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1 **Noncontact injury distribution and relationship with preseason training load and non-**
2 **modifiable risk factors in Rugby Union players across multiple seasons.**

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23 **Running title:** Preseason training load and injury risk Rugby Union.

24

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Noncontact injury distribution and relationship with preseason training load and non-modifiable risk factors in Rugby Union players across multiple seasons.

26 **ABSTRACT**

27 The study examined the distribution of noncontact injury during phases of the competitive
28 season and the association between preseason training load (TL) and non-modifiable risk
29 factors on injury risk during these phases. Injury data was recorded from one senior academy
30 team over 3 seasons (2017-2020) and analysed across early, mid and late-season phases. A
31 Generalized Estimating Equation was used to model risk factors with noncontact injury for
32 selected phases. The highest noncontact injury incidence occurred in the late-season phase
33 (22.2 per 1000 hours) compared to early (13.7 per 1000 hours, $p < 0.001$) and mid-season
34 phases (15.5 per 1000 hours, $p = 0.001$). Low preseason TL (8949-12589 AU; OR, 95% CI =
35 4.7, 1.0-21.6; $p = 0.04$) and low preseason TL combined with high early-season TL and injury
36 in the early-season phase (OR, 95% CI = 6.5, 1.1-35.5; $p = 0.03$) were associated with greater
37 mid-season noncontact injury risk. Additionally, low preseason TL combined with previous
38 injury was associated with increased risk of noncontact injury risk in the late season (OR, 95%
39 CI = 12.2, 0.9-15.6, $p = 0.05$). Our results suggest players are at a greater injury risk during the
40 late season phase, with low preseason cumulative loads combined with a history of previous
41 injury associated with increased in-season injury risk. Strength and conditioning coaches
42 should therefore monitor cumulative preseason TL alongside screening for previous injury
43 history to identify athletes at greater risk of noncontact injury risk during the competitive
44 season.

45
46

47 **Key words:** training demands, team sports, athlete monitoring, injury history, under-training

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49

50

51 INTRODUCTION

52 Rugby Union is a team sport characterised by frequent collisions and intense running and has
53 a relatively high-risk of injury particularly during match-play (43). Matches generally last ~80
54 minutes and include activities that call for maximal strength and power interspersed with
55 periods of lower intensity aerobic activity and rest (32). Given the physical demands of the
56 sport, there is a strong training emphasis, particularly during the preseason phase where
57 practitioners have more time and flexibility with respect to training prescription. Preseason
58 training in Rugby Union typically comprises of a 6 to 8-week intensified training period with
59 the primary aim of promoting adaptation to enhance performance in preparation for the
60 competitive season (38). An additional premise of preseason training is that adaptation during
61 this phase has a protective effect against injury during the season. As such a notable body of
62 recent research has examined the link between injury risk and training load, defined as the
63 cumulative stress placed on an individual from a single or multiple training sessions over a
64 period of time. Although the existence of a relationship between training load and injury is
65 supported in the literature, the factors that influence the direction of this relationship are not
66 clear (15).

67

68 Injury risk across the competition spectrum in Rugby Union is considered high in comparison
69 with other team sports (17, 33, 41). Mean injury incidence during match-play is reported as 87
70 injuries per 1000 hours equating to approximately one injury per match, with on average 25
71 days lost per injury (40). Despite contact injuries being the most prevalent in Rugby Union,
72 their cause is unpredictable in nature. Therefore, much of the research on the relationship
73 between training and injury has focused on noncontact injuries. These injuries account for
74 approximately 20% of total injuries in Rugby Union and are considered somewhat preventable
75 with the correct management of training load. Recent systematic reviews confirm that an

76 association between training load and injury exists in the literature (12, 15, 27). Nevertheless,
77 this relationship has variously been described as direct, inverse, and U-shaped; seemingly
78 dependent on the timing and metric of training load used (15). Within the body of recent
79 research, many authors have examined the effect of shorter periods of cumulative training load
80 on injury in subsequent weeks during the competitive season (6, 23). Surprisingly, little
81 research has focused on the influence of cumulative preseason training load on injury risk
82 within the competitive season. The limited findings available suggest that greater preseason
83 training frequency is associated with a decreased in-season injury risk in Rugby League players
84 (45) and low preseason cumulative workloads are associated with increased in-season injury
85 risk in Australian Rules Football (10). Although these findings are suggestive of an upper and
86 lower threshold of preseason training, beyond which injury risk may increase, caution must be
87 taken due to differences in training related metrics adopted. Treating training load as an isolated
88 risk factor of injury may also be a limited approach. Recent commentaries have demonstrated
89 the non-linear nature of injuries, and that their complex nature commonly arises from an
90 interaction between modifiable (e.g., training load) and non-modifiable risk factors (e.g., age,
91 sport, previous injury history) which when combined have the potential to predispose an athlete
92 to injury (5).

93

94 Considering that one of the primary goals of preseason training is to reduce injury risk, there
95 is currently a paucity of research focusing on the association of cumulative preseason training
96 load on injury risk during the competitive season, particularly when modelled alongside other
97 well established non-modifiable injury risk factors. There is also little research in Rugby Union
98 identifying in which phases of the season injury risk is highest. Therefore, the aim of the present
99 study was to examine the distribution of noncontact injury in Rugby Union across the different

100 phases of the season and to examine the relationship between cumulative preseason training
101 load and non-modifiable factors on injury risk within those phases.

102

103 **METHODS**

104 **Experimental Approach to the Problem**

105

106 A three-year prospective observational design was utilized to record noncontact injury during
107 training and match-play in senior academy male Rugby Union players across three competitive
108 seasons. Noncontact injury incidence, calculated per 1000 player-hours, for all seasons
109 combined was compared between phases of the season including preseason (July to late
110 August), early season (September to November), mid-season (December to February) and late
111 season (March to May) to determine injury risk in each phase. Non-modifiable risk factors for
112 injury (age, previous injury, including severity and date of injury) were recorded at the start of
113 each preseason phase. Training load was recorded for each training session and cumulative
114 training loads for each week and phase were calculated in arbitrary units (AU). All data were
115 analysed to examine the association of risk factors with noncontact injury for each phase of the
116 competitive season.

117

118 **Subjects**

119 Data were collected from a male regional senior academy Rugby Union team (N = 51) across
120 their 2017/18 (n = 29), 2018/19 (n = 29) and 2019/20 (n = 32) seasons. Player characteristics
121 were as follows; mean age (25.7 years \pm 4.5), stature (182.4 cm \pm 6.2), and body mass (101.1
122 kg \pm 12.2). Only players who completed the full preseason training phase for this team were
123 included in the analyses. Players were competing in the Welsh Premiership tournament a semi-
124 professional division immediately below the professional tier in Wales. The players were
125 exposed to three full days of training which included skill work and gym sessions lead by a

126 full-time strength and conditioning coach, and two evening rugby-based sessions. League
127 matches were played at the weekends from September until mid-May with full-time
128 physiotherapy provision and match-day doctors. All players provided informed consent prior
129 to participation, and ethical approval was obtained from the Bangor University Ethics
130 Committee.

131

132 **Procedures**

133 Injury definitions and procedures were compliant with the international consensus statement
134 for injury data reporting in Rugby Union (Fuller et al., 2007), carried out by the designated
135 physiotherapist, and collated in an injury coding database (cf, Orchard Sports Injury
136 Classification System; 31). All diagnosed noncontact injuries resulting in time-loss from
137 training and/or matches were recorded for the three seasons and further examined within the
138 phases of the season. Each player was assigned a binary outcome for noncontact injury
139 incidence (yes/no) for each phase of the season for analysis. For the season 2019-20, due to
140 the COVID-19 Global Pandemic, there were no data collected for the late season phase (March-
141 May 2020). Age (classified using z-scores) and previous injury (if a player sustained an injury
142 in the previous season resulting in moderate to severe time-loss) were recorded at the start of
143 every season.

144

145 Training load was quantified using Foster's rating of perceived exertion (RPE) to calculate a
146 session RPE (sRPE) (18). This method calculates the product of the RPE for the session
147 (training or match) and session duration to generate a value for internal training load in arbitrary
148 units (RPE X minutes). Session RPE has been reported in the literature as a valid and reliable
149 measure of internal training load against other internal and external measures and is the metric
150 that shows the strongest association with respect to the relationship between training load and

151 injury (8, 15, 25, 39). RPE values were obtained 30 minutes after completing each session on
152 training days, which has been reported as a sufficient amount of time to enable valid recall of
153 post-session training intensity (20, 35). Individual training load data were routinely collected
154 for each session across the study duration. During the preseason phase players completed 6 to
155 8 training sessions per week (Monday, Tuesday, Thursday and Friday), which reduced to 4 to
156 6 training sessions per week during the competitive season (Monday, Tuesday and Thursday)
157 with matches on Saturday. Training load was recorded for all on-feet (Rugby Conditioning,
158 Rugby, Unit Skills, Speed, Strength and Power) and off-feet (Cross-training e.g., cycle
159 ergometry, water-based recovery sessions) training sessions and matches during the
160 competitive season. If a player sustained a noncontact injury during the study period, their
161 training load was excluded over the period of rehabilitation until they returned to full training.
162 Cumulative preseason training load were calculated at the end of each preseason phase. The
163 classification of preseason cumulative loads from very low to very high were created by z-
164 scores and were referenced to the mean training load (moderate range). The ranges for
165 preseason workload classifications were as follows; very low (≤ -1.00), low (-0.99 to -0.50),
166 moderate (-0.49 to 0.49), high (0.50 to 0.99), and very high (≥ 1.00) (10). In assessing injury
167 risk in the mid-season, the covariate of the athlete's cumulative early season training load was
168 included in the model, and similarly for the late season phase the covariate of their cumulative
169 early and mid-season training load was included.

170

171 **Statistical Analysis**

172 Injury data was collated using an Excel spreadsheet (Microsoft Corporation, (2021), Microsoft
173 Excel Version 16.53) and statistical analysis performed with R Studio software (RStudio
174 (2020): Integrated Development Environment for R. RStudio, PBC, Boston, MA) utilizing the
175 package "geepack". Noncontact injuries per 1000 player-hours were calculated by dividing the

176 total noncontact injuries by the time spent in training or match play (exposure, hours) and
177 multiplied by 1000. General Linear Model was used with Poisson regression analysis to explore
178 the outcome effect of each season phase (early, mid and late) on noncontact injury incidence
179 whilst offsetting for exposure hours. Results are presented as Rate Ratio (RR) with 95%
180 confidence intervals. Cumulative training load 95% confidence intervals were calculated via
181 the Poisson distribution method. To effectively determine the best set of injury risk factors for
182 any given phase of season, mixed model generalized estimating equations (GEE) were used to
183 investigate risk factors for noncontact injuries for each of the respective time periods. GEE
184 modelling accommodates both repeated measures and within subject correlations across the
185 multiple seasons present within the current database and can identify the most relevant
186 combination of fixed and preseason variables for injury risk identification. As injury incidence
187 was a binary response (yes/no), binary logistic regression within the model was used with logit
188 link function. A model output of odds ratios (OR) with $OR > 1.0$ indicative of greater
189 likelihood, whilst $OR < 1.0$ signifies a lesser likelihood for injury. Univariate variables with a
190 significance of $p < 0.2$ were included into the multivariate model, and a significance of $p <$
191 0.05 was accepted.

192

193 **RESULTS**

194 **Training Load and Injury Incidence**

195 Mean training load was highest during the preseason phase compared to early, mid and late
196 season phases. However, game load from matches offset the overall figures during each phase
197 of the competitive season (**Table 1**). Late season noncontact injury incidence was higher than
198 early (RR, 95% CI = 2.5, 1.5-3.98, $p < 0.001$) and mid-season phases (RR, 95% CI = 2.2, 1.4-
199 3.5, $p = 0.001$) (**Table 2**). During the competitive season, lower limb injuries were the most
200 common accounting for 73% of all noncontact injuries across all phases and were higher in the

201 late season phase compared to early and mid-season phases (RR, 95% CI = 2.0, 1.1-3.6, $p =$
202 0.024) (**Table 2**). Muscle and tendon noncontact injuries were the most frequent noncontact
203 injury type for each phase of the season; late season injury rate showed a trend towards being
204 significantly greater than the early season (RR, 95% CI = 1.9, 1.0-3.7, $p = 0.051$).

205

206 **Cumulative Preseason Training Load and Injury Risk in Phases of the Competitive** 207 **Season**

208 When examining preseason data in relation to phase of the competitive season, low cumulative
209 preseason training load (8949-12589 AU) was associated with a higher risk of noncontact
210 injury in the mid-season phase (OR, 95% CI = 4.7, 1.0-21.6, $p = 0.040$) when compared to the
211 reference group (13081-10909 AU) (**Table 3**). Low preseason loads also showed a trend to
212 increase the odds of sustaining noncontact injury by more than tenfold in the late-season phase
213 (OR, 95% CI = 10.2, 0.8-20.9, $p = 0.06$) (**Table 3**).

214

215 **Non-modifiable Injury Risk Factors and Injury Risk in Phases of the Competitive Season**

216 Players between the ages of 25-26 years were at lower risk of sustaining an early season
217 noncontact injury (OR, 95% CI = 0.110, 0.0-1.0, $p = 0.049$; **Table 4**) compared to the reference
218 group (22-24 years). Whereas, sustaining a moderate to severe injury in the preceding season
219 increased noncontact injury risk in the mid-season phase (OR, 95% CI = 2.7, 1.0-6.9, $p = 0.033$)
220 compared to those who did not sustain a previous injury. Injury in the previous season
221 combined with sustaining a preseason injury significantly increased the odds of sustaining a
222 noncontact injury in the early season phase (OR, 95% CI = 4.2, 1.3-13.1, $p = 0.011$) compared
223 to those with no previous injury history (**Table 4**).

224

225 **Multivariate Analysis of Preseason Training Load and Non-modifiable Risk Factors on**
226 **Injury in the Competitive Season.**

227 Combining non-modifiable risk factors and preseason training load parameters into the
228 multivariate risk regression model revealed that low preseason loads in conjunction with
229 sustaining an injury in the early-season phase and high early-season training load increased
230 mid-season noncontact injury risk (OR, 95% CI = 6.5, 1.1-35.5, $p = 0.03$) compared to the
231 reference group. Similarly, low preseason loads combined with moderate to severe injury
232 sustained in the previous season as well as injury in the early season phase increased the risk
233 of noncontact injury risk in the late-season phase (OR, 95% CI = 12.2, 0.9-15.6, $p = 0.05$).

234

235 **DISCUSSION**

236 The aim of this study was to examine the distribution of noncontact injury in Rugby Union for
237 different phases of the season and to examine the relationship between cumulative preseason
238 training load and non-modifiable risk factors on injury within those phases. To our knowledge,
239 this is the first study to investigate the influence of preseason training load alongside non-
240 modifiable risk factors on injury risk in the competitive season in Rugby Union providing a
241 more holistic and realistic examination of injury risk in this sport. The main findings of the
242 study showed that the late-season phase had the highest incidence of noncontact injury
243 compared to both the early- and mid-season phases. In isolation, both a low preseason training
244 load and injury in the preceding season were associated with a higher risk of noncontact injury
245 within the competitive season, particularly in the mid-season phase. When these risk factors
246 were examined in combination, late-season noncontact injury risk was greater with a low
247 preseason training load, an injury in the early-season phase combined with a moderate to severe
248 injury in the previous season. In the mid-season phase the risk of noncontact injury was greater
249 with a low preseason and high early-season training load, combined with sustaining an injury

250 in the early-season phase. These finding suggest that alongside recording established non-
251 modifiable risk factors, strength and conditioning practitioners should emphasize the
252 monitoring of players exposed to a low cumulative training load for the preseason period,
253 particularly those that have sustained an injury in the preceding season, as they may be more
254 prone to noncontact injury during the competitive season.

255

256 The highest incidence of noncontact injury in the current study occurred in the late-season
257 phase (22.2 injuries per 100 player hours), with lower incidence of noncontact injury in the
258 early and mid-season phases (13.7 and 15.5 injuries per 100 player hours, respectively). These
259 findings contrast with others that suggest an early-season bias for injuries in Rugby Union,
260 reporting that the total injury incidence is higher earlier in the playing season (1, 29). From
261 these studies the authors postulated that climatic conditions and the resulting harder pitch
262 conditions at the beginning of the season (September-October) accounted for the increased
263 incidence of injury in the early-season phase. However, it must be noted that many of these
264 studies examining injury distribution have not distinguished between contact and noncontact
265 injuries and have not expressed injury frequency relative to exposure time, which confound
266 injury risk. A possible explanation for our findings that noncontact injury incidence was
267 greater in the late season could be related to an increase in fatigue across the competitive
268 season, which is known to be a risk factor for injury. Injury incidence in Rugby Union is higher
269 towards the latter phases of matches, with increased fatigue as a possible factor for this greater
270 incidence of injury (43). Whether an increase in chronic fatigue was present towards the latter
271 part of the season and contributed to our findings is unclear. Nevertheless, knowledge of the
272 distribution of noncontact injury in different phases of the season is likely useful for
273 practitioners in order to adjust training prescription at key periods of the season. Notably, an
274 additional finding in the current study was that muscle and tendon injuries in the lower limb

275 were the most common noncontact injury. This finding is consistent with many findings from
276 injury surveillance studies suggesting that the lower limb is the most frequent location of
277 noncontact injury in Rugby Union (3, 4, 7, 17, 40, 43).

278

279 The preseason phase is a key period for strength and conditioning practitioners to physically
280 prepare Rugby Union players for the demands of the competitive season. The training loads
281 reported in this study highlight the greater cumulative training load from practice in this period
282 (17131 AU) compared to the competition season (mean of 12693 AU). When classifying
283 players according to their cumulative training load in the preseason period we found that a low
284 cumulative training load (training load between 8949-12589 AU) was associated with
285 subsequent noncontact injury in the competitive season, particularly during the mid-season
286 phase and a trend for increased injury risk in the late season. This is in agreement with other
287 studies that have shown an association between low cumulative training load and greater injury
288 risk in other team sports (10, 11, 24) and Rugby Union specifically (2, 13). Tentatively, it is
289 suggestive that higher preseason training loads may offer a protective effect against injury
290 during the competitive season. However, contrary to our findings, others have found a positive
291 relationship between risk of injury and exposure to higher chronic training load (9, 34). That
292 said, many of these studies examined cumulative training load over 1-3 weeks (9, 6, 22, 34),
293 with others examining the relationship between injury and external training load in the form of
294 high-speed running distances or weekly force load (6, 9). Therefore, comparison between
295 studies is difficult. Although it is possible that our cumulative preseason training load was not
296 enough to enable us to examine the effect of larger training load on injury risk, our range during
297 preseason (12953-21309 AU) was greater than the cumulative preseason training loads
298 previously reported for team sport athletes (22). To clarify the relationship between preseason

299 training and injury risk, further research is required utilizing different training load metrics and
300 injury within the competitive season.

301

302 A well-established linear relationship exists between noncontact injury and age and previous
303 injury (11, 21, 28, 42). In the current study, we did not find a relationship between age and
304 increasing injury risk. However, players between the ages of 25-26 were at a lesser risk of
305 sustaining an injury in the competitive season compared to the younger reference group. This
306 may be associated with greater training age, which has been found to moderate injury risk in
307 team sport (14, 30), with players in their debut years having an increased risk of injury when
308 exposed to sudden increases in training load compared to their older, more experienced
309 counterparts (30). Our findings also indicate a previous moderate to severe injury significantly
310 increases injury risk in the subsequent season. Previous injury is a predominant non-modifiable
311 risk factor for injury across teams sports (11, 21, 28), particularly to the lower body (19, 37).
312 Fulton et al. (2014) noted that this may be attributed to post-injury maladaptive changes in
313 strength, proprioception, and kinematics that increase future injury risk (19). Rehabilitation
314 and screening of injury history during preseason and the competitive season alongside
315 recording playing experience is essential in establishing the risk an individual athlete may have
316 to injury based on their inherent, predisposing factors, and to implement appropriate prevention
317 strategies.

318

319 It is widely accepted that the cause of noncontact injuries is multifactorial in nature (5).
320 Therefore, identifying a combination of injury risk factors, through a multivariate analysis, is
321 most relevant and applicable. In the mid-season phase the odds of a noncontact injury was
322 increased from 4.7 to 6.5 with a combination of a low preseason training load, high early-
323 season training load combined with sustaining an injury in the early-season phase. In the late-

324 season the odds of a noncontact injury was 12.2 with a combination of a low preseason training
325 load, an injury in the early-season phase combined with a moderate to severe injury in the
326 previous season. The current findings from our multivariate analysis further reinforces
327 theorizing that the nature of injuries in sport are complex and multifactorial (5), and that the
328 extent of injuries are not always associated with a single training load value. The magnitude of
329 the effects of cumulative training load is heavily influenced by previous injury history (16),
330 and understanding how these risk factors contribute to injury risk is essential when formulating
331 injury prevention programmes. Enhanced understanding of the characteristics that predispose
332 individuals to further injury is crucial to reduce medical costs and athlete time lost due to injury
333 (36).

334

335 Rapid growth in training load and injury modelling research has led to multiple attempts to
336 explain injury-risk particularly with respect to under-training and over-reaching. Some have
337 suggested that the equivocal findings in the field are due to inadequate statistical analyses that
338 do not account for time-varying variables, recurrent events, or repeated measures (26). In the
339 current study, the use of mixed model generalised estimating equations (GEE) is a strength as
340 it accounts for repeated individual measures across multiple seasons, identifying the optimal
341 combination of non-modifiable and modifiable risk factors. GEE has previously been identified
342 as an appropriate way to model repeated measures within injury risk studies (44), a key
343 component of monitoring athletes across multiple seasons. A limitation to our study was that
344 due to the COVID-19 pandemic, the final season (2019-20) was terminated early in March,
345 therefore data from the late phase of 2019-20 season was not available for analysis. Future
346 research should aim to include within season data across an extended longitudinal period to
347 strengthen the reproducibility of findings. Also, to further enhance the modelling of injury risk
348 associated with training load, more athlete monitoring variables should be incorporated to

349 account fully for the multifactorial nature of sport injuries such as relative strength, subjective
350 data related to fatigue, athlete capacity. Examining the association of these risk factors to
351 specific noncontact injury diagnosis may increase the sensitivity of the model, which will aid
352 in developing specific injury prevention strategies targeting specific locations of injury.
353 Furthermore, future research needs to consider the impact of strength training intensity and
354 volume alongside other factors such as volume of high-speed running and sprinting on injury
355 risk within the competitive season and the impact of the addition or removal of exercises across
356 modalities during the competitive season.

357
358 *Conclusion*

359 In conclusion, based on non-modifiable risk factors of injury and cumulative preseason training
360 load, we identified that athletes exposed to lower cumulative loads in the preseason were at
361 greater risk of noncontact injury in the later stages of competition, with the odds of sustaining
362 an injury increasing when injury in the previous or current season was accounted for. To reduce
363 the risk of noncontact injury, athletes below the moderate range of cumulative training load in
364 the preseason should be closely monitored and prescribed additional training prior to exposing
365 them to greater in-competition workloads. A previous injury alongside lower cumulative
366 training loads in the preseason significantly increased the risk of sustaining in-competition
367 noncontact injury, emphasising the importance of preseason screening to formulate tailored
368 injury prevention programs prior to season commencement.

369

370 **PRACTICAL APPLICATIONS**

371 Strength and conditioning staff and coaches should place emphasis on adequate preparatory
372 loading in the preseason to not only prepare Rugby Union athletes for greater competitive
373 season loads, but also to protect athletes from preventable time-loss injuries during later stages
374 of the season. Identifying players with lower thresholds of preseason loads prior to the

375 commencement of the competitive season can aid practitioners in determining whether an
376 athlete is sufficiently prepared and protected against injury during the competitive season.
377 Preseason screening of previous injury history and possibly training age is an important
378 monitoring component and applying appropriate and specific prehabilitation strategies to
379 reduce the risk of further injury is central to a holistic approach to injury prevention.

380

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385

386

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551 **Table 1** Mean training and game load (95% CI) for each phase of the season.

Phase	Training Load (95% CI)	Game Load (95% CI)	Total Load (95% CI)
Preseason	17131 (12953-21309)	N/A	17131 (12953-21309)
Early Season	11172 (9717-12627)	7877 (4667-11088)	19049 (13464-24634)
Mid-Season	12097 (10909-13285)	5896 (4167-7625)	17993 (13411-22576)
Late Season	14690 (11170-18210)	4608 (3507-5709)	19298 (13876-26211)

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555 **Table 2** Noncontact injury incidence (95% CI) and proportion by location, type and severity
 556 during the competitive season.
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	Early Season			Mid-Season			Late Season		
Noncontact									
Injury	N	Injury Incidence	%	N	Injury Incidence	%	N	Injury Incidence	%
Total	25	13.7 (12.9-14.5)		26	15.5 (14.7-16.3)		34	22.2* (16.3-28.1)	
Location									
Head/Neck	0	0.0 (-)	0	1	0.6 (0.0-2.4)	4	1	0.7 (0.0-2.6)	3
Upper Limb	4	2.2 (0.2-3.7)	16	4	2.4 (0.3-4.3)	15	5	3.3 (0.4-5.5)	15
Trunk	4	2.2 (0.2-3.7)	16	1	0.6 (0.0-2.4)	4	2	1.3 (0.1-3.2)	6
Lower Limb	17	9.3 (5.0-15.7)	68	20	11.9 (7.0-19.4)	77	26	17.0 (10.8-25.4)*	76
Type									
Bone	1	0.5 (0.0-2.3)	4	1	0.6 (0.0-2.4)	4	2	1.3 (0.0-3.2)	6
Joint/Ligament	9	4.9 (1.9-10.5)	36	5	3.0 (0.8-7.7)	19	7	4.6 (1.8-10.5)	21
Muscle/Tendon	15	8.2 (3.9-14.4)	60	20	11.9 (7.0-19.4)	77	25	15.7 (10.1-24.3)	71
Severity									
Minimal	5	2.7 (0.8-7.8)	20	5	3.0 (0.8-7.8)	19	8	5.2 (1.9-10.5)	24
Mild	4	2.2 (0.2-3.7)	16	8	4.8 (1.8-10.4)	31	8	5.2 (1.9-10.5)	24
Moderate	10	5.5 (2.6-11.8)	40	6	3.6 (1.3-9.1)	23	8	5.2 (1.9-10.5)	24
Severe	6	3.3 (0.8-7.7)	24	7	4.2 (1.4-9.2)	27	10	6.5 (3.3-13.1)	29

558 *Significantly different from injury incidence during other phases of the season ($p \leq 0.05$).

559 Severity is grouped by number of days lost from Minimal (1-3), Mild (4-7), Moderate (8-28),
 560 Severe (>28)

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566 **Table 3** Injury risk regression of cumulative preseason load groups (AU) and influence on in-season injury risk.

Cumulative	n	Preseason TL	% Injured	Early Season	<i>p</i> -value	Mid-Season	<i>p</i> -value	Late-Season	<i>p</i> -value
Preseason TL		(AU)		Injury Risk		Injury Risk		Injury Risk	
				OR (95%CI)		OR (95%CI)		OR (95%CI)	
Very Low	17	< 7758	64	0.8 (0.2-3.8)	0.813	1.3 (0.3-5.0)	0.712	0.8 (0.1-5.3)	0.873
Low	14	8949-12589	98	0.4 (0.1-4.1)	0.509	4.7 (1.0-21.6)	0.040*	10.2 (0.8-20.9)	0.061
Moderate	26	13081-20909	55	1 (-)	-	1 (-)	-	1 (-)	-
(reference)									
High	20	21587-25567	70	2.6 (0.7-9.1)	0.101	2.1 (0.6-7.2)	0.229	1.7 (0.3-9.4)	0.599
Very High	14	25824 >	77	2.1 (0.5-8.8)	0.234	2.4 (0.6-9.2)	0.298	1.0 (0.2-5.2)	0.913

567 *Significantly greater risk ($p \leq 0.05$) of noncontact injury compared to the reference group. Abbreviation, TL, training load

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569 **Table 4** Non-modifiable injury risk factor (Age, Previous Injury) regression for each phase of
 570 the season.
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Age (years)	N	Early Season Injury Risk		Mid-Season Injury Risk		Late Season Injury Risk	
		OR	<i>p</i>	OR	<i>p</i>	OR	<i>p</i>
< 20	17	0.6 (0.1-2.4)	0.445	1.3 (0.4-4.8)	0.681	0.7 (0.1-5.0)	0.129
20-21	23	0.9 (0.3-3.2)	0.990	0.8 (0.2-2.8)	0.773	1.3 (0.3-5.4)	0.745
22-24 (reference)	26	1.0	-	1.0	-	1.0	-
25-26	18	0.1 (0.0-1.0)	0.049*	1.2 (0.3-4.3)	0.792	0.9 (0.2-5.5)	0.942
27 >	6	0.4 (0.0-3.8)	0.406	0.9 (0.1-6.3)	0.956	0.1 (0.0-0.3)	0.112
Previous Injury	51	2.1 (0.8-5.7)	0.152	2.7 (1.0-6.9)	0.033*	1.0 (0.3-3.4)	0.971

572 *Significantly greater/reduced risk ($p \leq 0.05$) of noncontact injury compared to the reference
 573 group.
 574