

# Injuries in elite-level women's football—a two-year prospective study in the Irish Women's National League

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We investigated the pattern of injuries in elite-level women's football in Ireland, during a two-season prospective injury surveillance study in the Women's National League (WNL). Seven out of the eight clubs (271 players) in the WNL were followed prospectively during the 2018 and 2019 seasons. The injury incidence rate in matches (19.2/1000 h) was 7.5 times higher than in training (2.5/1000 h). Players, on average, sustained 0.69 injuries per season (266 injuries/383 player seasons), which equates to 15 time-loss injuries per season for a squad of 22 players. The majority of the injuries sustained by players were lower extremity injuries (85%), of which, 46% had a non-contact injury mechanism. Muscle, ligament, and contusion injuries were the most common injury types, while the ankle, knee, and thigh were the most commonly injured body sites. The most common injuries sustained over the two seasons were lateral ankle sprains (13.9%), hamstring strains (12.4%), knee meniscus/cartilage injuries (7.5%), adductor strains (6%), quadriceps strains (4.5%), and ankle contusions (4.5%). The injuries with the highest injury burden were ACL injuries (59 days lost/1000 h), knee meniscus/cartilage injuries (23/1000 h), lateral ankle sprains (21/1000 h), hamstring strains (12/1000 h), MCL sprains (11/1000 h), and quadriceps strains (11/1000 h). There were 8 ACL tears documented over the 2 seasons, which accounted for 28% of all time lost to injury with a mean days lost per injury of 247. We recommend that clubs in the WNL in Ireland should implement injury risk mitigation strategies, with a particular focus on injuries with a high injury burden.

## KEYWORDS

football, soft tissue injuries, sports, sports medicine, women

## 1 | INTRODUCTION

Women's football is now more popular than ever, and a recent Union of European Football Associations (UEFA) report documented a 7.5% increase in the number of registered female players and an 11% increase in the number of

qualified female coaches between 2016 and 2017.<sup>1</sup> It also highlighted a 70% increase in the number of qualified female match officials between 2013 and 2017.<sup>1</sup>

There is evidence that the physical demands of elite-level women's football have increased. FIFA's analysis of the 2019 Women's World Cup in France detailed that

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the distances teams covered in the highest speed zone increased by almost 30% when compared to the 2015 World Cup.<sup>2</sup> As proposed by Meeuwisse et al<sup>3</sup>, frequent exposure to more physically demanding training and match play increases the susceptibility of athletes, and in this case, female football players to injury occurrence.

Several prospective injury surveillance studies have been undertaken in women's national leagues in Germany, Belgium/Netherlands, Nigeria, Norway, Sweden, Trinidad and Tobago and the USA.<sup>4-14</sup> These studies report time-loss match injury incidence rates (IIRs) ranging from 12.5 to 55.5/1000 h and time-loss training IIRs ranging from 1.4 to 10.9/1000 h.<sup>4-13,15</sup> The lower extremity is the most commonly injured body region in elite-level female players, with knee, ankle, and thigh injuries having the highest IIRs.<sup>4-13,15</sup>

Player welfare has been an integral component of the Football Association of Ireland (FAI) Strategic Plan (2016 – 2020).<sup>16</sup> The protection of player health and the prevention of football-related illnesses and injuries are a primary focus for the FAI, with women's football a key pillar of the Strategic Plan (2016 – 2020).<sup>16</sup> To date, no research has been undertaken on elite-level women's football in Ireland. Thus, there is a critical need for research to inform future FAI strategic policies in women's football in Ireland.

We aimed to investigate the pattern of injuries in elite-level women's football in Ireland, by describing the incidence rates, location, type, severity, and burden of injuries incurred during a two-season prospective injury surveillance study.

## 2 | MATERIALS AND METHODS

All 8 Women's National League (WNL) clubs in Ireland were invited to participate in this two-season prospective injury surveillance study. The WNL is the highest level for female football players in Ireland and, although all players are amateur (ie, they receive no payment), is classified as elite-level by UEFA.<sup>12</sup> The competitive season entails an 8-team league, as well as two cup competitions (the FAI Women's Cup and the League Cup). In the league, teams play each other three times, either twice at home and once away, or once at home and twice away. Each team plays 21 games, either 10 home and 11 away, or 11 home and 10 away. The FAI Women's Cup and the League Cup have three rounds each (quarter-final, semi-final, and final). Seven of the eight clubs accepted the invitation to participate (152 players) in the 2018 season. Forty-four players dropped out of the league during the 2018 season and 36 players joined. Seven of the eight clubs agreed to participate (159 players) in the 2019 season. Twenty-eight

players dropped out of the league during the 2019 season and 36 players joined. Data from the players who withdrew their participation in the league were included until the time they withdrew. Five clubs were included in both seasons. One club was included in the 2018 season, but did not agree to participate in the 2019 season. One club was included in the 2018 season but withdrew from the league at the end of season and was replaced with a new club for the 2019 season. Another club did not have the personnel available to record training and match exposure in the 2018 season, but was able to join the study in the 2019 season. The season length in our study was 8 months running from mid-March to early November. In total, 271 players (age=20.86 ± 4.24 years; height=1.67 ± 0.06 m; body mass=63.26 ± 5.85 kg; body mass index=21.20 ± 5.83 kg/m<sup>2</sup>) were included in the analysis over the two seasons (188 players in 2018 and a further 83 players in 2019 who had not participated in the 2018 season) (Table 1). The number of players per club per season is presented in supplementary table A. During the two seasons all matches were played on natural turf surfaces.

All clubs received verbal and written instructions on the study aims, objectives, and methods of data collection in a manual from the principal investigator (DH) during a club visit prior to the 2018 and 2019 seasons. The manual also provided clarity on injury definitions and examples of possible injury scenarios and how they should be recorded. Ethical approval for the study was received from the University College Dublin Human Research Ethics Committee. All players signed informed consent forms to participate in the study. Parents or guardians of players younger than 18 years of age ( $n = 64$ ) provided written informed consent for them.

## 3 | DATA COLLECTION AND DEFINITIONS

Data was collected using injury surveillance forms utilized by UEFA.<sup>17</sup> Player baseline data, including body mass, height, playing position, and dominant kicking leg were recorded by club medical or fitness staff at the start of each season. A member of each club's medical, fitness or coaching staff recorded individual playing time, including friendly, league, cup, international, and college matches on a standardized UEFA exposure form during the whole season.

Training exposure was defined as team-based and individual physical activities under the control or guidance of the team's coaching or fitness staff that were aimed at maintaining or improving players' football skills or physical condition. Match exposure was defined as participation in a WNL or Under-17 National League match (league and

TABLE 1 Player and team characteristics in Ireland WNL 2018 &amp; 2019

	2018 Season	2019 Season	2018 & 2019 Seasons
<b>Player Characteristics</b>			
Total number of players	188	83 <sup>a</sup>	271
Total number of player seasons	188	195	383
Height (m)	1.67 ± 0.06 (1.54-1.83)	1.67 ± 0.06 (1.54-1.83)	1.67 ± 0.06 (1.54-1.83)
Body mass (kg)	63.60 ± 5.60 (51-83)	63.00 ± 6.10 (47-83)	63.30 ± 5.85 (47-83)
Body mass index (kg/m <sup>2</sup> )	21.18 ± 5.93 (19.20-30.86)	21.22 ± 5.76 (16.96-32.87)	21.20 ± 5.83 (16.96-32.87)
Age (years)	21.02 ± 4.16 (15-40)	20.71 ± 4.32 (16-41)	20.86 ± 4.24 (15-41)
Number of players at start of season	152	159	311
Number of players who dropped out during season	44 (23.40) <sup>b</sup>	28 (14.36) <sup>b</sup>	72 (18.79) <sup>b</sup>
Number of players who joined during season	36 (19.15) <sup>c</sup>	36 (18.46) <sup>c</sup>	72 (18.79) <sup>c</sup>
Number of players with 1 injury	60 (31.91) <sup>d</sup>	55 (28.21) <sup>d</sup>	115 (30.03) <sup>d</sup>
Number of players with 2 injuries	19 (10.11) <sup>d</sup>	21 (10.77) <sup>d</sup>	40 (10.44) <sup>d</sup>
Number of players with 3 injuries	13 (6.91) <sup>d</sup>	5 (2.56) <sup>d</sup>	18 (4.70) <sup>d</sup>
Number of players with 4 injuries	3 (1.60) <sup>d</sup>		3 (0.78) <sup>d</sup>
Number of players with 5 injuries	1 (0.53) <sup>d</sup>		1 (0.26) <sup>d</sup>
Total number of players injured	96 (51.06) <sup>d</sup>	81 (41.54) <sup>d</sup>	177 (46.21) <sup>d</sup>
<b>Age Group (years)</b>			
≤20	106 (56) <sup>e</sup>	109 (56) <sup>e</sup>	215 (56) <sup>e</sup>
21-25	54 (29) <sup>e</sup>	47 (24) <sup>e</sup>	101 (26) <sup>e</sup>
26-30	23 (12) <sup>e</sup>	34 (17) <sup>e</sup>	57 (15) <sup>e</sup>
>30	5 (3) <sup>e</sup>	5 (3) <sup>e</sup>	10 (3) <sup>e</sup>
<b>Team Characteristics</b>			
Squad size	21.72 ± 2.24 (17-26)	23.24 ± 3.26 (19-33)	22.48 ± 2.89 (17-33)
<b>National Team Players</b>			
Ireland under 17	9 (4.78) <sup>f</sup>	8 (4.10) <sup>f</sup>	17 (4.44) <sup>f</sup>
Ireland under 19	33 (17.55) <sup>f</sup>	24 (12.31) <sup>f</sup>	57 (14.88) <sup>f</sup>
Ireland senior	14 (7.45) <sup>f</sup>	7 (3.59) <sup>f</sup>	21 (5.48) <sup>f</sup>
Ireland universities		13 (6.66) <sup>f</sup>	13 (3.39) <sup>f</sup>
<b>Weekly Activities</b>			
Training sessions	2.86 ± 0.69 (0-4)	2.81 ± 0.87 (0-4)	2.83 ± 0.79 (0-4)
Matches	0.91 ± 0.46 (0-2)	0.85 ± 0.54 (0-3)	0.88 ± 0.5 (0-3)
Total activities	3.83 ± 0.66 (0-5)	3.68 ± 0.82 (0-6)	3.76 ± 0.74 (0-6)
<b>Exposure H</b>			
Training sessions	13856	12506	26362
Matches	3453	3514	6967
Total activities	17309	16020	33329

Values are mean ± SD (range) unless otherwise stated.

<sup>a</sup>Number of new players in 2019 season.

<sup>b</sup>Number in brackets is percentage of total number of players who dropped out during the season.

<sup>c</sup>Number in brackets is percentage of total number of players who joined during the season.

<sup>d</sup>Number in brackets is percentage of total number of player seasons.

<sup>e</sup>Number of players (% of totals).

<sup>f</sup>Number in brackets is percentage of total number of players.

cup competitions), friendly match, international match, or college match (Table 2A).<sup>18</sup> Exposure forms were returned to the principal investigator on a monthly basis. Clubs received monthly feedback on the data collected in order to ensure consistent and accurate data capture.

We used a time-loss definition of injury in this study. As per the consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries,<sup>18</sup> an injury was defined as any physical complaint incurred by a player during participation in a football match or football training session that resulted in the player being unable to participate fully in a future football training session or match. The club medical staff (chartered physiotherapist, certified athletic therapist, or certified physical therapist) recorded all time-loss injuries on an injury surveillance form utilized by UEFA. Injuries unrelated to football training or matches were not included. If a player was injured when entering the study, that injury was excluded from the analysis.

A sudden onset injury was classified as having an identifiable event while a gradual onset injury was defined as being of insidious onset without any identifiable event. A player was considered injured until the club's medical staff allowed her to return to full unrestricted participation in training or adjudged her to be available for match selection. Injuries were split into 5 categories of severity based on the number of days absent: slight (0 days), minimal (1-3 days), mild (4-7 days), moderate (8-28 days), and severe (>28 days).

A re-injury was defined as an injury of the same type and at the same site as the index injury, which occurred after the player's return to unrestricted participation in training and/or matches following the index injury.<sup>18</sup> A re-injury that occurred within 2 months of a player's return to unrestricted participation in training and/or matches was defined as an early recurrence injury, one that occurred between 2 months and 12 months of a player's return to unrestricted participation in training and/or matches was defined as a late recurrence injury, while one that occurred greater than 12 months after the index injury was defined as a delayed recurrence injury.<sup>18</sup> Injury circumstance was registered as contact or non-contact, depending on whether the player was injured as a result of contact with another player or object (ie, contact injury) or without contact (ie, non-contact injury). The specific time in matches when injuries were incurred was recorded, as well as the referee sanction (no foul, foul, yellow card, red card).

IIRs (95% confidence intervals) were calculated (sum of injuries/sum of exposure h×1000) and reported for total exposures, and for match play and training separately. The mean number of days lost was also recorded. Injury burden was calculated as the mean number of days lost to injury relative to exposure (sum of injury days lost/sum of exposure×1000).<sup>19</sup> The frequency of injuries relative to type, location, and circumstance are presented as absolute and relative values (percentage of total injuries). An independent t-test was used to compare the mean difference in days lost between contact and non-contact injuries.

	2018 Season	2019 Season	2018 & 2019 Seasons
Total number of players	188	195	383
Total club training exposure h	12669	11648	24317
Total national team training exposure h	1187	858	2045
Total club match exposure h	3243	3132	6375
Total national team match exposure h	124	150	274
Total club under 17/college match exposure h	86	232	318
Total training exposure h	13856	12506	26362
Total match exposure h	3453	3514	6967
Total exposure h	17309	16020	33329
Total training exposure h/player/season	74	64	69
Total match exposure h/player/season	18	18	18
Total exposure h/player/season	92	82	87
Match exposure ratio (match h/total h of exposure)	0.19	0.22	0.21

TABLE 2A Exposure (training & match) in Ireland WNL 2018 & 2019

## 4 | RESULTS

### 4.1 | Player match and training exposure and associated injury incidence rates

Over the two seasons, the total exposure of players to match play and training was 33 329 h (match play=6967 h; training=26 362 h). On average, players participated in 4 activities per week (3 training sessions, 1 match) (Table 1). A total of 266 injuries were incurred across the two seasons; 134 (50.4%) during match play, 67 (25.2%) during training, and 65 (24.4%) reported as gradual onset injuries (Table 2B). The overall IIR was 7.9/1000 h (95% CI: 7.0 – 8.9) (Table 3). Players incurred 0.69 injuries per season on average, which is equivalent to 15 time-loss injuries per season for a squad of 22 players.

The match and training IIRs were 19.2/1000 h (95% CI: 15.9 – 22.4) and 2.5/1000 h (95% CI: 1.9 – 3.1) respectively (Table 3). The majority (75.6%) of injuries incurred over the two seasons were classified as sudden onset injuries. Table 3 details the overall, match and training sudden onset contact and non-contact IIRs.

### 4.2 | Injury type and injury location

The most commonly reported injuries were muscle injuries (35.0%), ligament sprains (30.1%), contusions (9.0%), meniscus lesions (7.5%), concussions (3.4%) and fractures (3.4%) (Table 3). Lower extremity injuries accounted for 85% of all injuries (Table 4). The most common injury locations were the ankle (24.4%), knee (21.8%), hamstrings

(12.4%), lower leg/Achilles tendon (7.9%), trunk/spine (7.5%), quadriceps (6.8%) and hip/groin (6.4%) (Table 4). Lateral ankle sprains (13.9%) and hamstring injuries (12.4%) were the most commonly incurred injuries (supplementary table B).

### 4.3 | Injury severity and burden

Approximately a third of all contact and non-contact injuries were resolved within 1 week and 50% of gradual onset injuries were resolved within 1 week (Table 4). Fifteen percent of all injuries were re-injuries and 63% of the re-injuries were incurred within 2 months of the index injury (Table 3). Twenty-three percent of lower extremity injuries were severe. Forty-five percent of meniscus/cartilage injuries were severe in comparison to 30% of ligament and 7% of muscle injuries (Table 4). There was no statistically significant difference ( $p = 0.41$ ) in average time-loss between non-contact injuries and contact injuries (33 days lost per injury vs. 27 days; mean difference= 6.4 days, 95% CI 9.0 -21.9) (Table 5).

There was an overall injury burden of 213 days lost/1000 h and a mean days lost of 27 per injury (Table 5). Ligament and muscle injuries resulted in the highest injury burden (104/1000 h and 33/1000 h, respectively) (Table 5). The knee and ankle were the locations with the highest number of severe injuries and the highest injury burden (107/1000 h and 41/1000 h, respectively) (Table 5). Almost 50% of knee injuries and 21.5% of ankle injuries were severe (Table 4). The mean days lost per knee injury was almost three times that per ankle injury (61 days vs. 21 days)

**TABLE 2B** Injury prevalence (training & match) in Ireland WNL 2018 & 2019

	2018 Season	2019 Season	2018 & 2019 Seasons
Total number of players	188	195	383
Total number of injuries	154	112	266
Total club training injuries	30 (19.5)	34 (30.4)	64 (24.1)
Total national team training injuries	3 (1.9)		3 (1.1)
Total club match injuries	77 (50.0)	47 (41.9)	124 (46.6)
Total national team match injuries	7 (4.5)	1 (0.9)	8 (3.0)
Total club under 17/ college match injuries		2 (1.8)	2 (0.8)
Gradual onset injuries	37 (24.0)	28 (25.0)	65 (24.4)
Total training injury prevalence	17.6%	17.4%	17.5%
Total match injury prevalence	44.7%	25.6%	34.9%
Total gradual onset injury prevalence	19.7%	14.4%	16.9%
Total injury prevalence	82.0%	57.4%	69.3%

<sup>a</sup>Values in brackets show percentage of total injuries for 2018, 2019 and 2018/2019 combined.

TABLE 3 Injury incidence rates in Ireland WNL 2018 &amp; 2019

Injuries	2018 & 2019 Seasons 383 Player Seasons	2018 & 2019 Seasons Injury Incidence Rates
	<i>N</i> (%)	Incidence/1000 h (95% CI)
Total	266 (100)	7.98 (7.02–8.94)
Training	67 (25.2)	2.54 (1.93–3.15)
Match play	134 (50.4)	19.20 (15.98–22.49)
Gradual onset	65 (24.4)	1.95 (1.48–2.42)
<b>Severity</b>		
Slight (0 days)	3 (1.1)	0.09 (-0.01-0.19)
Minimal (1-3 days)	47 (17.7)	1.41 (1.00-1.81)
Mild (4-7 days)	54 (20.3)	1.62 (1.19-2.05)
Moderate (8-28 days)	105 (39.5)	3.15 (2.55-3.75)
Severe (>28 days)	57 (21.4)	1.71 (1.27-2.15)
<b>Re-Injury</b>		
No	226 (84.9)	6.78 (5.90-7.67)
Yes	40 (15.1)	1.20 (0.83-1.57)
Early (0-2 months)	25 (9.4)	0.75 (0.46-1.04)
Late (2-12 months)	13 (4.9)	0.39 (0.18-0.60)
Delayed (>12 months)	2 (0.8)	0.06 (0.00-0.14)
<b>Injury Type/Diagnosis</b>		
Fractures & bone stress	16 (6.0)	0.48 (0.24-0.72)
Fracture	9 (3.4)	0.27 (0.09-0.45)
Bone stress	7 (2.6)	0.21 (0.05-0.37)
Joint (non-bone) & ligament	103 (38.7)	3.09 (2.49-3.69)
Dislocation	3 (1.1)	0.09 (0.00-0.19)
Sprain/ligament injury	80 (30.1)	2.40 (1.87-2.93)
Lesion of meniscus or cartilage	20 (7.5)	0.60 (0.34-0.86)
Muscle & tendon	101 (37.9)	3.03 (2.44-3.62)
Muscle injury	93 (35.0)	2.79 (2.22-3.36)
Muscle strain	87 (32.7)	2.61 (2.06-3.16)
Hematoma	6 (2.3)	0.18 (0.04-0.32)
Tendon strain/tendinopathy	8 (3.0)	0.24 (0.07-0.41)
Contusion	24 (9.0)	0.72 (0.43-1.01)
Laceration	1 (0.4)	0.03 (0.00-0.09)
Central/peripheral nervous system	13 (4.9)	0.39 (0.18-0.60)
Concussion	9 (3.4)	0.27 (0.09-0.45)
Nerve injury	4 (1.5)	0.12 (0.00-0.24)
Synovitis/effusion	2 (0.8)	0.06 (0.00-0.14)
Overuse complaints unspecified	6 (2.3)	0.18 (0.04-0.32)
<b>Age Groups (years)</b>		
≤20	143 (53.8)	7.09 (5.93-8.27)
21-25	84 (31.6)	11.02 (8.67-13.38)
26-30	31 (11.7)	6.82 (4.42-9.22)
>30	8 (3.0)	7.98 (2.45-13.50)

(Continues)

TABLE 3 (Continued)

Injuries	2018 & 2019 Seasons 383 Player Seasons	2018 & 2019 Seasons Injury Incidence Rates
<b>International &amp; Domestic<sup>b</sup> v Domestic Only<sup>c</sup></b>		
International & domestic	92	6.93 (5.52-8.35)
Domestic only	174	8.67 (7.38-9.96)
<b>Circumstance</b>		
Sudden onset	201 (75.6)	6.03 (5.20-6.86)
Contact	79 (29.7)	2.37 (1.85-2.89)
Matches	57 (21.4)	8.18 (6.10-10.31)
Training	22 (8.3)	0.83 (0.49-1.18)
Non-contact	122 (45.9)	3.66 (3.01-4.31)
Matches	77 (28.9)	11.10 (8.58-13.52)
Training	45 (16.9)	1.71 (1.21-2.21)

<sup>a</sup>Values in brackets in total columns show percentage of total injuries for 2018/2019 combined.

<sup>b</sup>International and domestic players participated in Ireland under 17, under 19, senior team or Irish university squad in the 2019 World University Games. These players also played concurrently in the WNL and under 17/college football matches.

<sup>c</sup>Domestic only players participated in the WNL and under 17/college football matches.

(Table 5). There were 8 anterior cruciate ligament (ACL) tears documented over the 2 seasons. These accounted for 28% of all time lost to injury with a mean and median days lost per injury of 247 and 300, respectively (supplementary table B). The incidence rate of ACL tears was 0.2/1000 h and they had the highest burden for all injuries (59/1000 h).

## 5 | DISCUSSION

Our two-season prospective injury surveillance study in the WNL in Ireland is the first study to be conducted at any level of women's football in Ireland. By adhering to the consensus statement on injury definitions and data collection procedures in studies of football injuries,<sup>18</sup> we present data on IIRs, injury type, injury location, injury severity and injury burden.

### 5.1 | Match and training injury incidence rates

We recorded match and training IIRs of 19.2/1000 h and 2.5/1000 h, respectively. Our results are in the lower range of time-loss match (12.5–55.5/1000 h) and training (1.4–10.9/1000 h) IIRs reported in other elite-level women's football injury surveillance studies.<sup>4–13,15</sup>

Our finding that players, on average, incurred 0.69 injuries per season (approximately 15 injuries per season for a squad of 22 players) is lower than the 1–2 injuries per player per season reported in elite-level women's football in Sweden.<sup>12</sup> It is possible that the professional and

semi-professional status of the players in the Swedish League may have led to the higher rate of injuries. Male professional teams in the UEFA elite club injury study also incurred an average of 2 injuries per player per season.<sup>12</sup>

Our recorded match IIR (19.2/1000 h) is 7.5 times higher than our recorded training IIR (2.5/1000 h). Previous elite-level women's football injury surveillance studies have reported a 3.5 to 13 times higher match IIR compared to training IIR.<sup>4–13,15</sup> It is possible that the injury recording systems used in the different studies may have influenced this ratio. Jacobson and Tegner<sup>10</sup> used team leaders to record injuries, while most other studies have used medical personnel, with the exception of Nilstad et al<sup>8</sup> whereby players self-reported injuries via text message. Nilstad et al<sup>8</sup> reported that the IIRs calculated from medical staff injury reports were substantially lower than the IIRs calculated from individual player reports. It is possible that the medical personnel in our study may also have under-reported IIRs due to absence from training and matches or lack of motivation to complete the injury report cards. Players may also choose not to report injuries to medical personnel.

### 5.2 | Injury type and location

Lower extremity injuries accounted for 85% of all injuries incurred over the two seasons. This observation is consistent with previous studies, which have reported that lower extremity time-loss injuries account for between 59.7% and 89.6% of all time-loss injuries.<sup>4–7,9–13,15</sup>

TABLE 4 Injury location, type and circumstance in Ireland WNL 2018 &amp; 2019 stratified by severity of injuries

2018 & 2019 Seasons 383 Player Seasons 266 Injuries						
	Total <sup>a</sup>	0 Day <sup>b</sup> (Slight)	1-3 Days <sup>b</sup> (Minimal)	4-7 Days <sup>b</sup> (Mild)	8-28 Days <sup>b</sup> (Moderate)	>28 Days <sup>b</sup> (Severe)
<b>Injury Location</b>						
Head/neck	12 (4.5)		2 (16.7)		6 (50)	4 (33.3)
Upper limbs	8 (3.0)	1 (12.5)	3 (37.5)	1 (12.5)	3 (37.5)	
Trunk/spine	20 (7.5)		7 (35)	3 (15)	8 (40)	2 (10)
Hip/groin	21 (7.9)		2 (9.5)	8 (38.1)	11 (52.4)	
Thigh	51 (19.2)		10 (19.6)	14 (27.5)	20 (39.2)	7 (13.7)
Hamstrings	33 (12.4)		8 (24.2)	8 (24.2)	14 (42.4)	3 (9.1)
Quadriceps	18 (6.8)		2 (11.1)	6 (33.3)	6 (33.3)	4 (22.2)
Knee	58 (21.8)	1 (1.7)	7 (12.1)	10 (17.2)	13 (39.7)	27 (46.6)
Lower leg/achilles	21 (7.9)		5 (23.8)	5 (23.8)	9 (42.9)	2 (9.5)
Ankle	65 (24.4)	1 (1.5)	10 (15.4)	13 (20)	27 (41.5)	14 (21.5)
Foot/toe	10 (3.8)		1 (10)		8 (80)	1 (10)
Lower extremity injuries	226 (85.0)	2 (0.9)	35 (15.5)	50 (22.1)	88 (38.9)	51 (22.6)
<b>Injury Type</b>						
Fractures and bone stress	16 (6.0)	1 (6.25)		2 (12.5)	7 (43.8)	6 (37.5)
Dislocation	3 (1.1)			2 (66.7)		1 (33.3)
Sprain/ligament injury	80 (30.1)		13 (16.3)	11 (13.8)	32 (40)	24 (30)
Meniscus/cartilage	20 (7.5)		3 (15)	4 (20)	4 (20)	9 (45)
Muscle injury	93 (34.9)		20 (21.5)	27 (29.0)	40 (43.0)	6 (6.5)
Muscle strain	87 (32.7)		19 (21.8)	24 (27.6)	38 (43.7)	6 (6.9)
Hematoma	6 (2.3)		1 (16.7)	3 (50)	2 (33.3)	
Tendon injury	8 (3.0)		1 (12.5)	1 (12.5)	2 (25)	4 (50)
Contusion	24 (9.0)	1 (4.2)	6 (25)	4 (33.3)	13 (54.2)	
Laceration	1 (0.4)				1 (100)	
Concussion	9 (3.4)				5 (55.6)	4 (44.4)
Nerve injury	4 (1.5)		2 (50)	1 (25)		1 (25)
Synovitis/effusion	2 (0.8)			2 (100)		
Overuse complaints unspecified	6 (2.3)	1 (16.7)	2 (33.3)		1 (16.7)	2 (33.3)
<b>Circumstance</b>						
Contact (sudden onset)	79 (29.7)	2 (2.5)	13 (16.5)	15 (18.9)	33 (41.8)	16 (20.3)
Matches	57 (21.4)	1 (1.8)	7 (12.3)	10 (17.5)	26 (45.6)	13 (22.8)
Training	22 (8.3)	1 (4.5)	6 (27.3)	5 (22.7)	6 (27.3)	4 (18.2)
Non-contact (sudden onset)	122 (45.9)	1 (0.8)	16 (13.1)	23 (18.9)	51 (41.8)	31 (25.4)
Matches	77 (28.9)		7 (9.1)	14 (18.2)	38 (49.4)	18 (23.4)
Training	45 (16.9)	1 (2.2)	9 (20)	9 (20)	15 (33.3)	11 (24.4)
Gradual onset	65 (24.4)		24 (36.9)	10 (15.4)	22 (33.8)	9 (13.8)
Total injuries	266 (100)	3 (1.1)	47 (17.7)	54 (20.3)	105 (39.5)	57 (21.4)

<sup>a</sup>Values in brackets in total column shows percentage of total injuries for the 2018 & 2019 seasons.

<sup>b</sup>Values in brackets within severity columns show percentage of slight, minimal, mild, moderate and severe injuries relative to injury location, injury type and circumstance.



TABLE 5 Site and type of injuries in Ireland WNL 2018 &amp; 2019 stratified by injury burden

	Frequency	Percent of Total Number of Injuries (95% CI)	Days Lost (% of total)	Mean Days Lost Per Injury	Median Days Lost Per Injury (IQR) <sup>a</sup>	Injury Burden (95% CI)
<b>Injury Site</b>						
Ankle	65	24.4 (19.5-29.7)	1377 (19.4)	21.20	10.0 (21)	41.34 (31.30-51.40)
Knee	58	21.8 (16.9-27.1)	3555 (49.9)	61.29	20.5 (84)	106.70 (76.63-131.80)
Thigh	51	19.2 (14.7-24.1)	781 (10.9)	15.31	9.0 (13)	23.42 (17.00-29.85)
Lower leg	21	7.9 (4.9-11.3)	283 (3.9)	13.48	8.0 (19)	8.49 (4.86-11.99)
Hip/groin	21	7.9 (4.9-11.3)	231 (3.2)	11.0	11.0 (13)	6.93 (3.96-9.79)
Low back	12	4.5 (2.3-7.1)	127 (1.8)	10.58	5.0 (12)	3.81 (1.70-5.93)
Foot	10	3.8 (1.5-6.4)	215 (3.0)	21.50	19.5 (13)	6.45 (2.37-10.54)
Head/face	10	3.8 (1.5-6.0)	299 (4.2)	29.90	14.5 (27)	8.97 (3.29-14.65)
Hand	5	1.9 (0.4-3.8)	20 (0.3)	4.00	3.0 (8)	0.60 (0.08-1.12)
Shoulder/clavicle	3	1.1 (0.0-2.6)	32 (0.4)	10.67	12.0 (N/A) <sup>b</sup>	0.96 (0.00-2.03)
Sternum/upper back	2	0.8 (0.0-1.9)	111(1.6)	55.50	55.5 (N/A) <sup>b</sup>	3.33 (0.00-7.77)
Pelvis	2	0.8 (0.0-1.9)	19 (0.3)	9.50	9.50 (N/A) <sup>b</sup>	0.57 (0.00-1.33)
Cervical spine	2	0.8 (0.0-1.9)	3 (0.04)	1.50	1.50 (N/A) <sup>b</sup>	0.09 (0.00-0.21)
Abdomen	2	0.8 (0.0-1.9)	17 (0.2)	8.50	8.5 (N/A) <sup>b</sup>	0.51 (0.00-1.19)
Chest/ribs	2	0.8 (0.0-1.9)	44 (0.6)	22.00	22.0 (N/A) <sup>b</sup>	1.32 (0.00-3.08)
<b>Injury Type</b>						
Fracture/bone stress	16	6.0 (3.4-9.0)	748 (10.5)	46.75	24.5 (63)	22.44 (11.22-33.66)
Dislocation	3	1.1 (0.0-2.6)	50 (0.70)	16.66	5.0 (N/A) <sup>b</sup>	1.49 (0.00-3.17)
Sprain/ligament injury	80	30.1 (24.1-35.3)	3462 (48.7)	43.28	12.0 (35)	103.87 (80.94-126.81)
Lesion of meniscus or cartilage	20	7.5 (4.5-10.9)	754 (10.6)	37.70	15.5 (72)	22.62 (12.82-32.42)
Muscle injury	93	35.0 (29.0-40.2)	1109 (15.6)	11.92	7.0 (12)	33.26 (26.46-40.05)
Tendon injury	8	3.0 (1.1-5.3)	226 (3.2)	28.25	24.0 (48)	6.78 (1.98-11.58)
Contusion	24	9.0 (6.0-12.8)	229 (3.2)	9.54	9.0 (15)	6.87 (4.10-9.64)
Laceration	1	0.4 (0.0-1.1)	17 (0.24)	17.00	17.0 (N/A) <sup>b</sup>	0.51 (0.00-1.53)
Concussion	9	3.4 (1.5-5.6)	287 (4.0)	31.90	16.0 (36)	8.61 (2.87-14.35)
Nerve injury	4	1.5 (0.4-3.4)	63 (0.89)	15.75	3.0 (40)	1.89 (0.00-3.78)
Synovitis/effusion	2	0.8 (0.0-1.9)	9 (0.13)	4.50	4.5 (N/A) <sup>b</sup>	0.27 (0.00-0.63)
Overuse complaints	6	2.3 (0.8-4.1)	160 (2.2)	26.66	8.5 (57)	4.79 (1.06-8.53)
<b>Circumstance</b>						
Contact (sudden onset)	79	29.7 (24.4-35.3)	2076 (29.2)	26.28	11.0 (21)	62.28 (48.62-75.95)
Non-contact (sudden onset)	122	45.9 (39.5-52.3)	3991 (56.1)	32.71	11.5 (25)	119.72 (98.46-140.98)
Gradual onset	65	24.4 (19.2-30.1)	1047 (14.7)	16.11	6.0 (17)	31.41 (23.84-38.99)
Recurrent	40	15.1 (10.9-19.5)	1528 (21.5)	38.20	6.0 (17)	45.84 (31.71-59.97)
<b>Injury Event</b>						
Match	134	50.4 (44.0-56.8)	4469 (62.8)	33.35	12.0 (21)	640.32 (532.93-750.04)
Training	67	25.2 (20.3-30.1)	1598 (22.5)	23.85	8.0 (22)	60.58 (46.03-75.13)

(Continues)

TABLE 5 (Continued)

	Frequency	Percent of Total Number of Injuries (95% CI)	Days Lost (% of total)	Mean Days Lost Per Injury	Median Days Lost Per Injury (IQR) <sup>a</sup>	Injury Burden (95% CI)
<b>International &amp; domestic<sup>c</sup> v domestic only<sup>d</sup></b>						
International & domestic	92	34.6 (28.9-40.6)	1616 (22.7)	17.57	9 (12.8)	121.76 (96.99-146.71)
Domestic only	174	65.4 (59.4-71.1)	5498 (77.3)	31.59	12 (25.5)	273.89 (233.13-314.64)
Total	266		7114	26.74	11.0 (21)	213.39 (95% CI 187.71-239.06)

<sup>a</sup>IQR = Interquartile range.

<sup>b</sup>N/A = Not applicable

<sup>c</sup>International and domestic players participated in Ireland under 17, under 19, senior team or Irish university squad in the 2019 World University Games. These players also played concurrently in the WNL.

<sup>d</sup>Domestic only players participated in the WNL and under 17/college football matches.

We observed that muscle injuries, ligament injuries and contusions were the most common injury types incurred by players during both matches and training (supplementary table C). This concurs with the findings reported in other elite-level women's football injury surveillance studies.<sup>4-7,9-12,15,20</sup> The three most common injury locations in our two-season study were the ankle (24.4%), the knee (21.8%) and the thigh (19.2%) (Table 5). Some previous studies on elite-level female players have reported that the ankle was the most common injury location<sup>7,9,15</sup>, while others have reported that the knee was the most common injury location.<sup>4,5,10</sup> In contrast, Blokland et al<sup>6</sup>, Hägglund et al<sup>11</sup>, and Ekstrand et al<sup>12</sup>, all reported that the thigh was the most common injury location – accounting for 17.6% - 25.1% of all injuries. Thigh injuries are also the most common injuries incurred by male professional football players.<sup>21</sup> It is plausible that the increased running demands at higher levels of the women's game,<sup>22</sup> may lead to professional players incurring more thigh muscle injuries than amateur players. However, the playing status (ie, part-time unpaid amateur vs. full-time professional) of players who were included in many of the published elite-level women's football injury surveillance studies is unclear.<sup>4-6,9,10,12</sup> The length of seasons in these different studies may also have influenced the percentage of players who incurred injuries, with leagues lasting from 4 – 10 months.<sup>4-6,8-11,13</sup> The season length in our study was 8 months.

The six most common injury type diagnoses in our two-season study were lateral ankle sprains (13.9%), hamstring strains (12.4%), knee ligament injuries (8.3%), knee meniscus/cartilage injuries (7.5%), quadriceps injuries (6.8%), and adductor strains (6%) (supplementary table 1C). With the exception of knee meniscus/cartilage injuries, these injury type diagnoses have consistently

been shown to be the most common among elite-level female players.<sup>4,6,9,11,12</sup>

Due to the high proportion of ankle, thigh, knee and adductor (groin) injuries it would be prudent for medical teams in elite-level women's football to screen players at the start of each season to identify players' injury histories and modifiable intrinsic risk factors for injury such as strength impairments and poor landing mechanics.<sup>23</sup> Additionally, due to the fluctuation of injury risk factors over the course of a season, we recommend that this approach be continued throughout the season to monitor whether players are at a potentially heightened risk of injury so that pragmatic and evidence-informed injury risk mitigation strategies can be implemented.<sup>23</sup>

Injury prevention programs such as the FIFA 11+, PEP (Prevent Injury and Enhance Performance), Knäkontroll, and HarmoKnee programs have been shown to reduce the incidence rate of lower extremity injuries, specifically ankle and knee ligament injuries and thigh muscle injuries, in sub-elite senior and adolescent female football players.<sup>24-26</sup> However, with the exception of the eccentric hamstring and balance board intervention studies by del Ama Espinosa et al<sup>26</sup> and Söderman et al<sup>27</sup> respectively, the evidence for the efficacy of these neuromuscular exercise-based programs is limited to adolescent and college players.<sup>28</sup> The strength, power and proprioceptive exercises included in these programs are unlikely to provide sufficient neuromuscular stimulus for elite-level female players playing at the highest levels of the women's game. Taberner et al<sup>29</sup> provide a good example of the type of strength and conditioning programming required to prepare elite-level senior female players for the demands of match play.

Alongside musculoskeletal screening and implementing injury risk mitigation programs for ankle, thigh, knee

and hip/groin injuries, medical personnel and strength and conditioning coaches need to develop expertise in rehabilitating these injuries.<sup>29</sup> One of the challenges for medical personnel in elite-level women's football is that, despite lateral ankle sprains being one of the most commonly reported injuries,<sup>4-13,15</sup> there are no evidence-based criteria to inform return-to-sport (RTS) decisions for players recuperating from an acute lateral ankle sprain injury.<sup>30</sup> Likewise, despite the large injury burden associated with ACL injuries, the evidence underpinning current RTS test batteries in relation to the risk of graft rupture and contralateral ACL rupture is weak.<sup>31</sup>

Across the two seasons, we observed that 29.7% and 45.9% of injuries were classified as sudden onset contact and non-contact injuries, respectively. Of the 45.9% sudden onset non-contact injuries (eg, muscle strains, tendon strains, ligament sprains), 63% occurred in matches, which may suggest that the players in our study were not optimally prepared for the physical demands of match play. Despite players spending 3.8 times more time training than playing matches (26 362 h vs. 6967 h, respectively), we observed that the match IIR (19.2/1000 h; 95% CI: 15.9 – 22.4) was 7.5 times higher than the training IIR (2.5/1000 h; 95% CI: 1.9 – 3.1). Data from GPS technologies and camera-based player tracking systems allows coaches to monitor the high speed running and sprinting distances, as well as the number of accelerations and decelerations completed by players in matches and training sessions.<sup>32,33</sup> These data should be used by coaches to ensure that players are adequately prepared for the demands of match play.

Considering our observation that a substantial proportion of non-contact sudden onset injuries (eg, muscle and tendon strains) were incurred during match play, it is imperative that particular consideration be given to the design of training sessions (eg, position specific small, medium, and large-sided games manipulation as well as football specific sprinting exercises) at the highest level of the women's game.<sup>34</sup> We believe that coaches in elite-level women's football need to design training sessions that prepare players for matches against opponents who challenge their players to complete large amounts of high speed running and sprinting.<sup>35</sup> We also suggest that players need to be prepared for the period within matches with the greatest running demands (ie, the worst case scenario).

Twenty-four percent (24%) of injuries incurred during our two-season study were gradual onset injuries (Table 5). This finding is similar to that reported in other elite-level women's football injury surveillance studies.<sup>5,7,10,11,15,20</sup> In our study we used a time-loss injury definition. The nature of gradual onset injuries (ie, overuse injuries) often

allows players with physical symptoms to continue to participate fully in training and matches for some time, so it is probable that gradual onset injuries were under-reported in our study and in other injury surveillance studies in elite-level women's football that have used a time-loss injury definition.<sup>36</sup>

Eleven percent of the injuries in our study were re-injuries (injuries of the same type and at the same site as the index injury), which is lower than the 21% and 28% reported in studies in elite-level Swedish football.<sup>10,11</sup> Sixty-three percent of the re-injuries in our study were incurred within 2 months of the index injuries, in comparison to 85% reported by Hägglund et al.<sup>11</sup> Two of the early re-injuries (<2 months) in our study were thigh muscle injuries, which were incurred when players returned to match play before returning to full unrestricted training. This highlights the importance of training in preparation for the return to the demands of match play.

Jacobson and Tegner<sup>10</sup> also suggested that due to the mixed composition of playing squads (ie, international-level and non-international-level players), international-level players often competed against players with inferior physical capacities and technical abilities, which could heighten the risk of injury among non-international-level players – as they may struggle to cope with the high tempo of match play. In our study, players who played international football as well as in the WNL had a lower IIR in comparison to players who only played in the WNL (Table 3). Players who played international football also had a much lower injury burden than players who didn't (122/1000 h vs. 274/1000 h respectively) despite the fact that international-level players participated in 70% more match play during the season than non-international-level players (supplementary table D). International-level players' increased match exposure in comparison to non-international-level players may have better prepared them for the demands of training and matches and reduced their risk of incurring severe injuries.

Despite all the top division women's leagues in each European country being classified by UEFA as elite-level,<sup>12</sup> there is a difference between the standards of the leagues across European countries based on the UEFA ranking coefficients. The UEFA women's association coefficients are based on the results of each association's clubs in the UEFA Women's Champions League over a five-year period. In the 2017/2018 and 2018/2019 UEFA seasons, Ireland was ranked 31<sup>st</sup> and 33<sup>rd</sup> respectively in the UEFA coefficient.<sup>37</sup> It is important to note that these ranking coefficients are likely to influence the observations of injury surveillance studies in women's football in Europe due to differences in the intensity and physical demands of matches.

### 5.3 | Injury severity and burden

Over our two-season study, 1% of the injuries were classified as slight (0 days), 18% as minimal (1-3 days), 20% as mild (4-7 days), 40% as moderate (8-28 days) and 21% as severe (>28 days). We used the thresholds suggested in the consensus statement on injury definitions and data collection procedures in studies of football injuries.<sup>18</sup> Our results are not too dissimilar to other studies in elite-level women's football<sup>6,11,13,20</sup> – for example Larruskain et al<sup>20</sup> reported that in the Spanish women's first division, 16% of injuries were minimal, 22% mild, 40% moderate and 23% severe. In total, 39% of the injuries incurred in our study were resolved within 1 week, while 1-in-5 injuries required more than 4 weeks to resolve. The high percentage of injuries resolved within 1 week, may have been due to effective medical treatment or, alternatively, due to pressure on players to return to play as quickly as possible following minor injuries. One third of the re-injuries (13/40) in our study were incurred by players who had returned to play from their index injury within one week. Ivarsson et al<sup>38</sup> in their analysis of elite-level Swedish football, highlighted the potential increased risk of injury in female players due to sociocultural expectations to play even if they are not physically or psychologically ready.

Our study is the first to report upon injury burden in an elite-level women's football league. While Hägglund et al<sup>11</sup> reported IIRs and mean day's lost per injury (which allows for the calculation of injury burden), they did not report upon injury burden explicitly. Larruskain et al<sup>20</sup> reported on overall injury burden while injury type and location burdens were calculable from the data presented in their single club study in Spain. The overall injury burden in our study was 213/1000 h with a mean loss of 27 days per injury (Table 5). This compares to a (calculated) injury burden in Hägglund et al's<sup>11</sup> study on elite Swedish players of 127/1000 h with a mean loss of 23 days per injury, and an injury burden of 216/1000 h with a mean loss of 35 days per injury in a Spanish women's first division club.<sup>20</sup> Despite the differences in the provision of sports medicine support between the league in Ireland and the professional Spanish club, the overall injury burden and mean days lost per injury were similar. In our study, clubs typically had access to a physiotherapist/physical therapist/athletic therapist but did not have routine access to a sports medicine physician. This is consistent with the club-level experiences identified in a survey of elite-level female players participating in the FIFA 2019 Women's World Cup.<sup>39</sup> In contrast, Larruskain et al<sup>20</sup> reported that the team in their study was supported by a physician, a physiotherapist, as well as a masseur and a pitch rehabilitator who was responsible for facilitating the re-introduction of players returning from injury to full team training.

In our study ligament and muscle injuries resulted in the highest injury burden, 104/1000 h and 33/1000 h, respectively. They were associated with a mean loss of 43 days per injury and 12 days per injury. This compares to ligament and muscle injury burdens of 148/1000 h and 62/1000 h in the study by Larruskain et al.<sup>20</sup> Injury burden in our study for the knee was 107/1000 h with a mean loss of 61 days per injury. Injury burden for the ankle was 41/1000 h with a mean loss of 21 days per injury. This compares to an injury burden for the knee of 32/1000 h with a mean loss of 54 days per injury and an injury burden for the ankle of 10/1000 h with a mean loss of 12 days per injury in the study by Hägglund et al.<sup>11</sup> An injury burden for the knee of 116/1000 h with a mean loss of 114 days per injury and an injury burden for the ankle of 27/1000 h with a mean loss of 29 days per injury was reported by Larruskain et al.<sup>20</sup>

The same locations (ie, knee and ankle) and injury types (ie, ligament sprains and muscle strains) were associated with the highest injury burdens in our study and those by Hägglund et al<sup>11</sup> and Larruskain et al<sup>20</sup> but the size of the burden and mean day's lost per injury were highest in the study by Larruskain et al.<sup>20</sup>

We contend that injury prevention initiatives should not just focus on reducing those injuries which are most frequently incurred but should prioritize those with the highest injury burdens (eg, those injuries that keep players out of training and match play the longest).<sup>40</sup> In our study, knee, ankle and thigh injuries had the highest injury burdens – 107/1000 h, 41/1000 h and 25/1000 h, respectively. The FAI should promote the implementation of knee, ankle and thigh injury risk mitigation strategies to protect the musculoskeletal health of players competing in the WNL. We also suggest that the FAI should develop initiatives to raise the awareness among players, coaches and match officials of the signs and symptoms of concussion.

### 5.4 | Limitations

The WNL teams included in our study trained 2 or 3 days per week, so it is possible that some slight or minimal injuries were not captured, considering that we used a time-loss definition of injury.

While the players who participated in our study are classified as elite and play at the highest level in Ireland, they are all amateur and also have work and/or school/college commitments, which could have affected their training and playing availability, as well as their availability to receive medical attention. Some of the players may also have been engaged in other sporting activities during the season which could have increased their susceptibility to injuries.

Diagnoses of meniscus/cartilage lesions were made clinically and, without the evidence of MRI findings, it is

possible that they were over-diagnosed. Also, injury location, type and severity were not analyzed relative to different age categories, although the majority of players (82%) included in our study were  $\leq 25$  years of age so such an analysis may not have provided any meaningful information.

## 5.5 | Perspective

Our two-season study of the pattern of injuries in elite-level women's football players in Ireland has shown that the incidence of training, match and overall injuries is similar to other studies in elite-level women's football. Players incurred 0.69 injuries per season on average (266 injuries/383 player seasons), which is equivalent to 15 time-loss injuries per season for a squad of 22 players. The majority of the injuries were in the lower extremity (85%) and had a non-contact mechanism (46%). Muscle, ligament and contusion injuries were the most common and the sites most commonly injured were the ankle, knee and thigh. There were 7.5 times more injuries in matches than in training and the injury burden in matches was much higher than training (640/1000 h and 61/1000 h, respectively). International-level WNL players had a lower IIR and injury burden in comparison to players who only played in the WNL despite international-level players participating in 70% more match play. The FAI should prioritize the implementation of injury risk mitigation strategies focusing on injuries with a high injury burden such as ACL injuries, knee meniscus/cartilage injuries, lateral ankle sprains and hamstring strains.

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### DATA AVAILABILITY STATEMENT

De-identified data is available upon request from the authors

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## SUPPORTING INFORMATION

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