n = 364)	Total (n = 152)	Ankle OA (n = 7)	No ankle OA (n = 145)
Age in years * (median; IQR; min-max/ mean ± SD)	36 (32-40; 25-50)	39 (36-42; 27-49)*	36 (32-40; 25-50)*	40 ± 6	41 ± 7	40 ± 6
Height in cm (mean ± SD / median; IQR; min-max)	181 ± 7	180 ± 7	182 ± 7	186 (180-191; 166-203)	191 (173-192; 172-192)	186 (180-191; 166-203)
Weight in kg (in kg (mean ± SD))	82 ± 9	82 ± 13	82 ± 9	100 (91-114; 59-170)	108 (89-123; 82-130)	100 (91-113; 59-170)
BMI in kg/m ² (median; IQR; min-max))	24.8 (23.5-26.2; 20.1-32.7)	24.8 (22.9-26.6; 20.3-29)	24.7 (23.5-26.1; 20.1-32.7)	29.0 (27.1-31.4; 20.4-52.5)	32.2 (28.5-33.7; 27.4-35.3)*	28.9 (27.0-31.2; 20.4-52.5)*
Employed in % (n)	89% (350)	92% (33)	89% (317)	91% (139)	86% (6)	92% (133)
Professional career duration in years (median; IQR; min- max)	13 (10-15; 2-19)	13 (12-16; 5-18)	13 (9-15; 2-19)	10 (7-15; 2-20)	10 (8-12.5; 8-13)	10 (7-15; 2-20)
Retirement duration in years (median; IQR; min-max)	4 (2-7; 1-17)	5 (3-9; 1-12)	4 (2-7; 1-17)	8 (3-12; 0-22)	12 (2-16; 1-19)	8 (4-11; 0-22)
Level of play top league; % (n)	81% (314)	92% (34)	80% (280)	80% (106)	86% (6)	80% (100)
Forced retirement % (n)	29% (113)	27% (10)	30% (103)	36% (55)	57% (4)	35% (51)
Severe ankle injuries (median; IQR; min-max)	1 (0-2; 0-10)	2 (1-3; 0-10)	1 (0-2; 0-10)	1 (0-2; 0-20)	1 (1-2; 0-3)	1 (0-2; 0-20)
Ankle surgeries (median; IQR; min-max)	0 (0-0; 0-5)	1 (0-2; 0-5)	0 (0-0; 0-5)	0 (0-0; 0-4)	1 (0-1; 0-2)	0 (0-0; 0-4)

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* Statistically significant difference between ankle OA and no ankle OA. Abbreviations: OA = Osteoarthritis; IQR = interquartile range; n = number

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Table 2: Subcategories for prevalence of reported ankle OA, severe injuries and ankle surgeries in retired football and rugby players

	Football			Rugby		
	Total (n = 401)*	≤ 40 years (n = 271)	> 40 years (n = 83)	Total (n = 152)	≤ 40 years (n = 82)	> 40 years (n = 66)
Prevalence ankle OA in % (95%CI)	9.2% (6.4 – 12.1)	8.5% (5.2 – 11.8)	12.0% (5.0 – 19.1)	4.6% (1.2 – 8.0)	2.4% (0.9 – 5.8)	4.5% (0.5 – 9.6)
	0 ankle injuries	1 ankle injury	> 1 ankle injury	0 ankle injuries	1 ankle injury	> 1 ankle injury
Severe ankle injuries total (% (n))	42.5% (156)	25.3% (93)	32.2% (118)	40.5% (60)	27.7% (41)	31.8% (47)
- With ankle OA (% (n))	5.7% (2)	28.6% (10)	65.7% (23)	14.3% (1)	42.9% (3)	42.9% (3)
- Without ankle OA (% (n))	46.4% (154)	25.0% (83)	28.6% (95)	41.8% (59)	27.0% (38)	31.2% (44)
	No ankle surgeries	1 ankle surgery	> 1 ankle surgery	No ankle surgeries	1 ankle surgery	> 1 ankle surgery
Ankle surgeries total in % (n)	81.5% (299)	10.9% (40)	7.6% (28)	79.7% (118)	15.5% (23)	4.7% (7)
- With ankle OA % (n)	38.2% (13)	29.4% (10)	32.4% (11)	42.9% (3)	42.9% (3)	14.3% (1)
- Without ankle OA % (n)	85.9% (286)	9% (30)	5.1% (17)	81.6% (115)	14.2% (20)	4.3% (6)

*The sum of patients in the subcategories ≤ 40 years and > 40 years does not equal the "Total number of participants" due to missing data (regarding age).

Abbreviations: OA = Osteoarthritis; n = number; CI = confidence interval;

Table 3: Association (odds ratio and 95% CI) of severe ankle injury and ankle surgery with ankle osteoarthritis among recently retired professional football and rugby players

	Football (n = 401)		Rugby (n = 152)	
	Unadjusted	Adjusted ^ψ	Unadjusted	Adjusted ^ψ
Severe ankle injury (OR, 95%CI)	1.34 (1.17-1.53)	1.33 (1.14-1.55)	1.01 (0.74-1.38)	1.05 (0.75-1.47)
Ankle surgery (OR, 95%CI)	2.20 (1.61-3.00)	2.09 (1.41-3.08)	1.99 (0.92-4.3)	1.96 (0.81-4.71)

^ψAdjusted for age and body mass index (BMI); Abbreviations: OR = Odds Ratio; n = number; CI = confidence interval

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231 **Mental and physical QoL**

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233 For the PROMIS physical health score a statistically significant lower outcome was found for football (p = 0.01) and rugby players (p = 0.009) with
234 OA (48 and 45 points respectively) compared to players without OA (51 and 51 points respectively). The PROMIS mental health score was not
235 significantly different between players with OA vs players without OA. Data is presented in Table 4.

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Table 4: Mental and physical quality of life (0-100) of recently retired football and rugby players with ankle OA compared to players without ankle OA

	Football				Rugby			
	Total (n = 401)	With ankle OA (n = 37)	Without ankle OA (n = 364)	p-value	Total (n = 152)	With ankle OA (n = 7)	Without ankle OA (n = 145)	p-value
PROMIS mental health (median; IQR; min-max)	51; 46-56; 31-68	51; 46-53; 31-63	53; 46-56; 31-68	0.251	52; 46-56; 28-68	48; 48-53; 46-56	53; 46-56; 28-68	0.567
PROMIS Physical health* (median; IQR; min-max)	51; 46-56; 27-68	48; 42-54; 35-62*	51; 48-58; 27-68*	0.010	51; 45-54; 30-68	45; 37-48; 37-51*	51; 37-56; 30-68*	0.009

*Statistically significant difference; Abbreviations: OA = Osteoarthritis; IQR = Interquartile range; n = number

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3 241 **Post-hoc analysis**
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5 242 In the literature, forced retirement is a risk factor for post-career mental health symptoms.²⁶ Following
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7 243 data analysis, we were concerned by the seemingly high percentage of football and rugby players who
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9 244 stopped due to a career ending injury. As we were analysing the impact ankle OA had on QoL, we felt
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11 245 the effect of a career ending injury on QoL to be in line with our initial objectives. Consequently we
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13 246 performed a post-hoc analysis to determine any associations between reported forced retirement and
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15 247 mental and physical PROMIS health scores. In this study, 31% of players reported to have been forced to
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17 248 retire, specifically: 29% of football players and 36% of rugby players.
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23 250 The post-hoc sub-analysis of all players regarding mental and physical health scores associated with
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25 251 voluntary retirement and in conjunction with ankle OA is presented in Table 5. No post-hoc sub-analysis
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27 252 was done for football and rugby players separately, regarding voluntary retirement in conjunction with
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29 253 ankle OA, due to the low number of ankle OA cases among rugby players. However mental and physical
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31 254 health scores in football and rugby due to forced retirement is presented separately in Table 5.
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Table 5: Post-Hoc analysis regarding mental and physical quality of life of recently retired football and rugby players who reported to have been forced to retire, and quality of life of players who reported to have been forced to retire with ankle OA compared to players without ankle OA

	PROMIS mental health (median; IQR; min-max)	p-value	PROMIS physical health (median; IQR; min-max)	p-value
<i>Total</i>				
<i>Voluntarily retired*</i> (n = 369)	53; 48-56; 31-68*		54; 48-58; 30-68*	
<i>Forced to retire*</i> (n = 168)	48; 44-53; 28-68*	p < 0.001	48; 42-51; 27-68*	p < 0.001
<i>Voluntarily retired with OA* (n = 30)</i>	51; 46-53; 36-63		51; 45-54; 35-62*	
<i>Voluntarily retired without OA* (n = 339)</i>	53; 48-59; 31-68	p = 0.074	54; 48-58; 30-68*	p = 0.001
<i>Forced to retire with OA (n = 14)</i>	48; 46-55; 31-63		42; 40-46; 37-58	
<i>Forced to retire without OA (n = 154)</i>	48; 44-53; 28-68	p = 0.841	48; 42-52; 27-68	p = 0.159
<i>Football*</i>				
<i>Voluntarily retired*</i> (n = 272)	53; 48-56; 31-68*		54; 48-58; 30-68*	
<i>Forced to retire*</i> (n = 113)	48; 44-53; 31-63*	p < 0.001	48; 42-51; 27-62*	p < 0.001
<i>Rugby*</i>				
<i>Voluntarily retired*</i> (n = 97)	53; 48-56; 31-68*		54; 48-58; 35-68*	
<i>Forced to retire*</i> (n = 55)	48; 44-56; 28-68*	p = 0.018	48; 37-54; 30-68*	p < 0.001

*Statistically significant difference; Abbreviations: IQR = Interquartile range; OA = Osteoarthritis; n = number

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260 **Discussion**

261 Our most important findings were that (i) the prevalence of ankle OA among former professional
262 football and rugby players was, 9.2% (95%CI 6.4 –12.1) and 4.6% (95%CI (1.2 – 8.0), respectively; (ii)
263 previous severe ankle injuries and ankle surgeries are associated with ankle OA among former
264 professional football players; and (iii) ankle OA does not lead to reduced mental or physical QoL in
265 former professional football and rugby players.

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267 **Ankle OA in football and rugby compared to other sports and the general population**

268 Several studies have reported symptomatic ankle OA prevalence among a variety of former elite
269 athletes, ranging from 0% in volleyball (n = 22), long distance running (n = 30), elite high-jump (n = 30)
270 and ballet (n = 27) to 10% among former military parachutists (n = 40).^{27–31} In our study, the prevalence
271 of ankle OA among former professional football (9.2%) and rugby players (4.6%) was higher than the
272 estimated prevalence among the general population (3.4 %).¹² Murray et al. (2018) invited participants
273 with self-reported ankle pain (11.7%) from the general population for a radiograph (radiological atlas of
274 Foot OA).^{12,32}

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276 Our study reports a lower ankle OA prevalence compared to previous studies among former
277 professional football players (12-19%).^{13–15} In these studies, data was similarly collected using cross-
278 sectional retrospective self-reported questionnaires.^{13,14} No previous data is available concerning ankle
279 OA among former professional rugby players. The low ankle OA prevalence among rugby players in this
280 study is likely due to either an under reporting of ankle OA among rugby players or a type II error.

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282 ***Association of severe ankle injuries and ankle surgeries with ankle OA***

283 In our study, football players were 1.3 (95%CI: 1.1 - 1.6) and 2.1 (95%CI: 1.4 – 3.1) times more likely to
284 develop ankle OA for every ankle injury and ankle surgery, respectively. This is in line with previous

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3 285 studies that showed an association between ankle OA and ankle injuries, stating traumatic ankle injuries
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5 286 to be the main cause of ankle OA (70-78%).^{6,7} Consequences of ankle injuries are thought to be due to
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7 287 either direct damage the articular surfaces or change in ankle joint biomechanics (e.g. through chronic
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9 288 ankle instability due to ankle ligament damage).³³ No association was seen for severe ankle injuries or
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11 289 ankle surgeries and ankle OA among rugby players. Although the best estimate for the association of
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13 290 ankle surgeries and OA is similar to football (OR = 2), the 95%CI includes 1 (0.8 – 4.7). This may be due
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15 291 to insufficient power among rugby players, as only 7 reported ankle OA.
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21 293 ***Health-related quality of life***

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23 294 Filbay et al. (2019) reported factors such as age, type of sport (contact/collision sports), OA and
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25 295 involuntary retirement from sport to possibly negatively impact QoL.^{26,34–36} However the positive
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27 296 impacts associated with elite sport participation, such as pride of accomplishments, social network
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29 297 (through sport participation) and coping and adjustment to musculoskeletal pain (due to resilience and
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31 298 determination), may persist and even compensate reduced physical QOL beyond retirement of the
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33 299 player's athletic career.³⁴
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39 301 Our post-hoc sub-analysis revealed 29% of football players and 36% of rugby players were forced to
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41 302 retire. Although we reported several instances of statistically significant differences in our study for both
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43 303 physical and mental PROMIS health scores, all were similar to the estimated norm for the general
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45 304 population (50 points). Unfortunately, there is no robust minimally clinically important difference
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47 305 (MCID) threshold for the PROMIS-10 global short form applicable for this population. Consequently, it is
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49 306 difficult to interpret the results. Nevertheless, although statistically significant, the PROMIS mental and
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51 307 physical health scores observed, for both football and rugby players, are unlikely clinically significant.
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3 308 Based on our data, ankle OA does not lead to reduced mental or physical QoL in former professional
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5 309 football and rugby players.
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10 311 ***Strengths and limitations***

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12 312 We had an overall good response rate (56%) and a large group of participating football players (401).

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14 313 However, several limitations should be mentioned. Firstly, this study had a cross-sectional design,

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16 314 therefore no causal-association can be determined. Secondly, there were only 7 rugby players with OA,

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18 315 implying a potential serious type II error. Thirdly, recruitment procedures were blinded to the research

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20 316 team, a non-response analysis could not be performed. Fourthly, research based (retrospective)

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22 317 questionnaires are dependent on the accuracy and understanding of the participant. Professional

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24 318 athletes might generally remember the number of severe ankle injuries or surgeries resulting in a

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26 319 training or match absence of ≥ 4 weeks. However, we cannot exclude that participants were not able to

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28 320 precisely recall all their sustained severe ankle injuries and ankle surgeries or that they did not consult

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30 321 their most recent medical professional. Finally, our OA definition did not include a clinical and

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32 322 radiological evaluation.
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37 324 ***Implications for practice***

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39 325 The epidemiological data from this study regarding ankle OA prevalence among former professional

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41 326 football and rugby players, and its association with both severe ankle injuries and ankle surgeries, is an

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43 327 essential part of protecting the athlete's health. In both professional football and rugby, a higher

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45 328 prevalence of ankle OA can be expected compared to the general population. Furthermore, As the

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47 329 majority are post-traumatic, preventive measures and adequate rehabilitation are recommended.

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49 330 Awareness should be raised, regarding the increased risk of developing ankle OA following each ankle

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51 331 injury and surgery. Additionally primary and secondary prevention programmes should be implemented.
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3 332 Exercise based prevention intervention programs, such as the FIFA11+ in football and the movement
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5 333 control injury prevention programme in rugby, have found reduced ankle injury incidence and
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7 334 burden.^{37,38} Finally, management of ankle OA is key for retired players, focusing on healthy lifestyle
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10 335 including physical activity, pain alleviation, function and minimising disability.³⁹⁻⁴¹ With this intention,
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12 336 FIFPRO has developed an "After Career Consultation".⁴² Future studies will evaluate its relevance.
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14 337

16 338 **Conclusion**

18 339 This cross-sectional study found an athlete reported ankle OA prevalence of 9.2% and 4.6% among
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20 340 recently retired professional football and rugby players, respectively. Severe ankle injuries and ankle
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22 341 surgeries were associated with a higher prevalence of ankle OA in former professional football players.
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24 342 No clinically relevant differences in QoL were reported in players with OA compared to players without
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26 343 OA. As a higher prevalence of ankle OA can be expected in both professional football and rugby
27
28 344 compared to the general population, and the majority are post-traumatic, primary and secondary
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30 345 preventive measures for ankle injuries and an optimal diagnosis and treatment plan are recommended.
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34 346

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43 350

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47 352 Authorship was determined according to the ICMJE authorship recommendations. All authors (LP, HA,
48
49 353 SK, ML, CR, KS, WV, GR, JT, GK, VG) were involved in the design of the study, data analysis and
50
51 354 data interpretation. VG and GK were responsible for data collection. LP drafted the manuscript, with
52
53 355 critical review provided by all authors (LP, HA, SK, ML, CR, KS, WV, GR, JT, GK, VG). All
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3 356 authors approved the final version of the manuscript (LP, HA, SK, ML, CR, KS, WV, GR, JT, GK,
4
5 357 VG).

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19 363 **Competing interests**

20
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26 366 **Ethics approval**

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28 367 Ethical approval for the study was provided by the Ethical Committee of the Yokohama City Sports

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30 368 Medical Center (17.003; Yokohama, Japan) and the Medical Ethics Review Committee of the Academic

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32 369 Medical Center (W16_366#16.431; Amsterdam, The Netherlands)

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37 371 **Data sharing statement**

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39 372 No additional data available

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract – ✓ (b) Provide in the abstract an informative and balanced summary of what was done and what was found – ✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported – ✓: p. 4 line 64 – 96
Objectives	3	State specific objectives, including any prespecified hypotheses – ✓: p. 4 line 98 – 104
Methods		
Study design	4	Present key elements of study design early in the paper – ✓: p. 6 line 108 – 114
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection – ✓: p. 6 line 116 – 133
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants – ✓: p. 6 line 116 – 133
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – ✓: p. 6 line 135 – 159
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group – ✓: p. 6 line 161 – 172
Bias	9	Describe any efforts to address potential sources of bias – ✓: p. 6 line 117
Study size	10	Explain how the study size was arrived at – ✓: p. 6 – 7 line 130 – 133
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why – ✓: p. 8-9 line 175 – 188
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses – ✓: p. 8-9 line 175 – 188
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed – ✓: p. 10 line 192 – 196 (b) Give reasons for non-participation at each stage – ✓: p. 10 line 192 – 196 (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders – ✓: p 11 table 1 (b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures – ✓: p 11 – 14, table 2 -4
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included – ✓: p 11 – 14, table 2 -4 (b) Report category boundaries when continuous variables were categorized

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(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses – √: p 15, line 227 – 237 + p 16 table 5
Discussion		
Key results	18	Summarise key results with reference to study objectives – √: p 17, line 242 - 245
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias – √: p 3, line 53 - 62
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence – √: p 19 - 20, line 293 - 317
Generalisability	21	Discuss the generalisability (external validity) of the study results p 19 - 20, line 293 - 305
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based p 21, line 339 - 340

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.