

## ORIGINAL ARTICLE

# Incidence and risk factors for limb fracture in greyhound racing in Western Australia

MJ Gibson,<sup>a,\*</sup> KA Legg,<sup>a</sup> EK Gee,<sup>a</sup> A Smet,<sup>b</sup> J Medd,<sup>b</sup> C McMullen,<sup>b</sup> L Auld<sup>b</sup> and CW Rogers<sup>a,c</sup>

Identification of risk factors for race day injury can improve greyhound welfare. Race day fractures are the most significant injury event and have the greatest negative impact on dog welfare and the industry's social license to operate. This study aimed to describe the incidence and risk factors for race-related fractures in greyhounds racing in Western Australia. Electronic extracts describing race level data and race day injuries were provided by Racing and Wagering Western Australia (RWVA). The incidence rate (IR) of fractures for all greyhound race starts in Western Australia from 1 January 2017–31/12/2023 was calculated per 1000 starts. Univariable and multivariable models using Poisson regression were used to calculate the IR ratio of fracture type based on race and greyhound-level factors. There were 198,008 racing starts and 662 ( $n = 643$ , 97.1% involving the limbs) fractures resulting in an IR of 3.3 fractures per 1000 starts (95%CI 3.1–3.6). Greyhounds that had an injury in their previous race were 2.3 times (95%CI 1.4–4.3) more likely to have a forelimb fracture than greyhounds that did not have an injury ( $P = 0.013$ ). The risk of tarsal bone fracture was greater in greyhounds older than 30 months and greyhounds that had not raced in the previous 15 days. Risk factors for fractures in the forelimb were associated with trauma after interference or dog collisions, whereas tarsal fractures were associated with strain and cyclic loading from race training/racing. Changes to racing structure, rules and policies based on these risk factors may help to reduce fracture incidence in racing greyhounds.

**Keywords** bone fatigue; greyhound racing; injury; musculoskeletal; race day; social license to operate; tarsal bone fracture

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Race day fractures and injuries have a negative impact on greyhound welfare and the industry's social license to operate.<sup>1</sup> A significant area of focus and priority for the greyhound industry has been actively improving the safety of racing for greyhounds thereby reducing injury rates. Recently, attention has focused on investigating the impact of the racing infrastructure variables, such as track shape and design, on training and race day injury rates.<sup>2</sup> However, there is a need to examine the impact of animal and

race level risk factors for injury because there are limited data describing these.

Within Australia, race day injuries are currently monitored, with any injury or incident that occurs on race day recorded by stipendiary stewards in the form of a stewards' report.<sup>3</sup> Each report requires a veterinary examination of the greyhound to be recorded in an online database. The report includes information on the reason for the examination, clinical outcomes, the stand-down period from racing activity and any other information pertaining to the examination. In New Zealand, this type of information has been used to describe race day injuries in the greyhound population and the risk factors for injuries, lacerations and fractures.<sup>4,5</sup>

Greyhounds are subject to musculoskeletal injuries associated with racing and training, which encompass minor injuries such as a muscle strain to catastrophic fracture.<sup>4,5</sup> Fractures, particularly in the distal limb, are associated with a greater incidence of stand-down periods over 60 days, dog retirement and fatality than all other injuries.<sup>4</sup> The hindlimb, particularly the tarsus,<sup>6</sup> is the most commonly observed fracture site, due to the large forces placed on the limb during running, and the role of the tarsus (hock) to absorb ground impact force.<sup>7</sup> In addition, the hindlimb supports 62% of body weight during high-speed exercise.<sup>8</sup> Races are run in an anticlockwise direction, which results in asymmetrical limb loading, with greater force placed on the left forelimb and right hindlimb to counteract centrifugal forces.<sup>9,10</sup> As a result, the incidence of fracture in the left forelimb and right hindlimb is typically greater than their contralateral limbs.<sup>11</sup> Fracture risk and fracture site are thought to be affected by risk factors at both a greyhound and jurisdictional level.

Australian greyhound racing takes place across seven jurisdictions which are governed at the state level under a federated national model. Differences in the regulation and management of racing in addition to unique environmental factors within each jurisdiction may also affect characteristics of the racing population. As a result, risk factors for sustaining an injury may differ between jurisdictions and should therefore be examined at a jurisdictional level. Racing and Wagering Western Australia (RWVA) have been undertaking proactive changes to rules and policies and altered track configurations, aimed at reducing injury risk based in part on a report completed by Eager et al.<sup>2</sup> In addition, since 2017 RWVA has funded various greyhound injury recovery schemes with the intent of reducing the incidence of euthanasia of greyhounds that have sustained a significant race day injury. However, there is currently no published literature describing the incidence and risk factors for fracture in

\*Corresponding author.

<sup>a</sup>School of Veterinary Sciences, Massey University, Palmerston North, 4442, New Zealand; [m.gibson@massey.ac.nz](mailto:m.gibson@massey.ac.nz)<sup>b</sup>Racing and Wagering Western Australia, Perth, Western Australia 6017, Australia<sup>c</sup>School of Agriculture and Environment, Massey University, Palmerston North, 4442, New Zealand

greyhound racing specific to Western Australia, which is essential to consider when addressing racing safety. Therefore, the aim of this study was to identify the incidence and risk factors for race day limb fractures in greyhounds racing in Western Australia.

### Materials and methods

Data were acquired for all greyhound racing starts in Western Australia from the 1<sup>st</sup> of January 2017 to the 31<sup>st</sup> of December 2023 with permission from RWWA through OzChase (a national database for greyhound statistics). The Microsoft Excel spreadsheet included greyhound level information including name, age, sex, bodyweight and career starts. Race level data included racetrack, race date, race grade, race distance, starting box number (position in the starting boxes), finishing position and starters per race. An additional dataset included all records of on-track veterinary examination results entered by the on-track veterinarian into OzChase on race day. Injury data included a description of the event, anatomical location, injury type, stand-down period and whether the injury resulted in death. Multiple clinical findings (injury and anatomical location) could be reported for one veterinary examination.

### Definitions

Start position was classified based on race distance and individual track configuration using the maps on the Greyhounds Western Australia website ([www.greyhoundswa.com.au](http://www.greyhoundswa.com.au)). For reporting purposes, any greyhound that was listed as deceased or was euthanased was automatically allocated a stand-down period of 90 days to reflect the greatest penalty that could be given.

Injury in previous race was defined as a dog having a clinical finding from a veterinary examination on its previous race day. A fracture event was defined as any fracture that occurred on race day after a dog had entered the starting box. Fracture location was defined by affected bone as follows: proximal forelimb (scapula, humerus, radius and ulna), distal forelimb (carpal, metacarpal and phalange bones), proximal hindlimb (femur, tibia and fibula), tarsus, distal hindlimb (metatarsal and phalange bones) and other (skull, spine and tail).

Duplicate clinical outcomes were removed from the database when the greyhound ID, date and injury type were the same. Veterinary examination reports were merged using RStudio (version 4.2.1, 2022: R Foundation for Statistical Computing, Vienna, Austria) with race data by greyhound ID and race date to link racing conditions with injury finding.

### Data analysis

Race number, starting box number, race distance, dog age, dog bodyweight, change in bodyweight from previous race, time since previous race and number of previous races (career races) were examined using descriptive statistics. Differences in age between fracture types and the population was examined using a Kruskal–Wallis test. Incidence rates (IRs) for fracture type were described as the number of events per 1000 starts with 95% confidence intervals (95% CI).<sup>4</sup> Differences between IRs were tested using a Chi-squared test. Normality was tested using an Anderson Darling test. Variables

were categorised using the author's discretion, based on quartiles, or clustering due to the structure of the racing programme or the underlying biology. Race grades were grouped based on the lowest grade dog permitted in a race as follows: category 1 (maiden, 0 wins), category 2 (novice, <3 wins), category 3 (grade 6), category 4 (grades 4–5 and free for all) and category 5 (grades 1–3 and open). Higher race grade categories represented greyhounds with greater athletic ability and performance records.

The incidence rate ratio (IRR) of fracture type and 95% CI at a univariable level were calculated using a Poisson regression in a generalised linear model for the following variables: year, season, race-track, race number, race grade category, start position, starting box number, race distance, dog sex, dog age (months), career races, change in bodyweight from previous race (kg), days since previous race and injury in previous race (yes/no). Variables were screened using a significance level of  $P < 0.2$  for inclusion in the multivariable model. The multivariable model for each fracture type was built using a backwards selection process whereby variables, that improved the model based on a Chi-squared likelihood ratio test ( $P \leq 0.05$ ), were retained in the model. Due to the low incidence of fractures in the proximal hindlimb, distal hindlimb and “other”, univariable and multivariable analyses could not be conducted for these fracture types. Tarsal bone fractures were considered as a separate entity from other hind limb fractures due to the high frequency of fractures at this anatomical location and potential differences in aetiology for tarsal bone fracture compared to the long bones. Confounding variables and interactions were examined and included if they improved model fit.

Statistical analyses were conducted using RStudio with a level of significance set at  $P < 0.05$ .

### Results

Over the seven-year study period (2017–2023), there were 198,008 starts in 26,795 races. There were 6163 greyhounds that had at least one start on tracks in Western Australia (WA). There was a relatively even distribution of male ( $n = 3299$ , 53.5%) and female ( $n = 2864$ , 46.5%) greyhounds racing, and they had a similar distribution of race starts ( $n = 106,438$ , 53.8% dogs vs.  $n = 91,570$ , 46.2% bitches). Greyhounds were a median of 21 months of age at their first career start [IQR 19–23 months] and had a median career length of 274 days [IQR 107–513 days]. The median age of a starter was 32 months [IQR 26–39 months]. Greyhounds typically raced weekly with a median time between races of 7 days [IQR 7–9 days]. The median race distance was 405 m [IQR 302–490 m].

During the seven years, there were 10,442 veterinary examinations from which 4168 examinations that did not report a clinical finding. There were 7530 recorded clinical findings from 6254 veterinary examinations. Fractures represented 8.9% of these clinical findings (670/7530).

### Fractures

There were 670 fractures identified in the clinical outcomes, of which 662 were related to a race. Eight fractures were excluded because they occurred before the race start and the dog was withdrawn from

the race. Therefore, the IR of race day fracture was 3.3 per 1000 starts (95% CI 3.1–3.6). These fractures were from 642 “events”, with multiple fractures recorded for 16 greyhounds. The median age of a greyhound with a fracture was 34 months [IQR 27–40 months]. Half of the fracture events (320/642, 49.8%) received the maximum stand-down period of 90 days (median 90, IQR 42–90 days). Of the fracture events, 137 resulted in fatality (euthanasia or sudden death) with an IR of 0.7 per 1000 starts (95% CI 0.6–0.8). There was a significant decrease ( $P < 0.05$ ) in the number of fatal fracture events after the introduction of the Greyhound Injury Full Recovery Scheme in 2019. The IR of fracture associated with a fatality before introduction of the Scheme (2017–2018) was 1.5 per 1000 starts (95% CI 1.2–1.9) and after introduction of the scheme (2020–2023) was 0.4 per 1000 starts (95% CI 0.3–0.5).

The majority of fractures were associated with a limb ( $n = 643$ , 97.1%) with only 19 (2.9%) fractures classed as “other” (Table 1). Of the fractures classed as other, 14 were tail fractures, 4 were spinal fractures and 1 was a nasal fracture. There were twice as many fractures reported in hindlimbs as in forelimbs (Table 1). The right hindlimb was the most commonly fractured limb (370/642, 57.6% of all fractures). The tarsus was the most common fracture site of all anatomical locations (344/642, 51% of all fractures).

**Forelimb fractures.** There was no difference in the incidence of fractures between the left and right forelimb or the proximal and distal regions. Greyhounds sustaining a forelimb fracture were younger than the median age of the racing population (30 months, IQR 24–38 months,  $P = 0.007$ ).

At the univariable level, racetrack, season, race grade category, race start position, race distance, age, career races, time since previous race and injury in previous race met the threshold to be included in the multivariable model for forelimb fractures (Supplementary Table 1,  $P < 0.2$ ). In the multivariable model, greyhounds were less likely to sustain a forelimb fracture on racetrack B (compared to A

or C) and if they were racing in the middle grades (categories 3 or 4) compared to inexperienced or higher-grade dogs. Greyhounds that had previous injury were more likely to sustain a forelimb fracture than uninjured greyhounds (Table 2).

**Tarsal bone fractures (Tarsus).** There were 344 tarsal bone fractures (Table 1), resulting in an IR of 1.7 (95% CI 1.6–0.8). Most tarsal bone fractures were in the right hindlimb (310/344, 90.1%). Greyhounds sustaining a tarsal bone fracture were older than the median age of the racing population (36 months, IQR 30–41 months,  $P < 0.001$ ).

At the univariable level, year, season, racetrack, race number, race grade category, age, time since previous race and career races met the threshold to be considered in the multivariable model (Supplementary Table 2,  $P < 0.2$ ). At the multivariable level, season, racetrack, age and days since previous race had an association with the risk of tarsal bone fractures (Table 3). Greyhounds that were 30 months or older had a greater risk of tarsal bone fracture than greyhounds 29 months and younger.

## Discussion

The current study is the first documented analysis of risk factors for race day fractures in the Western Australia greyhound racing jurisdiction. The results presented in the current study provide a basis of evidence for mitigation strategies to be put in place, that could reduce fracture risk. Although greyhound racing has similarities between jurisdictions, differences in racing population, management of racing and local geographic and environmental factors emphasise the need for identification of jurisdiction-specific risk factors.

In New Zealand, a jurisdiction with a similar base population and pattern of racing, the incidence for all fractures was two-thirds the rate in the current study (2.0 per 1000 starts).<sup>4</sup> However, there is a similar rate of fatal fractures between New Zealand and Western Australia. A possible contributing factor to the difference in IR for fractures is the method used for recording these events. Fractures on race day resulting in on-track euthanasia of the greyhound represent a significant event have a clear and easily identified case definition and are generally well recorded by the respective regulatory bodies. Therefore, differences in case definition and recording process may be a contributing factor in the jurisdictional differences in fracture IR. In Western Australia, injury data are recorded online with a series of drop-down boxes including boxes for body system and injury description. The use of prompts in an online recording system ensures specific and consistent recording of clinical findings,<sup>12</sup> which may mean greater identification of fracture cases and contribute to the greater IR found in this study. In contrast, the New Zealand study represented data collected using a paper-based system where race day veterinarians entered injury data into a series of tick and free text boxes which may result in a lack of consistency in reporting.<sup>5</sup> Since 2019, an online reporting process similar to WA has been implemented, which may result in a different IR being reported if the New Zealand study was subsequently repeated.

**Table 1.** Anatomical location and incidence rate (per 1000 race starts) of fractures for greyhounds racing in Western Australia in calendar years 2017–2023

Location	Affected limb		Total	Incidence rate [IQR]
	Left limb	Right limb		
Proximal forelimb	58	48	106	0.5 [0.4–0.6]
Distal forelimb	45	52	97	0.5 [0.4–0.6]
Total forelimb	103	100	203	1.0 [0.9–1.2]
Proximal hindlimb	3	10	13	0.07 [0.04–0.11]
Tarsus	34	310	344	1.7 [1.6–1.9]
Distal hindlimb	33	50	83	0.4 [0.3–0.5]
Total hindlimb	70	370	440	2.2 [2.0–2.4]
Other	-	-	19	0.1 [0.1–0.1]

$n = 662$ , 16 greyhounds had multiple fractures resulting in 642 fracture events.

**Table 2.** Multivariable incidence rate ratios (IRR) and 95% confidence intervals of forelimb fractures with race and greyhound-level variables sustained in calendar years 2017–2023 in Western Australia

Variable	Fractures	Starts	Incidence rate ratio	P-value	Wald P-value
<i>Race factors</i>					
<i>Racetrack</i>					
Track A	110	97,057	(referent)		0.022
Track B	63	86,287	0.7 [0.5–0.9]	0.007	
Track C	16	14,320	1.0 [0.6–1.7]	0.930	
<i>Race grade group</i>					
Category 1	33	23,992	(referent)		0.027
Category 2	48	40,378	0.9 [0.6–1.4]	0.514	
Category 3	32	38,288	0.6 [0.4–1.0]	0.040	
Category 4	65	86,345	0.6 [0.4–0.9]	0.006	
Category 5	11	8957	0.9 [0.4–1.7]	0.748	
<i>Dog factors</i>					
<i>Injured in previous race</i>					
Yes	9	4022	2.3 [1.1–4.3]	0.013	
No	180	193,986	(referent)		0.013

**Table 3.** Multivariable incidence rate ratios (IRR) and 95% confidence intervals of tarsal bone fractures with race and greyhound-level variables sustained in the 2017–2023 calendar years in Western Australia

Variable	Fractures	Starts	Incidence rate ratio	P-value	Wald P-value
<i>Race factors</i>					
<i>Season</i>					
Summer	112	47,250	1.5 [1.1–2.0]	0.004	
Autumn	85	49,906	(referent)		<0.001
Winter	76	50,667	0.8 [0.6–1.1]	0.276	
Spring	71	50,185	0.9 [0.6–1.2]	0.385	
<i>Racetrack</i>					
Track A	200	97,057	(referent)		<0.001
Track B	108	86,287	0.6 [0.5–0.7]	<0.001	
Track C	36	14,320	1.2 [0.9–1.8]	0.186	
<i>Dog factors</i>					
<i>Age (months)</i>					
<24	20	30,002	(referent)		<0.001
24–29	55	50,506	1.6 [1.0–2.8]	0.084	
30–35	87	46,338	2.7 [1.7–4.7]	<0.001	
36–41	102	34,900	4.1 [2.6–7.1]	<0.001	
42+	80	36,262	3.2 [2.0–5.5]	<0.001	
<i>Time since previous race (days)</i>					
<7	56	40,425	0.8 [0.6–1.1]	0.280	
7	149	89,056	(referent)		0.002
8–14	69	40,252	1.0 [0.7–1.3]	0.920	
15+	63	21,775	1.6 [1.2–2.1]	0.002	

The fatal fracture IR in Western Australia decreased dramatically during the study period, decreasing from 1.5 to 0.4 per 1000 starts. This change was mainly the result of RWWA implementing various

greyhound injury recovery schemes which provide funding towards the cost of repair and rehabilitation after serious race day injury. Historically, serious injuries and fractures were often associated with

euthanasia of the greyhound, as the cost of surgical repair and time to rehabilitate the greyhound were prohibitive for the owner/trainer.<sup>13</sup> However, in recent years, WA and other racing jurisdictions (including the rest of Australia and New Zealand) have placed greater emphasis on reducing the incidence of euthanasia from injury by greater investment from regulatory bodies towards injury management, rehabilitation and rehoming programmes.<sup>14,15</sup>

Within this study, fractures of the forelimb were separated from those of the hindlimb (specifically the tarsus) because they appear to have different aetiologies. The most common limb associated with fracture was the right hindlimb, which is similar to previous literature for greyhounds racing in an anticlockwise direction.<sup>10</sup> However, there was no difference in fracture risk between the left and right forelimbs. In racing Thoroughbreds, the centrifugal and ground reaction forces are greater on the bends, particularly in the leading limb in the forelimb and trailing limb in the hindlimb.<sup>16</sup> Likewise, greyhound racing on an oval track in an anticlockwise direction would place the most loading forces on the left forelimb and right hindlimb.<sup>17</sup> This mechanism of limb loading is supported by the finding of bone density asymmetry in the tarsal bones, such that dogs racing in an anticlockwise direction have a greater volumetric bone mineral density in the right versus the left tarsal bones.<sup>9,10</sup> The lack of difference between forelimbs in IR indicates that mechanical limb loading may not be the primary driver for injury in the forelimb, but rather fracture in the forelimb is associated with collision or interference events between greyhounds or with track infrastructure.

A lower risk of both forelimb and tarsal fractures was identified on track B, possibly due to a greater track circumference than track A and C. A smaller track circumference reduces the turn radius on the bends, increasing the loading and torsional forces placed on the limbs when turning and also increases the likelihood of dog-to-dog contact.<sup>6</sup> Track surface type has been reported to have an effect on greyhound galloping dynamics and injury risk, with sand tracks having a lower rate of injury than grass tracks.<sup>18,19</sup> However, all three tracks in this study were sand tracks so differences in risk of fracture are unlikely to be due to track surface unless the preparation of each track varied. Differences in fracture risk between tracks could also be due to other track features such as banking on corners and track condition that could not be accounted for in the current data.

Fractures in the forelimb, are most commonly associated with trauma sustained after a fall or collision with other greyhounds.<sup>6</sup> This agrees with the current study, because lower grade races were associated with a greater risk of forelimb fracture. Greyhounds in these races are likely to be less experienced and have a greater chance of making errors in judgement that result in collisions. The association of inexperienced greyhounds and tracks with a smaller turn radius would potentially exacerbate this risk.

A greater risk of forelimb fracture for greyhounds that were injured in their previous race may be confounded with the greater time between previous races. At the univariable level, there was a tendency for a greater fracture risk in the forelimb of greyhounds that had >15 days from the previous race. Days between races was not retained in the multivariable model,

which may be due to the variable “injury in previous race” providing a better model fit. However, days between races did remain in the multivariable model for tarsal bone fractures, possibly reflecting the differences in primary aetiology between forelimb and hindlimb fracture.

Trainers preferentially race their greyhounds every 7 days when in work. This racing frequency was associated with a lower risk of tarsal bone fracture than greyhounds that had not raced in the previous 15 days. Rest periods have been previously identified in Thoroughbred racehorses as a risk factor for fracture with spells (rest period) greater than 60 days reported to have greater risk of fracture.<sup>20</sup> Bone remodels by firstly resorbing damaged bone, making the bone more porous and secondly forming new bone which increases bone strength. The process of bone resorption is relatively quick, whilst bone formation is slow and depends on location and the severity of the remodelling.<sup>21</sup> In Thoroughbred racehorses, it has been proposed that bone remodelling is inhibited by continual cyclic loading during exercise, such as training or racing at high speeds.<sup>20,22</sup> However, there is a tipping point, and continued exposure to cyclic loading and inhibition of bone remodelling can result in microcracks that may propagate and merge to form stress fractures.<sup>23</sup> Although there are differences in racing frequency and spell length between horses and greyhounds, the principle that periods of decreased exercise intensity after periods of high-intensity training promotes bone remodelling remains the same for both species. It is possible that a spell of 15 days in greyhounds is sufficient to induce bone remodelling. If high-intensity exercise is resumed during this early stage of remodelling, bone strength may not be sufficient to withstand the loading and torsional forces associated with racing, and the risk of stress fracture may increase. Another possible reason for greyhounds racing every 7 days having a lower tarsal bone fracture IR is a “healthy dog” effect whereby greyhounds that are fit and healthy can maintain a consistent racing frequency and greyhounds that are unable to maintain a consistent pattern of racing due to pre-existing health conditions have greater risk of fracture.<sup>4,24</sup> However, the clinical outcome for the previous injury was not examined in the current study.

The tarsus has been previously reported to have the highest incidence of musculoskeletal injury in greyhounds.<sup>6</sup> During acceleration, the tarsus joint provides the most power for acceleration, particularly in the trailing limb.<sup>17</sup> Tarsal bone fractures were associated with track level variables, dog age and days since previous race, suggesting the cause of fracture is unlikely to be the result of interference with other dogs (as in the forelimb) but is instead related cyclic bone fatigue.<sup>6</sup> The seasonal effect of summer with a higher incidence of tarsal bone fractures may be a proxy or indicator variable for track condition. In summer, higher temperatures and less rain will result in firmer track conditions. Tracks in WA are frequently irrigated, but a recent review identified poor moisture content in tracks during summer.<sup>2</sup> It is often difficult in high temperatures and windy conditions to provide sufficient irrigation to mitigate the evaporation of moisture from the track. Track moisture content directly reflects track conditions such as cushioning and shear, and drier tracks are associated with faster race times as well as a greater risk of injury.<sup>19</sup> During the study period a number of different measurement techniques for track condition were

trials in WA, and this restricted the inclusion of a track condition descriptor within the analysis.

Increasing risk of fracture with increasing age has been reported in both greyhounds and Thoroughbred racehorses.<sup>4,25</sup> The increase in risk of fracture with increasing age is suggested to be as a result of the accumulation of microdamage on bone over time, from a high number of load cycles.<sup>22</sup> The lower relative risk of tarsal bone fractures in greyhounds over 42 months of age compared to 36–41 months of age may be a “healthy dog” effect, whereby dogs that do not have health concerns or career-ending fractures are more likely to be retained in the racing population to an older age.<sup>4,12</sup>

A limitation of the current study was that information on the fractures was constrained to information recorded in the WA racing dataset. Variables relating to trainer management, husbandry techniques and exercise regimes were outside the scope of this study but may be contributing factors to fracture risk. Although the number career races the greyhound had includes all races in Australia, the days between races and injury in previous race may not be accurate if a greyhound's previous race was outside of the WA jurisdiction. It is estimated that only 305 of the 6163 greyhounds included in this study may have had a race in other jurisdictions, contributing to only 4.9% of the racing population. Therefore, this effect was considered likely to be marginal. In addition, there were six forelimb fractures and seven tarsal bone fractures that were not included in their respective multivariable models, because these injuries occurred in greyhounds having their first race. These cases could not fit into a category for either; injured in previous race, or days since last race. Given these fractures represent less than 3% of their fracture types they were not expected to have a significant effect on the risk factor outcomes.

### Conclusion

This study provides evidence for the WA greyhound industry to develop evidence-based mitigation strategies to reduce the risk of greyhound limb fractures on race day. The most common greyhound race day fractures were in the forelimbs and the tarsus. Differences in risk factors between anatomical location reflects differences in injury aetiology. The greater risk of forelimb fracture in lower grades of racing suggests that these fractures are due to the inexperience of greyhounds resulting in racing errors, whereas tarsal bone fractures are associated with increasing age and cyclic bone fatigue. The significant effect of racetrack on fracture risk for both fracture types suggests that track configuration plays an important role in the likelihood of greyhound collisions as well as the magnitude of mechanical forces placed on bone around bends during high-intensity exercise. Increased risk of fracture associated with injury in previous race and increased days between races emphasises the importance of achieving an optimal balance between maintaining race fitness (and physiological adaptation) and providing sufficient recovery time after injury.

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### Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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### Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site: <http://onlinelibrary.wiley.com/doi/10.1111/avj.13377/supinfo>.

**Data S1.** Supplementary Tables.

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