Injury incidence, characteristics and burden among female sub-elite futsal players: A prospective study with three-year follow-up

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The main purpose of the current study was to analyze the injury incidence, characteristics and burden among sub-elite female futsal players. Individual exposure to match play and training, injury incidence and characteristics (player position, injury mechanism, type of injuries, severity of injuries, recurrent versus new injuries, season variation of injury pattern) in a female futsal team were prospectively recorded for three consecutive seasons (2015-2018). Incidences were calculated per 1000 hours of exposure. A total of 30 injuries were reported during the three seasons within a total exposure of 4446.1 hours. The overall, match and training incidence of injuries were 6.7, 6.4 and 6.8 injuries/1000 hours of exposure, respectively. Most injuries had a non-contact mechanism (93%), with the lower extremity being the most frequently injured anatomical region (5.62 injuries/1000 hours of exposure). The most common type of injury was muscle/tendon (4.9 injuries/1000 hours of exposure) followed by joint (non-bone) and ligament (1.3 injuries/1000 hours of exposure). The injuries with the highest injury burden were those that occurred at the knee (31.9 days loss/1000 hours exposure), followed by quadriceps (15.3 day loss/1000 hours) and hamstring (14.4 day loss/1000 hours) strains. The first few weeks of competition after pre-season and soon after the Christmas break were the time points when most injuries occurred. These data indicate that sub-elite female futsal players are exposed to a substantial risk of sustaining an injury. To reduce overall injury burden, efforts should be directed toward the design, implementation and assessment of preventative measures that target the most common diagnoses, namely, muscle/tendon and ligament injuries.

1 **TITLE PAGE**

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23 **Abstract**

24 The main purpose of the current study was to analyze the injury incidence, characteristics and

25 burden among sub-elite female futsal players. Individual exposure to match play and training,

26 injury incidence and characteristics (player position, injury mechanism, type of injuries, severity

27 of injuries, recurrent versus new injuries, season variation of injury pattern) in a female futsal

28 team were prospectively recorded for three consecutive seasons (2015-2018). Incidences were

29 calculated per 1000 hours of exposure. A total of 30 injuries were reported during the three

30 seasons within a total exposure of 4446.1 hours. The overall, match and training incidence of

31 injuries were 6.7, 6.4 and 6.8 injuries/1000 hours of exposure, respectively. Most injuries had a

32 non-contact mechanism (93%), with the lower extremity being the most frequently injured

33 anatomical region (5.62 injuries/1000 hours of exposure). The most common type of injury was

34 muscle/tendon (4.9 injuries/1000 hours of exposure) followed by joint (non-bone) and ligament

35 (1.3 injuries/1000 hours of exposure). The injuries with the highest injury burden were those that

36 occurred at the knee (31.9 days loss/1000 hours exposure), followed by quadriceps (15.3 day

37 loss/1000 hours) and hamstring (14.4 day loss/1000 hours) strains. The first few weeks of

38 competition after pre-season and soon after the Christmas break were the time points when most

39 injuries occurred. These data indicate that sub-elite female futsal players are exposed to a

40 substantial risk of sustaining an injury. To reduce overall injury burden, efforts should be

41 directed toward the design, implementation and assessment of preventative measures that target

42 the most common diagnoses, namely, muscle/tendon and ligament injuries.

43 **Key words:** epidemiology, injury surveillance, muscle/tendon injuries, injury patterns,

44 prevention.

1. Introduction

45

46 Futsal, the five-a-side version of associated football, is played worldwide with more than one

47 million registered players all over the world (FIFA, 2007; Gorostiaga et al., 2009; Beato et al.,

48 2017). Futsal requires players to perform on a reduced (usually indoor) pitch size (40 x 20 m)

49 and during two x 20 min periods (with time stopping at every dead ball and unlimited

50 substitutions) a high number of repeated high intensity multiplanar movements such as sudden

51 acceleration and deceleration, rapid changes of direction, tackling and kicking (Castagna et al.,

52 2009; Beato, Coratella & Schena, 2016; Naser, Ali & Macadam, 2017). At top levels, the

53 combination of these repeated high intensity movements that are performed during training and

54 match play alongside current congested training and competitive calendars and exposure to

55 contacts might place futsal players at high risk of injury. However, prior to implementing injury

56 prevention programmes into everyday futsal training routines, it is essential to establish the

57 extent of the problem in terms of the incidence and characteristics of injuries (van Mechelen,

58 Hlobil & Kemper, 1992; Finch, 2006; Van Tiggelen et al., 2008).

59 Despite being one of the most played sport in several countries, a limited number of prospective

60 epidemiological studies have been published investigating injuries sustained by elite futsal

61 players (mainly during match play) (Ribeiro, Oliveira & Costa, 2006; Junge & Dvorak, 2010;

62 Angoorani et al., 2014; Hamid, Jaafar & Ali, 2014; Álvarez Medina et al., 2016). These studies

63 have reported incidence rates for male players ranging from 3.5 to 89.9 injuries per 1000 h of

64 match play, most of them affecting the lower extremity with contusions of the lower leg and

65 ankle sprains the most frequently diagnosed types of injury (Ribeiro, Oliveira & Costa, 2006;

66 Junge & Dvorak, 2010; Angoorani et al., 2014; Hamid, Jaafar & Ali, 2014; Álvarez Medina et

67 al., 2016; Larruskain et al., 2018). However, it should be noted that among these epidemiological

68   studies, only two (Angoorani et al., 2014; Hamid, Jaafar & Ali, 2014) have reported incidence

69   data of female futsal players. Angoorani et al. (2014) showed an incidence rate in female players

70   of 10.7 injuries per 1000 h of match play during camps with the Iran national team (18 months of

71   follow-up), whereas Hamid et al. (2014) found an incidence rate of 19.7 injuries per 1000 h of

72   match play during the Malaysian national futsal league. In both studies, ankle sprains and

73   ligament ruptures were the most observed injuries, similar to what has been observed in other

74   team sports such as football (Hägglund, Waldén & Ekstrand, 2009; Asker et al., 2018), handball

75   (Asker et al., 2018) and rugby (Peck et al., 2013). It is likely that the anatomical, hormonal and

76   neuromuscular sex-related differences (among other factors) may contribute to sex-specific

77   differences in injury incidence. Furthermore, only Angoorani et al. (2014) provided injury

78   incidence rates during training in male and female futsal players, reporting an incidence of 1.8

79   and 3.1 injuries per 1000 h of exposure, respectively. As the training volume (Almeida et al.,

80   1999) and the number of hours of high intensity training (Brooks et al., 2008) have been

81   significantly correlated with an increased risk of sustaining non-contact injuries in team sports

82   (mainly attributed to an acute and/or cumulative fatigue state), knowing the injury incidence

83   rates during futsal training may help coaches and physical trainers to identify if the training load

84   and content allows players to recover fully from match demands. None of the studies that have

85   provided epidemiological data of futsal-related injuries in male and female players have

86   calculated the injury burden (the product of severity [consequences] and incidence [likelihood])

87   and/or built a risk matrix. A risk matrix is a graph of injury severity plotted against injury

88   incidence with criteria incorporated into the graph for evaluating the level of risk, usually by

89   dividing the graph into some risk areas using descriptive or quantified incidence, severity and

90   risk evaluation categories (Fuller, 2018).

91   Consequently, there is a clear need for more prospective epidemiological studies that inform

92   about injury incidence and burden in female futsal players. Identifying the most common and

93   burdensome futsal-related injuries, as well as how (traumatic or overuse) and when (matches or

94   training sessions) they usually occur would lead coaches, physical trainers and physiotherapists

95   to prioritise the application of specific measures to prevent or reduce the risk of sustaining such

96   injuries. Therefore, the main purpose of the current study was to analyze the injury incidence,

97   characteristics and burden among sub-elite female futsal players during three consecutive

98   seasons.

99

2. Method

2.1 Participants

102   All female sub-elite futsal players from the same team that were playing in the Spanish second

103   division were prospectively followed during three consecutive seasons (2015/16, 2016/17 and

104   2017/18) which covered the period between September and May. Twenty-two different female

105   futsal players participated in this study. However, as some players remained in the team for more

106   than one season, the total number of player seasons was 39 (2015/16: 14 players followed,

107   2017/17: 13 players followed, 2017/18: 12 players followed). All players had more than 5 years

108   of futsal experience. The team finished all three seasons in the top 10 of the league (4st, 6st and

109   9st). All players were verbally informed about the study procedures and provided written

110   informed consent. For players younger than 18 years old (n = 3), written informed consent was

111   also obtained from their parent or legal guardian. Players who left the team during the season

112   (e.g. due to transfer) were included in the analysis according to their time on the team. The

113   experimental procedures used in this study were in accordance with the Declaration of Helsinki

114   and were approved by the University Office for Research Ethics (*Órgano evaluador de*

115   *proyectos, Universidad Miguel Hernández de Elche*) (DPS.FAR.02.14).

116

2.2 Data collection

118   The study design and data collection followed both the consensus on definitions and data

119   collection procedures for studies of football injuries outlined by the Union of European Football

120   Associations (UEFA) (Hägglund, Waldén & Bahr, 2005) and the consensus document for

121   football injury surveillance studies (Fuller et al., 2006). An injury was defined as any physical

122   complaint sustained by a player that resulted from a futsal match or futsal training and where the

123   player was unable to participate in a match or training sessions on the day after the injury (time-

124   loss injury) (Fuller et al., 2006). The day on which an injury occurred was day 0 and was not

125   counted when determining the severity of an injury. If a player had to stop training or

126   participating in a match because of injury on 1 day but could participate the next day, the time

127   loss was recorded as zero days.

128   The club's medical staff (which remained the same for all three seasons), diagnosed, treated and

129   recorded all time-loss injuries on a standardised injury report form that was sent to the study

130   group each month. Specifically, the team was supported by one certified medical doctor, one

131   physical trainer and one physiotherapist. The doctor was the member of the medical staff who

132   assessed and diagnosed injured players through the use of clinical judgements (e.g.: physical

133   examination, posture and gait inspection, inspection and palpation of muscle bellies, etc.).

134   Diagnostic imaging techniques (e.g.: echography, magnetic resonance imaging and ultrasound

135   imaging) were also applied when it was needed. Although early treatment actions were delivered

136   as soon as possible when a player sustained an injury during training or competition, the initial

137   assessment and diagnosis were often carried out within 12 hours to 4 days post-injury as some

138   signs of injury may arise a few hours or days later (Askling, Tengvar, Saartok & Thorstensson,

139   2007). The physiotherapist administered the therapeutic exercises during the first stages of the

140   rehabilitation process. The physical trainer was responsible for introducing injured players to the

141   drills and skills that would be required to return to full participation in training and to be

142   available for match selection. A futsal player was considered injured until the medical staff

143   (upon agreement) allowed full participation in training and they were eligible for match play.

144   For all injuries that satisfied the inclusion criteria (time-loss injury), team medical staff provided

145   the following details to investigators: date of injury, moment (training or competition), player

146   position (goalkeeper or field player [lastwoman, wing or pivot]), injury mechanism (traumatic

147   [contact or non-contact] or overuse), injury location, type of injury (the specific injury diagnosis

148   was also recorded), extremity of the injury (dominant/non dominant), injury severity based on

149   lay off time (0 days [when a player could not participate fully on the day of an injury but was

150   available for full participation the next day], minimal [1-3 days], mild [4-7 days], moderate [8-28

151   days], severe [>28 days] and career ending injury), whether it was a recurrence or new injury and

152   total time taken to resume full training and competition. Illnesses and any physical or mental

153   complaint that did not result from a futsal match or training were excluded. Individual player

154   exposure time in training and matches (friendly and competitive) were recorded daily in minutes

155   by the physical trainer.

156   The operational definitions adopted by this study have been widely followed by both football and

157   futsal epidemiological studies (Hägglund, Waldén & Ekstrand, 2009; Junge & Dvorak, 2010;

158   Ekstrand et al., 2013; Hamid, Jaafar & Ali, 2014; Larruskain et al., 2018) and they are displayed

159   in Appendix A1.

160   Those players who were already injured when the follow up process started (September 2015)

161   were included in this study once medical staff agreed return to training and availability for match

162   selection. Those individuals who were still injured at the end of the study period were included

163   in the statistical analyses, and the estimated duration of the recovery period was established after

164   discussion with the respective medical staff. As a medical history based on information from the

165   player may be confounded by recall bias, previous injuries of those players who were recruited to

166   the team after the study started were not included unless an accurate and detailed description of

167   them were provided in the form of a report or standard form and signed by either a certified

168   medical doctor or a former physiotherapist.

169   Demographic information such as stature, body mass, and age were collected during the last

170   week of the preseason period (which was before the start of the season).

171   **2.3 Data Analysis**

172   Descriptive data are presented as a mean with the corresponding standard deviation (SD),

173   proportions (%), incidence rates and 95% confidence intervals (CI). The overall injury incidence,

174   match injury incidence, and training injury incidence were the number of injuries divided by

175   1000 player-hours in total, match, and training, respectively. For incidence rates, 95% CIs were

176   calculated as the incidence ±1.96 times the square root of the number of injuries divided by the

177   number of participants. The injury burden was calculated as the number of lay-off days/1000 h.

178   (Bahr, Clarsen & Ekstrand, 2017) Player overall hours were calculated by adding match and

179   training hours. Player match hours were calculated by multiplying total number of matches in the

180   season per five players per match duration (40 minutes with stopped clock)/60, and player

181   training hours were calculated by adding individual training hours (warm up of the matches was

182   not included). All of the analyses were performed using the PASW statistical package, version

18.0 (SPSS Inc., Chicago, IL, USA), with $p < 0.05$ considered statistically significant. A post-

184 hoc power analysis was conducted using the software package, G * Power 3.1.2 (Faul et al.,

185 2007; Erdfelder et al., 2009) The sample size of 39 was used for the statistical power analyses.

186 The alpha level used for this analysis was $p < 0.05$. The post-hoc analyses revealed the statistical

187 power for this study was 0.74. It could be concluded that the given sample size was large enough

188 to detect significant effects.

189 The spreadsheet designed by Hopkins (2007) for combining effect statistics was used to make

190 clinically (qualitative) inference for paired-comparisons between incidence rates. In particular,

191 the incidence rate ratio (and its associated confidence limits) was assessed against predetermined

192 thresholds. Thus, an incidence rate ratio of 0.91 represented a substantially lower injury risk,

193 while an incidence rate ratio of 1.10 indicated a substantially higher injury risk (Hopkins, 2010).

194 An effect was considered unclear if its confidence interval overlapped the thresholds just

195 mentioned; in other words, if the effect could be substantial in both a positive and negative sense.

196 Otherwise the effect was clear and deemed to have the magnitude of the largest observed

197 likelihood value. The following scale was used to qualify with a probabilistic term the magnitude

198 of the observed effect: <0.5 %, most unlikely; 0.5–5 %, very unlikely; 5–25%, unlikely; 25–75

199 %, possible; 75–95 %, likely; 95–99.5 %, very likely; >99.5 %, most likely (Hopkins, 2007).

200 ## 2.4 Study quality assessment

201 The quality of the study was assessed using the "Strengthening the Reporting of Observational

202 Studies in Epidemiology" (STROBE) (von Elm et al., 2014) and the risk of bias of external

203 validity quality, using an adapted version of the Newcastle Ottawa Scale (NOS) (Saragiotto et

204 al., 2014; Videbæk et al., 2015). The study fulfils all the criteria of the STROBE scale except the

205 items 9, 10 and 22 (Appendix A2). Regarding the NOS adapted scale just item 6 was not fulfilled

206 (Appendix A3). Thus, the reporting and external validity quality of the present study could be

207 considered as high according to the qualitative descriptors proposed by von Elm et al. (2014) and

208 Wells et al. (2013) respectively.

3. Results

210 During the three seasons, four players dropped out due to transfers to another club or they were

211 released by the club but their injury data were included based on their time at the club. The

212 average duration of each season was 34.3 ± 2.1 weeks with 31 ± 2.7 matches per season and 3.3

213 ± 1.3 trainings sessions per week. Player and team characteristics are presented in table 1.

214

215   ******Table 1 near here******

216

3.1 Overall, match and training incidence

218 A total of 30 injuries were reported in 15 different players during the three seasons (2 match

219 injuries and 28 training injuries) within a total exposure time of 4446.1 h (310 h of match

220 exposure and 4136.1 h of training exposure), which is equivalent to an overall incidence rate of

221 6.75 injuries per 1000 hours of exposure (95% CI = 6.47 to 7.02). One of the injuries was not

222 taken into account due to the player having to retire from sport because of the injury. The match

223 injury rate was similar (no statistically [$p > 0.05$] and clinically irrelevant [very likely trivial]

224 differences) to the training injury rate (6.45, 95% CI = 6.38 to 6.52 vs 6.77, 95% CI = 6.50 to

225 7.04 /1000 h) and 38% (15/39) of players sustained at least one injury during the three seasons.

226 Players sustained 0.77 injuries per season on average, which is equivalent to 10 injuries per

227 season for a squad of 13 players.

228   The injury incidence and characteristics of the injuries during the three seasons are shown in

229   table 2.

230

231   ******Table 2 near here******

232

233   3.2 Injury characteristics

234   3.2.1 Player position

235   Lastwomen (3.37, 95% CI = 2.74 to 4.01 /1000 h) incidence rate was most likely higher (100%

236   likelihood) than wings (2.02, 95% CI = 1.57 to 2.48 /1000 h), goalkeepers (0.90, 95% CI = 0.34

237   to 1.46 /1000 h) and pivots (0.45, 95% CI = 0.05 to 0.85 /1000 h). Wings had a very likely

238   higher incidence rate (96.6% likelihood) than goalkeepers and most likely higher (100%

239   likelihood) than pivots. Finally, goalkeepers had a likely higher incidence rate (76.6%

240   likelihood) than pivots.

241   3.2.2 Injury mechanism

242   Two out of three injuries were due to trauma and one out of three injuries was due to overuse.

243   The incidence rate of traumatic injuries was most likely higher (100% likelihood) than overuse

244   injuries (4.5, 95% CI = 4.27 to 4.72 vs 2.25, 95% CI = 2.09 to 2.41 /1000 h). Most injuries were

245   caused by non-contact situations (93%), with only 7% of injuries occurring during contact

246   situations.

247   3.2.3 Injury location

248   Table 3 shows the injury location and type of injury per season. Lower extremity injuries (5.62

249   per 1000 hours of exposure, 95% CI = 5.37 to 5.87) were the most frequently injured location,

250   followed by upper limb injuries (0.67 per 1000 hours of exposure, 95% CI = 0.59 to 0.76), and

251   then trunk injuries (0.45 per 1000 hours of exposure, 95% CI = 0.38 to 0.52). No head and neck

252   injuries were reported. The lower extremity region predominantly injured was the thigh (3.37 per

253   1000 hours of exposure, 95% CI = 3.18 to 3.57), followed by the ankle (0.90 per 1000 hours of

254   exposure, 95% CI = 0.8 to 1.0), with the knee, hip/groin and lower leg/Achilles tendon regions

255   demonstrating the same incidence rate (0.45 per 1000 hours of exposure, 95% CI = 0.38 to 0.52).

256   No foot/toe injuries were reported. In terms of paired-comparisons, thigh injuries occurred more

257   frequently (100% likelihood) than injuries in other lower extremity regions. Ankle injury rates

258   were most likely higher (100% likelihood) than knee, hip/groin and lower leg/Achilles tendon

259   injuries. There were no meaningful differences between the remaining paired combinations.

260

261   ****Table 3 near here****

262

263   3.2.4 Type of injuries

264   The mean incidence of injury type grouping is presented per 1000 hours of exposure with 95%

265   CIs. Most injuries were diagnosed as muscle/tendon injuries (4.95, 4.71 to 5.18), followed by

266   joint (non-bone) and ligament (1.35, 1.23 to 1.47), and fractures and bone stress and contusions

267   with the same injury incidence (0.22, 0.17 to 0.28). No central/peripheral nervous system injuries

268   and skin lesions were recorded. The most common injury types were hamstring muscle injuries

269   (1.80 per 1000 hours of exposure, 95% CI = 0.66 to 1.94), followed by quadriceps muscle

270   injuries (1.57 per 1000 hours of exposure, 95% CI = 1.44 to 1.71), ankle sprains (0.90 per 1000

271   hours of exposure, 95% CI = 0.8 to 1.0) and anterior cruciate ligament tears (0.45 per 1000 hours

272   of exposure, 95% CI = 0.38 to 0.52). Muscle/tendon injury incidence rates were most likely

273   higher than other types of injury rates (100% likelihood). Likewise, joint (non-bone) and

274   ligament incidence rate were most likely higher (100% likelihood) than fractures, bone stress and

275   contusions.

276   **3.2.5 Severity of injuries**

277   Concerning the severity of injuries, moderate injuries (2.70 per 1000 hours of exposure, 95% CI

278   = 2.52 to 2.87) were the most usual injuries, followed by minimal and mild injuries (1.80 per

279   1000 hours of exposure, 95% CI = 1.66 to 1.94), and finally severe and career ending injuries

280   (0.22 per 1000 hours of exposure, 95% CI = 0.17 to 0.28). No 0 days injuries were recorded.

281   Comparisons between each severity level showed that the moderate injury incidence rates were

282   most likely higher (100% likelihood) than other severities. Minimal and mild injury incidence

283   rates were most likely higher (100% likelihood) than severe and career ending injuries.

284   The recorded overall time-loss injuries was 429 days, so overall injury burden during the three

285   seasons was 96.5 days loss/1000 hours exposure (58.1 in matches and 99.4 in trainings). Figure 1

286   shows a quantitative risk matrix illustrating the relationship between the severity and incidence

287   of the most common reported injuries For each injury type, severity is shown as the average

288   number of days lost (log scale), while incidence is shown as the number of injuries per 1000

289   hours of total exposure for each injury type. The shading illustrates relative importance of each

290   of the injury types; the darker the colour, the greater the injury burden, and the greater the

291   priority should be given to prevention. Furthermore, lastwomen and pivots showed the highest

292   injury burden (40.9 and 33.3 days loss/1000 hours exposure) compared to goalkeepers and wings

293   (7.9 and 14.4 days loss/1000 hours exposure). On the other hand, muscle/tendon injuries and

294   joint (non-bone) and ligament injuries showed similar injury burden (44.98 and 49.48 days

295   loss/1000 hours exposure) although their overall incidence was significantly different. Regarding

296   injury location, the knee showed a significantly higher injury burden (31.9 days loss/1000 hours

297   exposure) compared to the rest of the lower extremity muscle groups (ankle: 17.5; quadriceps:

298   15.3; hamstring: 14.4; hip/groin: 5.8 and lower leg/Achilles tendon: 4.0).

299

300   ****Figure 1 near here****

301

302

303   **3.2.6 Recurrent injuries**

304   The incidence rate of new injuries (5.62 per 1000 hours of exposure, 95% CI = 5.37 to 5.87) was

305   most likely higher (100% likelihood) than recurrent injuries incidence rate (1.12 per 1000 hours

306   of exposure, 95% CI = 1.01 to 1.24). One-fifth of the overall injuries were recurrent injuries; of

307   these, 20% of injuries were classified as "early recurrence" (within 0-2 months); 60% of injuries

308   were classified as "late recurrence" (2-12 months); and 20% of injuries were classified as

309   "delayed recurrence" (>12 months) (Fuller et al., 2007). The most common recurrent injury was

310   quadriceps and hamstring strains. Regarding injury burden, new injuries had a significantly

311   higher injury burden compared to recurrent injuries (86.4 vs 1.1 days lost/1000 hours exposure).

312   **3.2.7 Season variation of injury pattern**

313   Figure 2 illustrates monthly distribution of injuries, both overall, during training and match over

314   the three seasons. The highest incidence of injuries was observed in October (1.35 per 1000

315   hours of exposure, 95% CI = 1.23 to 1.47). Training and match number of injuries follow a

316   similar trend, in which the risk of injuries was higher in the early stages of the season and post

317   winter/Christmas break.

318

319   ****Figure 2 near here****

320

4. Discussion

322 The overall, training and match incidence rates reported in the current study were comparable to

323 those found in the only study (to the authors´ knowledge) that has provided three incidence rates

324 separately in a cohort of 17 female futsal players (Angoorani et al., 2014) (4.7, 3.1 and 10.7

325 injuries per 1000 h of exposure to overall, training and match play, respectively). Conversely, the

326 match injury incidence reported in the current study (6.4 injuries per 1000 h of match play) is

327 lower than that reported by Hamid et al. (Hamid, Jaafar & Ali, 2014) in the Malaysian female

328 futsal league (29.6 injuries per 1000 h of exposure to match play). An explanation of this

329 discrepancy may be attributed to the more congested competitive calendar in the study carried

330 out by Hamid et al. (Hamid, Jaafar & Ali, 2014) compared to our study. Thus, while in their

331 study the Malaysian league had a duration of approximately 22 weeks (1st July until 28th

332 November) with a break in August (because of fasting during Ramadan) and one or two matches

333 per week, the three seasons (2015-2018) of the Spanish second division analyzed in the current

334 study lasted eight months (average of 34.3 ± 2.1 weeks) with two breaks periods of 2-3 weeks (at

335 Christmas and Easter) with one match played per week (usually at the weekend days). This

336 hypothesis may be supported by evidence from prospective epidemiological studies carried out

337 in elite male futsal players (Ribeiro, Oliveira & Costa, 2006; Junge & Dvorak, 2010) and football

338 players (Dvorak et al., 2011; Junge & Dvořák, 2015) during international tournaments (i.e.

339 World cups) which have shown higher incidence rates in comparison with those conducted

340 during national league futsal (Hamid, Jaafar & Ali, 2014; Álvarez Medina et al., 2016) and

341 football (Noya Salces et al., 2014; Stubbe et al., 2015). This is likely due to the higher match

342 demands during international tournaments with relatively shorter recovery times between

343   matches. These tournaments also tend to occur at the end of long competitive league seasons

344   where accumulated fatigue may also be a factor in the higher incidence rates.

345   Unlike data from other team sports (regardless of the sex of the players) [i.e. football, (Giza et

346   al., 2005; Waldén, Hägglund & Ekstrand, 2007) basketball (Borowski et al., 2008), netball

347   (Best, 2017)] where match injury incidence is always notably higher (almost ten times) than the

348   injury rate obtained for training sessions, in our study both incidence rates were similar. The

349   latest trends in strength and conditioning for team sports have suggested that training session

350   design (i.e. work-load, intensity, duration), when possible, should mimic match demands so that

351   players are better prepared for what they face during matches (Gabbett, 2016). Perhaps, the

352   training sessions designed by the team staff might have included a large number of repeated

353   high-intensity actions (e.g. accelerations and decelerations, changes of direction) in order to

354   replicate the evolving nature of the futsal game. However, an excessive training load and/or an

355   insufficient recovery of previous efforts might have forced players to perform some of these

356   highly demanding training sessions under suboptimal states of readiness and this could have

357   potentially increased the risk of injuries (mainly muscle-tendon and ligament injuries) (Gabbett,

358   2004). To determine whether or not futsal players are in an optimal state of readiness for the

359   stress that will be a priori elicited by training, it is advisable to monitor daily training load

360   (internal and external) and strain, wellbeing and recovery status from previous efforts and also

361   include regular physical performance tests as a component of the training program (Bouaziz et

362   al., 2016; Elloumi, Makni, Moalla, Bouaziz, Tabka, Lac, Chamari, 2012). This information

363   might help coaches and physical trainers to constantly re-adjust the design of the training

364   sessions throughout the season so that the physical and psychological demands that will be

365   imposed on the players do not negatively affect their optimal readiness to re-perform.

366   When exploring differences in playing position on incidence rates our data from the goalkeepers

367   and outfield player's differed from the findings previously reported by Hamid et al. (2014) Their

368   study, also in female futsal players, showed a higher incidence rate in goalkeepers but we found

369   outfield players showed higher incidence and higher amount of days off per injury than

370   goalkeepers. Our findings are similar to that which has been reported in other team sports such as

371   handball (Tsigilis & Hatzimanouil, 2005) and football (Mallo et al., 2011; Falese, Della Valle &

372   Federico, 2016). It is difficult to prescribe a reason for the discrepancy between the findings of

373   Hamid et al. (Hamid, Jaafar & Ali, 2014) and our current study. However, it might be due to the

374   fact that outfield players need to perform a larger number of repeated high intensity multiplanar

375   movements that occur every few seconds (Dogramaci & Watsford, 2006), which may place

376   outfield players at a higher risk of injury than goalkeepers.

377   Previous studies have indicated that a large percentage of injuries in male futsal players (Ribeiro,

378   Oliveira & Costa, 2006; Junge & Dvorak, 2010) are caused by contact trauma, however the

379   current study demonstrates that most injuries sustained by female players are due to non-contact

380   trauma (>90%). Our results are in agreement with the study of Angoorani's et al. (2014) and

381   might be partly attributed to the fact that both studies included training injury incidence data,

382   something that other studies have failed to do. Furthermore, the higher number of high intensity

383   phases observed in elite male players during the course of futsal play (Carling et al., 2015;

384   Naser, Ali & Macadam, 2017) might contribute to generate more tackling situations and partially

385   explain the fact that males suffer more contact injuries than females.

386   With respect to the location of futsal-related injuries, and similar to previous studies in male

387   (Ribeiro, Oliveira & Costa, 2006; Junge & Dvorak, 2010; Álvarez Medina et al., 2016) and

388   female futsal players (Angoorani et al., 2014; Hamid, Jaafar & Ali, 2014), lower extremity

389   injuries were, by far, the most frequent injuries (83.3% of all the injuries recorded). The thigh

390   (50% of all the injuries recorded) was the anatomical region of the lower extremity where

391   injuries occurred significantly more followed by the knee (6.7% of all the injuries recorded) and

392   ankle (6.7% of all the injuries recorded). Furthermore, the most common type of injury grouping

393   was muscle/tendon injuries followed by joint (non-bone) and ligament injuries. As futsal is a

394   fast-paced game relying mostly on the lower extremity for ball control, involving sprinting and

395   frequent changes in direction such observations were anticipated. In football, it has been

396   demonstrated that player match availability has a strong correlation ($r > 0.85$) with team success

397   (i.e. ranking position, games won, goals scored, total points) (Eirale et al., 2013; Hägglund et al.,

398   2013; Carling et al., 2015). If this statement also holds for futsal, then injury prevention

399   measures should focus not just on reduction of the incidence of the most frequent injuries but

400   also on reduction of the injuries with the highest burden (e.g. those injuries that keep players out

401   of training and match play the longest) (Bahr, Clarsen & Ekstrand, 2017) . According to the

402   results found in this study, knee and thigh injuries are those with the highest injury burden with

403   31.9 and 29.7 days of absence per 1000 player hours, respectively. In particular, medical and

404   fitness staff should implement measures mainly aimed (but not solely) at reducing the number

405   and severity of anterior cruciate ligament (ACL) and hamstring and quadriceps muscle injuries.

406   It should be noted that one player from the team had to retire from futsal due to an ACL rupture,

407   which was not included in the injury burden calculation as the number of days lost were not

408   defined. This reinforces the need to deliver targeted interventions aimed at reducing this

409   devasting and relatively frequent (two cases in the three seasons recorded in our study for a

410   single team) type of injury in female athletes. It should be also highlighted that the overall (31.7

411   days) and training (30 days) injury burdens of the last season analyzed (2017/18) were

412 significantly lower than those obtained for the two previous seasons (overall = 155.3 [2015/16]

413 and 108.4 [2016/17] days; training = 165.6 [2015/16] and 108.0 [2016/17] days). Perhaps, the

414 fact that during the three seasons that were object of study the club kept the same medical staff

415 and head coach may have been a factor that may explain in part this circumstance. In this sense,

416 and similar to what was found in previous studies (Ekstrand et al., 2018; Lausic et al., 2009), the

417 potential and gradual improvement in the quality of the internal communication not only within

418 the members of the medical staff but also between the medical staff and the coach that might

419 have occurred throughout the three consecutive seasons may have had a positive impact on the

420 players´ availability for futsal play in the last season. In fact, according to Ekstrand, et al. (2018),

421 the measures designed to reduce the injury burden in elite teams should not only address the

422 traditionally proposed modifiable injury risk factors [e.g. eccentric strength deficits (Croisier et

423 al., 2008; Petersen et al., 2011; van Dyk et al., 2016), poor neuromuscular control (Lees &

424 Nolan, 1998; Hewett et al., 2005), altered muscle architecture (Lees & Nolan, 1998; Arnason et

425 al., 2004; Timmins et al., 2016), player load and match frequency (Rahnama et al., 2003;

426 Miloski, Freitas & Barra-Filho, 2012) but also some new external factors such as job security

427 and club stability and players adherence and coaches compliance to the injury prevention

428 programs applied. The inclusion of updated and evidence-based advancements in factors related

429 to injury management (including diagnosis techniques, treatment approaches and monitoring

430 tools) might also have a positive impact on the injury burden.

431 As expected, new injury rates were higher than recurrent injury incidence rates (5.6 vs. 1.1

432 injuries per 1000 h). However, the recurrent rate identified in the present study may be

433 considered high. It was found that 20% of recurrent injuries (mainly lower extremity muscle and

434 tendon injuries) occurred within 2 months after return to play. This may be regarded as a sign of

435   premature return to train/play and incomplete or inadequate rehabilitation. The lack of and

436   evidence-based criteria for a safe return to train/play may have resulted in letting injured players

437   return to play sooner than recommended. This may have been due to the desire to let them play

438   in important matches or to let them play with ongoing minor symptoms, and this might be two

439   primary reasons behind the high recurrent injury incidence rate. Future studies should extend our

440   current knowledge further in relation to the improvement of the decision-making process for a

441   safe return to train/play by developing learning algorithms or artificial intelligence-based models

442   that allow the identification of when a player is successfully rehabilitated before returning to

443   train/play. Furthermore, medical and fitness team staff should allow players enough time for

444   rehabilitation before return to train/play.

445   Regarding the moment when most injuries took place, the findings indicates that there are two

446   periods when they are more likely to occur, October and January-February. The higher amount

447   of injuries during October may be explained by the fact that within the pre-season period the

448   training loads are much higher than during the competitive period (Miloski, Freitas & Barra-

449   Filho, 2012) and accumulating fatigue may increase the injury risk during the first weeks of

450   competition. Petersen et al. (2010). reported a higher incidence in the two months after the winter

451   break (January-February) which is consistent with the results of the present study.

452   **4.1 Limitations**

453   Despite being one of the first prospective studies that has analysed the incidence rates and

454   characteristics of futsal related injuries in female players, some limitations must be considered.

455   The sample size of players and injuries is small, and results should be cautiously interpreted

456   (especially the incidence rates reported for specific and less frequent injuries). The analysis of

457   only one team limits the external validity of the results. Consequently, it is unknown if female

458   players from other teams in which there could be a higher (or lower) medical staff-to-player ratio

459   or access to other staff (such as strength and conditioning coaches, psychologists and

460   nutritionists) may show similar injury incidence rates and characteristics than those reported in

461   the current study. Even though all female players had sub-elite status, most of them had jobs

462   besides futsal that could alter their risk of injury and recovery time, for example, by preventing

463   them from training or taking full advantage of medical treatment. Therefore, future studies are

464   needed in order to analyze if elite female futsal players on full-time (professional) contracts may

465   show different injury incidence rates, characteristics and burden.

466   **5.   Conclusions**

467   Sub-elite female futsal players (particularly outfield players) are exposed to a substantial risk of

468   sustaining injuries. Most injuries had a non-contact mechanism, with the lower extremity the

469   most frequently injured anatomical region. Knee (anterior cruciate ligament tears) and thigh

470   (hamstring and quadriceps muscle strains) injuries are those with the highest injury burden.

471   Special attention should be given to the first weeks of competition after pre-season and soon

472   after the Christmas break as incidence rates peak during this period in female futsal players.

473   Medical and fitness team staff should focus their attention on designing, implementing and then

474   evaluating preventative measures that target the most common diagnoses, namely, ligament and

475   muscle/tendon injuries highlighted in this study, as well as making sure that return to train/play

476   criteria are in place in order to reduce the injury burden within female sub-elite futsal players.

477

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483

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488

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683

Figures legend

686 Figure 1. Quantitative risk matrix of injuries, illustrating the relationship between the severity

687 (consequence) and incidence (likelihood) of the most common injuries.

688 Figure 2. Distribution of total injury incidence.

689

690

Appendices legend

692 Appendix A1. Definitions used in the study. Injury definitions.

693 Appendix A2. Description of the 22 of STROBE Statement—checklist of items that should be included in

694 reports of observational studies.

695 Appendix A3: Description of the 8 criteria designed to assess risk of bias of external validity quality in the

696 studies. This instrument is an adapted version of the Newcastle Ottawa Scale (NOS) for cohort studies.

697

698

Figure 1

Quantitative risk matrix of injuries, illustrating the relationship between the severity (consequence) and incidence (likelihood) of the most common injuries.

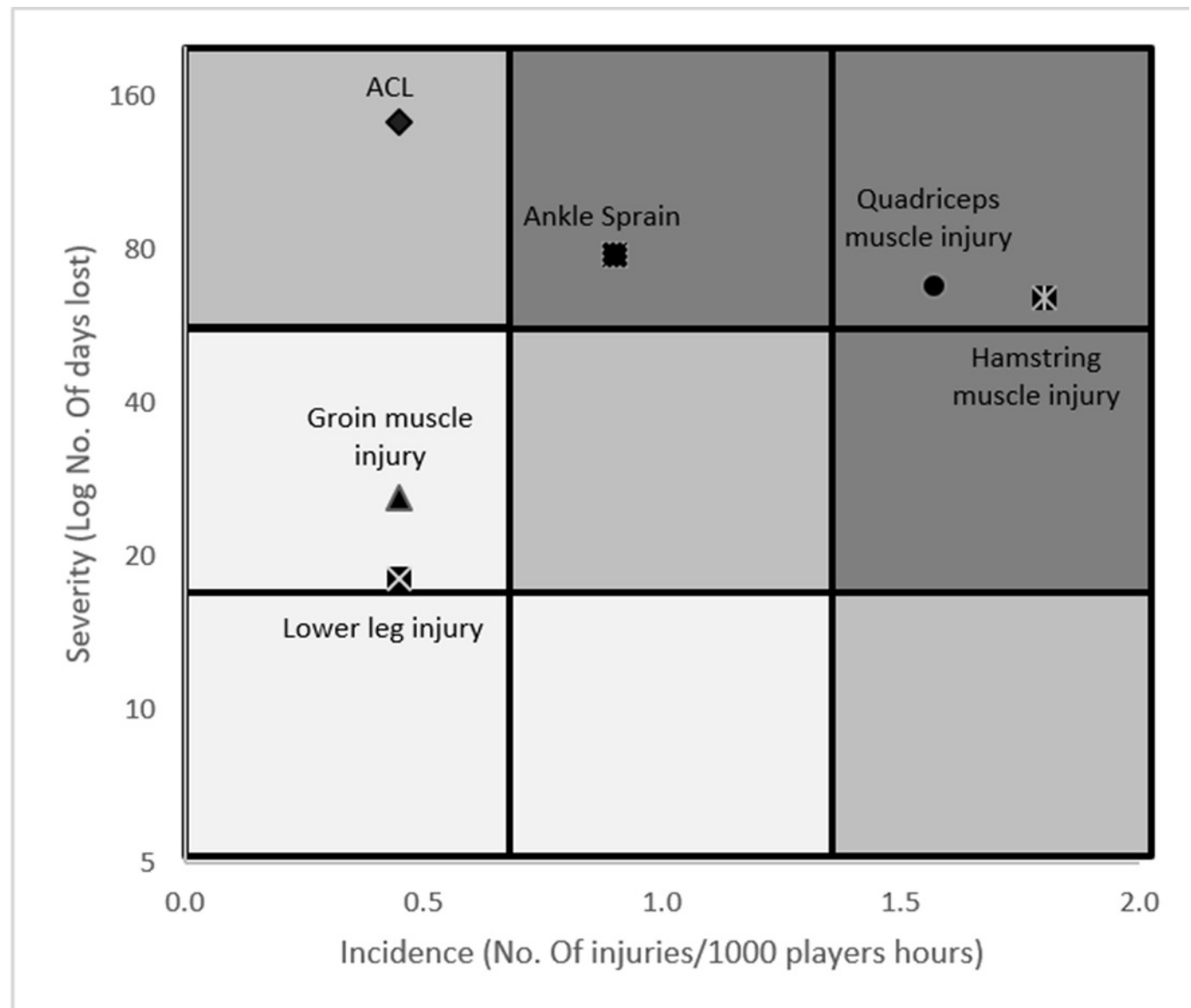
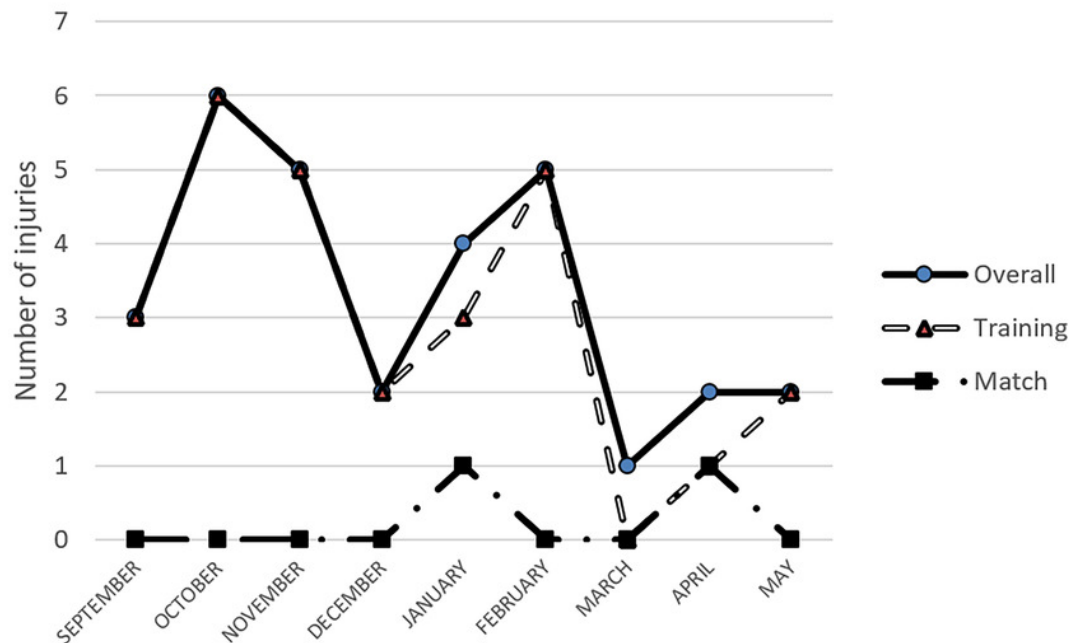



Figure 2

Distribution of total injury incidence

Distribution of total injury incidence

Players and team characteristics and exposure time.

h: hours; a: match hours/total hours of exposure. Values are mean ± SD.

Table 1. Players and team characteristics and exposure time.

	Season 15/16	Season 16/17	Season 17/18	Total	Mean
Team size	14 (14)	13 (12)	12 (9)	39 (35)	13 ± 1
Age (years)	23.8 ± 2.9	24.2 ± 4.1	24.2 ± 4.8	-	24.1 ± 3.9
Height (cm)	1.65 ± 0.05	1.65 ± 0.04	1.65 ± 0.04	-	1.65 ± 0.04
Body mass (kg)	60.4 ± 5.1	62.3 ± 7.4	61.9 ± 7.4	-	61.5 ± 6.6
Weeks of follow-up	32	35	36		34.3 ± 2.1
Exoposure					
Total h	1506.7	1328.78	1610.7	4446.1	1482.1 ± 142.6
Training h	1413.3	1222.1	1500.7	4136.1	1378.8 ± 142.5
Match h	93.3	106.7	110	310	103.3 ± 8.8
Training sessions/week	4 ± 0.3	3.2 ± 0.7	3.8 ± 0.5	-	3.7
Matches/week	0.875	0.914	0.917	-	0.903
Match exposure ratio	0.062	0.080	0.068	-	0.070
Days of absence due to the injury	234	144	51	429	143 ± 91.5

h: hours; a: match hours/total hours of exposure.
Values are mean ± SD.

Table 2. Injury incidence

CI: Confidence interval

1   Table 2. Injury incidence

Injuries	Season 15/16 Number (%)	Incidence (95%CI)	Injury Burden n	Season 16/17 Number (%)	Incidence (95%CI)	Injury Burden n	Season 17/18 Number (%)	Incidence (95%CI)	Injury Burden	Total Number (%)	Incidence (95%CI)	Injury Burden n
Overall	8	5.31 (4.9-5.71)	155.3	12	90.3 (8.51-9.55)	108.4	10	9.09 (8.93-9.25)	31.7	30	6.75 (6.47-7.02)	96.5
Training	8 (100)	5.66 (5.26-6.06)	165.6	11 (91.7)	9.00 (8.50-9.50)	108.0	9 (90)	6.00 (5.51-6.49)	30.0	28 (93.3)	6.77 (6.50-7.04)	99.4
Match	0 (0)	0	0	1 (8.3)	9.38 (9.22-9.53)	112.5	1 (10)	6.21 (5.69-6.73)	54.5	2 (6.7)	6.45 (6.38-6.52)	58.1
Mechanism												
Traumatic training	5 (62.5)	3.32 (3.01-3.63)	145.4	8 (66.7)	6.02 (5.59-6.45)	87.3	7 (70)	4.35 (3.91-4.78)	16.1	20 (66.7)	4.50 (4.27-4.72)	82.1
Traumatic match	0 (0)	0	0	1 (8.3)			1 (10)			2 (6.7)		
Overuse training	3 (37.5)	1.99 (1.75-2.23)	10	4 (33.3)	3.01 (2.71-3.31)	21.1	3 (30)	1.86 (1.58-2.15)	15.5	10 (33.3)	2.25 (2.09-2.41)	14.4
Circumstance												
Contact	0 (0)	0	0	0	0	0	2 (20)	1.24 (1.01-1.47)	5.6	2 (6.7)	0.45 (0.38-0.52)	2
Non-Contact	8 (100)	5.31 (4.91-5.71)	155.3	12 (100)	9.03 (8.51-9.55)	108.4	8 (80)	4.97 (4.50-5.43)	26.1	28 (93.3)	6.30 (6.03-6.56)	94.5
Recurrence												
No	8 (100)	5.31 (4.91-5.71)	155.3	9 (75)	6.02 (5.59-6.45)	82.0	8 (80)	4.97 (4.50-5.43)	25.5	25 (83.3)	5.62 (5.37-5.87)	86.4
Yes	0 (0)	0	0	3 (25)	2.26 (2.00-2.52)	26.3	2 (20)	1.24 (1.01-1.47)	6.2	5 (16.7)	1.12 (1.01-1.24)	10.1
Early	0 (0)	0	0	1 (33.3)	0.75 (0.60-0.90)	12.0	0 (0)	0	0.0	1 (20)	0.22 (0.17-0.28)	3.6
Late	0 (0)	0	0	2 (66.7)	1.51 (1.29-1.72)	14.3	1 (50)	0.62 (0.46-0.78)	1.9	3 (60)	0.67 (0.59-0.76)	4.9
Delayed	0 (0)	0	0	0	0	0	1 (50)	0.62 (0.46-0.78)	4.3	1 (20)	0.22 (0.17-0.28)	1.6
Severity												
0 days	0 (0)	0	0	0 (0)	0	0	0 (0)	0	0	0 (0)	0	0
Minimal (1-3 days)	1 (12.5)	0.66 (0.52-0.80)	2.0	2 (16.7)	1.51 (1.29-1.72)	4.5	5 (50)	3.10 (2.74-3.47)	6.8	8 (26.7)	1.80 (1.66-1.94)	4.5
Mild (4-7 days)	2 (25)	1.33 (1.13-1.53)	8.0	2 (16.7)	1.51 (1.29-1.72)	9.0	4 (40)	2.48 (2.16-2.81)	13.0	8 (26.7)	1.80 (1.66-1.94)	10.1
Moderate (8-28 days)	4 (50)	2.65 (2.37-2.93)	51.1	7 (58.3)	5.27 (4.87-5.67)	94.8	6 (60)	0.62 (0.46-0.78)	11.8	12 (40)	2.70 (2.52-2.87)	49.9
Severe (>28 days)	1 (12.5)	0.66 (0.52-0.80)	94.2	0 (0)	0	0	0 (0)	0	0	1 (3.3)	0.22 (0.17-0.28)	31.9
Career ending	0 (0)	0	0	1 (8.3)	0.75 (0.60-0.90)	-	0 (0)	0	0	1 (3.3)	0.22 (0.17-0.28)	-
Position												
Goalkeeper	2 (25)	1.33 (0.40-2.25)	16.6	2 (16.7)	1.51 (0.12-2.89)	7.5	0 (0)	0	0	4 (13.3)	0.90 (0.34-1.46)	7.9
Lastwoman	4 (50)	2.65 (1.67-3.63)	40.5	7 (58.3)	5.27 (3.97-6.56)	77.5	4 (40)	2.48 (1.50-3.46)	11.2	15 (50)	3.37 (2.74-4.01)	40.9
Wing	0 (0)	0	0	3 (25)	2.26 (1.58-2.94)	23.3	6 (60)	3.73 (2.52-4.93)	20.5	9 (30)	2.02 (1.57-2.48)	14.4

| Pivot | 2 (25) | 1.33 (0.40-2.02) | 98.2 | 0 (0) | 0 | 0 | 0 (0) | 0 | 0 | 2 (6.7) | 0.45 (0.05-0.85) | 33.3 |

2   CI: Confidence interval.

Injury characteristics and incidence according location and type of injury

CI: Confidence interval.

Table 3. Injury characteristics and incidence according location and type of injury.

Injury location	Season 15/16			Season 16/17			Season 17/18			Total		
	Number (%)	Incidence (95%CI)	Injury Burden	Number (%)	Incidence (95%CI)	Injury Burden	Number (%)	Incidence (95%CI)	Injury Burden	Number (%)	Incidence (95%CI)	Injury Burden
Upper limbs	1 (12.5)	0.66 (0.52-0.80)	14.6	0 (0)	0	0	2 (20)	1.24 (1.01-1.47)	2.5	3 (10)	0.67 (0.59-0.76)	5.8
Shoulder/clavicula	0 (0)	0	0	0 (0)	0	0	1 (10)	0.62 (0.46-0.78)	0.6	1 (3.3)	0.22 (0.17-0.28)	0.2
Hand/finger/thumb	1 (12.5)	0.66 (0.52-0.80)	14.6	0 (0)	0	0	1 (10)	0.62 (0.46-0.78)	1.9	2 (6.7)	0.45 (0.38-0.52)	5.6
Trunk	1 (12.5)	0.66 (0.52-0.80)	2.0	0 (0)	0	0	1 (10)	0.62 (0.46-0.78)	2.5	2 (6.7)	0.45 (0.38-0.52)	0.7
Lower back/pelvis/sacrum	1 (12.5)	0.66 (0.52-0.80)	2.0	0 (0)	0	0	1 (10)	0.62 (0.46-0.78)	2.5	2 (6.7)	0.45 (0.38-0.52)	0.7
Lower limbs	6 (75)	3.98 (3.64-4.33)	138.7	12 (100)	9.03 (8.51-9.55)	108.4	7 (70)	4.35 (3.91-4.78)	26.7	25 (83.3)	5.62 (5.37-5.87)	90.0
Hip/groin/adductor	0 (0)	0	0	1 (8.3)	0.75 (0.60-0.90)	16.6	1 (10)	0.62 (0.46-0.78)	2.5	2 (6.7)	0.45 (0.38-0.52)	5.8
Thigh	3 (37.5)	1.99 (1.75-2.23)	22.6	7 (58.3)	5.27 (4.87-5.67)	48.9	5 (50)	3.10 (2.74-3.47)	20.5	15 (50)	3.37 (3.18-3.57)	29.7
Hamstrings	1 (12.5)	0.66 (0.52-0.80)	10.0	5 (41.7)	3.76 (3.43-4.10)	33.1	2 (20)	1.24 (1.01-1.47)	3.1	8 (26.7)	1.80 (1.66-1.94)	14.4
Quadriceps	2 (25)	1.33 (1.13-1.53)	12.6	2 (16.7)	1.51 (1.29-1.72)	15.8	3 (30)	1.86 (1.58-2.15)	17.4	7 (23.3)	1.57-1.44-1.71	15.3
Knee	1 (12.5)	0.66 (0.52-0.80)	94.2	1 (8.3)	0.75 (0.60-0.90)	0	0 (0)	0.0	0	2 (6.7)	0.45 (0.38-0.52)	31.9
Lower leg/Achilles tendon	1 (12.5)	0.66 (0.52-0.80)	4.0	1 (8.3)	0.75 (0.60-0.90)	9.0	0 (0)	0.0	0	2 (6.7)	0.45 (0.38-0.52)	4.0
Ankle	1 (12.5)	0.66 (0.52-0.80)	17.9	2 (16.7)	1.51 (1.29-1.72)	33.9	1 (10)	0.62 (0.46-0.78)	3.7	4 (13.3)	0.90-(0.80-1.00)	17.5
Injury type												
Fracture and bone stress	0	0	0	0	0	0	1 (10)	0.62 (0.46-0.78)	1.9	1 (3.3)	0.22 (0.17-0.28)	0.7
Fracture	0	0	0	0	0	0	1 (10)	0.62 (0.46-0.78)	1.9	1 (3.3)	0.22 (0.17-0.28)	0.7
Joint (non-bone) and ligament	3 (37.5)	1.99 (1.75-2.23)	126.8	2 (16.7)	1.51 (1.29-1.72)	21.1	1 (10)	0.62 (0.46-0.78)	0.6	6 (20)	1.35 (1.23-1.47)	49.5
Sprain/Ligament injury	3 (37.5)	1.99 (1.75-2.23)	126.8	2 (16.7)	1.51 (1.29-1.72)	21.1	1 (10)	0.62 (0.46-0.78)	0.6	6 (20)	1.35 (1.23-1.47)	49.5
Muscle and tendon	5 (62.5)	3.32 (3.01-3.63)	28.5	10 (83.3)	7.53 (7.05-8)	87.3	7 (70)	4.35 (3.91-4.78)	25.5	22 (73.4)	4.95 (4.71-5.18)	45.0
Muscle rupture/tear/strain/cramps	4 (50)	2.65 (2.37-2.93)	24.6	9 (75)	6.77 (6.32-7.23)	74.5	7 (70)	4.35 (3.91-4.78)	25.5	20 (66.7)	4.5 (4.27-4.72)	39.8
Tendon injury/rupture/tendinosis/bursitis	1 (12.5)	0.66 (0.52-0.80)	4	1 (8.3)	0.75 (0.60-0.90)	12.8	0	0	0	2 (6.7)	0.45 (0.38-0.52)	5.2

1   CI: Confidence interval.