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Description of the incidence, clinical presentation and outcome of proximal limb and pelvic fracture in Hong Kong racehorses (2003-2014)

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Summary

Reasons for performing the study: Few studies have described the incidence of proximal limb and pelvic fractures (PLPF) occurring in Thoroughbred racehorses on race-day and during training. There is limited information regarding clinical presentation and future racing career in PLPF cases.

Objectives: Describe the incidence, clinical presentation and outcome of PLPF sustained by horses in racing and training at the Hong Kong Jockey Club (HKJC) between 2003 and 2014.

Study design: Retrospective cohort study.

Methods: Horses with PLPF confirmed by nuclear scintigraphy, ultrasound, radiography, or through post mortem examination were identified using veterinary clinical records. Training and racing data for case horses were described. Incidence of fractures was estimated per 1000 horses in training and per 1000 race starts, for fractures sustained during racing. Descriptive statistics were used to describe the study population.

Results: A total of 129 PLPF were sustained by 108 racehorses. The most commonly fractured bone was the humerus (50%), followed by the tibia (29%). Nine horses sustained fatal fractures, eight of these were during racing. The incidence of fracture during racing was 0.30 per 1000 starts. Two-thirds of fractures occurred during training. The majority of horses presented with a grade 3 lameness (n = 42; 35%), while all horses presenting with a grade 5 lameness sustained fatal injuries. Following injury, all horses underwent box rest, with 82 horses resuming racing; 45 of these winning a race. Horses were retired a median of 25 (Interquartile range 15 to 36) months after injury.

Main limitations: Inability to calculate horse days at risk due to the way non-training racehorses are rested at the HKJC and rehabilitation regimens post-injury are recorded.

Conclusions: The incidence of PLPF at the HKJC is low. PLPF is not necessarily a career ending injury, with many horses resuming racing successfully following conservative treatment.

Introduction

In Thoroughbred racing, musculoskeletal injury (MSI) is a major welfare and safety concern and is the leading reason for days lost to training [1; 2]. MSI is the greatest reason for horse turnover in racing stables, with corresponding financial implications for the owner and the racing industry [3]. In addition, injuries, particularly on race-day, have an impact on public perception of racing [3]. While the majority of MSI occur in the distal limb, in the UK 30% of race-day fractures were due to fractures in the bones of the proximal limb and pelvis (PLPF), 45% of which had a fatal outcome [4].

Fractures of the bones of the proximal limb and pelvis can have a variety of clinical presentations [5-7]. Typically stress fractures cause acute lameness following fast work that soon eases in severity, although PLPF can present as mild lameness with an insidious onset [5;6]. The degree of lameness associated with stress fracture is typically greatest when the scapular is involved and progressively less severe when the tibia, humerus or radius are affected [7]. The diagnosis of PLPF is usually straightforward if severe, complete fracture has occurred. In many cases, however, a diagnosis cannot be immediately made, and further diagnostic tests such as nuclear scintigraphy are required to confirm the presence of PLPF. Nuclear scintigraphy has become widely accepted as the most sensitive method to detect stress fractures of the long bones and pelvis [5;6;8-10]. The use of radiography and ultrasonography may also be useful in the detection of some long bone and pelvic fractures [5;11;12]. In flat racing Thoroughbreds in Canada, 200 PLPF were diagnosed from 1075 nuclear scintigraphy exams, with the tibia being the most fractured bone [13].

To date, the occurrence of PLPF, including clinical presentation, diagnosis and outcome in a complete population of racehorses in training and racing has not been reported. Consequently, the objective of the current study is to describe the incidence, clinical presentation and outcome following PLPF in horses training at the Hong Kong Jockey Club (HKJC) between 2003 and 2014 (eleven racing seasons). This descriptive study will form the basis for further multivariable analyses of risk factors for PLPF in horses in training and racing at the HJKC. Due to the good prognosis with appropriate care following stress fracture [14-17], significant financial investment and intensive veterinary monitoring of horses post-fracture, we hypothesised that the majority of horses sustaining non-catastrophic injuries would return successfully to a racing career. Additionally, when bone is loaded at a faster rate, as occurs during racing, it is stiffer and stores more energy [18]. Therefore, if the bone fails it releases more energy resulting in a more catasrophic inury. As race times are faster than training times, we hypothesised that the majority of fatal fractures would occur during racing.

Materials and methods

Study design and population

A retrospective cohort study of all Thoroughbreds in racing and training at the HKJC between August 2003 and July 2014 was conducted. All Thoroughbreds racing in Hong Kong are imported, and the majority are colts or geldings [19]. The HKJC administers and regulates all racing in Hong Kong, which is held on the flat, at one of two racecourses: Sha Tin and Happy Valley [20]. Racing takes place twice a week, from September to July, with turf and a conventional dirt track available for racing. All racehorses are housed and trained at facilities in Sha Tin, which can stable a maximum of 1250 horses at any one time. Most training in Hong Kong is undertaken on dirt tracks, with horses allowed an occasional gallop on turf.

All Thoroughbred racehorses in training at Sha Tin Racecourse were eligible for inclusion in the study. Horses were excluded from the study if they were not part of the training population (e.g. retired or riding school horses).

Case definition and identification

Cases were defined as any event when a racehorse suffered a fracture or fractures to the bones of the proximal limb or the pelvis during training or racing activities. In order to identify cases, a search of the HKJC's custom veterinary management information system (VMIS) was conducted to identify all fracture cases involving bones of the proximal limb (radius, humerus, scapular, tibia, femur) and pelvis (ilium, ischium and pubis). Search terms included fracture plus radius and/or humerus and/or tibia and/ or scapular and/or femur and pelvis.

Clinical records for each horse identified using the search criteria were retrieved from the VMIS and reviewed. PLPF sustained in circumstances unrelated to training or racing were not included in the study (n = 12). Fractures were categorised as either stress fractures or incomplete, complete, displaced or comminuted fractures of the long bones of the proximal

limb and pelvis. For a case to be included in the study a definitive diagnosis by post mortem examination, nuclear scintigraphy or bone scan and/or radiography and/or ultrasonography was required. Cases with only a tentative diagnosis of PLPF and/or in which no further diagnostic investigation was performed were excluded (n = 24).

Data collection and variables

Data were collected over 11 racing seasons and included complete population information for each year, encompassing the number of horses in training, number of races held (in total and on each surface; turf or dirt), the number of starts, and the proportion of the population that raced and won a race. These data were collected from an official HKJC racing information system (RIS). Data for the case starts included the country of origin, foaling date, sex, import date, retirement date, trainer and whether the horse had raced before importation to Hong Kong. Data relating to the fracture included: date of injury; age at the time of injury; time from injury to diagnosis; location and description of the fracture, limb(s) affected, degree of lameness at initial presentation, when the fracture occurred (racing, training, barrier trials, accident), modalities used for diagnosis (ultrasound, radiography, nuclear scintigraphy, necropsy) and the race records before and after the fracture.

Data analysis

In this descriptive study, non-normally distributed continuous explanatory variables were described as medians and interquartile range (IRQ) and normally distributed continuous variables as means and standard deviations (s.d.). Normality of the data was determined through the assessment of histograms. The remaining explanatory variables were described as counts and percentages.

In Hong Kong, the racing season runs from early September until the following July. The incidence of PLPF was presented per year as i) per 1000 horses in training at the HKJC and ii) per 1000 race starts (starts). As the total number of horses in training at Hong Kong was only available for each racing season, the overall incidence of PLPF was calculated as the average annual incidence per 1000 horses. Fractures sustained during racing were described

per 1000 starts in total, on turf surfaces and on dirt surfaces, respectively. Fatal fractures that occurred during racing were described per 1000 starts. Data were stored in a Microsoft Excel spreadsheet and manipulated in Stata version 11.1[a].

Results

During the 11 racing seasons included in the study (2003 to 2014) there were an average of 1468 (s.d. 102.4) horses in training each year (Supplementary Item 1). There were a total of 102,785 starts over 8147 races; of these, 11,111 starts (10.8%) in 881 (10.8%) races were held on dirt tracks, with the remaining starts on turf. One-third (32.5%) of the horses that had raced in Hong Kong over the study period had finished first in at least one race.

A total of 108 racehorses sustained 129 PLPF, during 119 injury events (Table 1). In ten injury events horses fractured multiple bones; the humerus and radius (n = 9 horses) and the tibia and radius (n = 1 horse). Eight horses sustained fractures on two separate occasions. One horse sustained fractures on four separate occasions; two tibial fractures (right hind and left hind) and two radial fractures in the right fore. The most commonly fractured bone was the humerus (n = 59/119; 49.6%), followed by the tibia (n = 35/119; 29.4%). The highest annual incidence of fracture occurred during the 2008/2009 racing season: 11.6 per 1000 horses (Fig 1).

The median age of horses at the time of fracture was 4 (IQR 3 to 5) years. Horses with scapular fractures had a median age of 7 (IQR 5 to 8) years, horses with tibia fractures had a median age of 4 (IQR 3 to 4) (Table 1). At the time of fracture, horses had been in Hong Kong a median of 12 (IQR 4 to 27) months. Of the horses with fracture, 88.0% (n = 95/108) were geldings, 11.1% (n = 12/108) were colts and one was a mare.

Nine horses sustained fractures that led to their immediate demise. Five horses were euthanised following comminuted fractures of the scapular; four of these fractures involved the scapulohumeral joint. Four horses were euthanised after fractures of the humerus: two of which were comminuted and two simple, complete.

Racing and training

The majority of horses (n = 74; 62.2%) had raced prior to fracture: 45 cases (37.8%) had not run in a race. Horses that had raced prior to fracture had raced a median of 16 (IQR 4 to 23) times (Table 2) and 65% (n = 48/74) of these had come first in at least one race, for a median of 2 (IQR 1 to 4) wins.

In total, 26.1% (n = 31/119) of PLPF occurred during racing, 8.4% (n = 10/119) during barrier trials and 65.5% (n = 78/119) during training. The overall incidence of PLPF in racing was 0.30 per 1,000 starts on both turf and dirt surfaces; 0.27 per 1,000 starts on dirt and 0.31 per 1,000 starts on turf tracks. The incidence of fractures during racing was highest in the 2007/08 racing season with 0.55 per 1000 starts (Fig 1). Five scapular fractures occurred during racing and one during barrier trials. Eight of the nine fatalities occurred during turf racing, for an incidence of 0.08 per 1000 starts.

Nine of the ten fractures occurring during barrier trials were on the dirt track. No information regarding the number of horses starting in barrier trials was available for the calculation of incidence rates.

The incidence of fracture during training was highest in the 2008/09 racing season, with 8.22 fractures per 1000 horses (Fig 1). One fatal fracture to the humerus occurred during training.

Clinical presentation

Other than cases euthanised immediately, horses were diagnosed with fracture a median of 7 (IQR 4 to 11) days after the incident during which the fracture was thought to occur (Table 1). Pelvic fractures were diagnosed a median of 1.5 (IQR 1-11) days, and radial fractures a median of 13 (IQR 7-20) days after the fracture was thought to occur. All horses presented with lameness on initial examination. In eight (6.7%) injury events horses were Grade 1 lame, 36 (30.3%) were Grade 2 lame, 42 (35.3%) Grade 3 lame, 25 (21.0%) Grade 4 lame

and eight (6.7%) Grade 5 lame. All horses that presented with Grade 5 lameness were euthanised. The affected limb was a forelimb in 72 (60.5%) injury events: 41 (57%) right fore, 27 (38%) left fore and 4 (5%) both fore. The hindlimb was affected in 46 (38.7%) injury events: 18 (39%) right hind, 25 (54%) left hind and 3 (7%) both hind. In one horse the right fore and left hind limb were affected. Five out of six scapular fractures occurred in the right fore.

All horses that were euthanised had the type of fracture confirmed at post mortem examination. In other cases, the diagnosis was made using nuclear scintigraphy (n = 99; 83.2%), all of which were positive; radiography (n = 62; 56.4%), 69% of which were positive; and ultrasonography (n = 11; 9.2%), 73% of which were positive. In 55.5% (n = 61) of horses more than one diagnostic modality was used to confirm the fracture. Of the fractures with non-fatal outcomes, treatment was conservative and consisted of box rest followed by hand walking only.

Outcome following fracture

The majority of horses (n = 81; 73.6%) returned to racing a median of 169 (IQR 123 to 204) days after sustaining a PLPF (Table 3). Horses that did race again competed in a median of 14 (IQR 6 to 24) races after recovery from the injury; 45 horses won races for a median of 2 (IQR 1 to 4) wins (Table 3). Seventeen horses were still in training at the end of the 2013/2014 racing season. In total, 59 horses had retired from training and racing a median of 25 (IQR 15 to 36) months after fracture. Twenty-three horses that suffered PLPF retired without returning to racing a median of 5 (IQR 2 to 8) months after sustaining the injury. In 13 of these horses, retirement was directly attributable to the PLPF.

The most common reasons for retirement were associated with MSI (n = 44; 52%; 13 due to PLPF, 7 distal limb fractures, 10 tendon injuries, 11 with “lameness”, 3 osteoarthritis), followed by voluntary retirement for performance related reasons and age (n = 25; 30%), exercise induced pulmonary haemorrhage (n = 11; 13%) and other medical reasons (n = 5; 5%).

Discussion

The current study, conducted over 11 racing seasons, has described the type and incidence of PLPF reported during training and racing in a cohort of Thoroughbred racehorses in Hong Kong. The population studied were under consistent, intense veterinary care and scrutiny. The overall incidence of PLPF on race-day was 0.30 per 1000 starts, with the incidence of race-day fatality 0.08 per 1000 starts. These rates appear to be lower than previous studies utilising surveillance data. Over comparable time periods, race-day PLPF rates were reported at 0.42 per 1000 starts in the UK [21], while race-day fatalities were reported at between 0.18 and 0.19 per 1000 starts, in the UK [21] and California [22]. When described separately, the rates of fatal scapular [22; 23] or humeral [22; 24] fracture were comparable with previous studies. In 2015, the California Post Mortem program reported 23 fatalities due to PLPF [25]. However, fatal PLPF were not stratified by where the injury occurred nor were the total number of horses in training provided, making comparison with the current study difficult. Despite this, the overall rates of injury due to PLPF and fatality appear to be lower than in other racing jurisdictions, although the reasons for this finding are not immediately apparent. Differences in training and racing regimens, racehorse surveillance and veterinary care will vary across these racing jurisdictions, leading to different risk profiles for horses racing in these different locations.

In the current study, the humerus was the most commonly fractured bone, followed by the tibia. The overall age of horses at the time of fracture (4 years old) was higher than reported in previous studies, with the majority of tibial and humeral fractures reported to occur in 2- and 3-year-olds, respectively in Australia [6]. In the UK 3-year-olds were at an increased risk of sustaining tibial and pelvic stress fractures [26]. In the US, the median age of horses presenting for upper limb stress fractures was 3 years [13], with studies in the US, Canada and the UK identifying the tibia and the pelvis to be the most commonly affected bones [4;13;27]. The age structure of racehorses in the population at the HKJC is different to those included in other studies and may explain why humeral fractures were relatively common. Tibial stress fractures are predominately seen in younger (2-year-old), unraced or lightly raced horses, whereas humeral stress fractures seen more commonly in 3-year-olds and/or more extensively raced horses [5;6;28;29]. The majority of horses in training in Hong Kong are 3-year-olds and many horses remain in competitive racing until forced retirement at 10 years of age.

The majority of fractures occurred during training, with 8% during barrier trials and 24% during races. This is consistent with a UK study, where 78% of all-cause fractures occurred during training [27]. In the current study, scapular fractures only occurred during racing, and of the six scapular fractures, five were catastrophic. In contrast, in the US, Vallance *et al*. [23] identified that 55% of scapular fractures occurred during training. Additionally, in the current study all scapular fractures occurred on the right front limb. The number of horses and limb affected is consistent with previous studies of catastrophic fractures in the US, where scapular fractures accounted for 2% of Thoroughbred MSI [30]. In the US, catastrophic scapular fractures had a right forelimb predilection and horses run to the left or in an anti-clockwise direction [23]. It was hypothesised that this was a result of horses relying more on support from the right limb, as the left limb was the lead [31;32], with the banking of the track also playing a role [23]. The current study would appear to contradict the previous hypothesis, as horses race and train in Hong Kong in a clockwise direction and the track is not banked. However, the number of scapular stress fractures were small in comparison to the study by Vallance *et al*. [23], with more Hong Kong horses having started in a race for more race starts prior to fracture, compared to horses in California with more race starts [23].

The high incidence of catastrophic failure of scapula fractures (83%) compared to that of humeral fractures (7%) presumably reflects the fact that stress fractures of the scapula progress to a critical point before horses show notable clinical signs (i.e. lameness). Our finding that 36% of all horses presented with only mild lameness emphasises how important it is for trainers and clinicians to take this sign seriously in horses at risk of sustaining stress fractures. Further, horses in this study were diagnosed on average seven days after the fracture was thought to have occurred. The precise reasons for this delay were not ascertained and we did not record if these horses were rested during this time and therefore lameness went unnoticed or if they were initially showing subtle clinical signs that worsened with work. Part of the delay can be explained by an inevitable wait to undertake a nuclear scintigraphic study in some cases.

The majority of horses with PLPF returned to racing, with more than half winning a race post-fracture. Given appropriate rest of 3-4 months with at least one month of complete stall rest, horses should recover from stress fractures of the PLPF with a good prognosis for a future athletic career [14-17]. Of the horses that were retired after PLPF, only a small number were as a result of the fracture. The percentage of horses that returned to racing is similar to a previous study (77% to 80% in Randwick, Australia versus 76% in Hong Kong),

although those authors only described fractures of the tibia and humerus [6]. There are multiple variables that may contribute to the occurrence of a fracture, such as pre-existing pathology [7;23;30;33], horse age [6;13;26], track surface [13;34], level of training [35], speed and distance [36]. It is interesting to note that over half of the horses that sustained a fracture subsequently raced, and won at least one race. This is in comparison to the population average of just under one-third of horses placing first in all races over the study period. This warrants further investigation of the performance of horses prior to fracture, to explore whether winning horses are predisposed to PLPF.

Geldings sustained the highest number of PLPF during the study period. However, as there is no Thoroughbred breeding in Hong Kong and all horses are imported for racing [14], the majority of horses are geldings or colts. The lack of mares in the population complicates comparison of our findings to those of other racing jurisdictions.

Further limitations of the current study relate to the collection of information regarding training regimes pre- and post-fracture and on the management of horses during rehabilitation. Lack of distinction in the records between horses in the overall population that were training and temporarily not training meant that we were unable to calculate horse days at risk. This further limits comparison of our data with previous studies. Collection of information regarding training and spelling regimens and racing frequency pre-fracture would allow for the identification of specific risk factors.

Conclusion

This study identified that the humerus was the most commonly fractured upper limb bone in racehorses in Hong Kong. It also highlighted the low rate of mortality associated with PLPF and the high rate of return to successful racing of horses following a stress fracture of the upper limb. Further work is required to compare cases reported here to a cohort of horses that did not experience PLPF in an attempt to identify risk factors associated with the development of a PLPF.

Authors' declaration of interests

No competing interests have been declared.

Ethical animal research

The publication of this study was approved by Royal Veterinary College Publication Committee, approval number PPH_01431. Owner consent to use retrospectively collected data was granted by the acceptance of owners of the Rules of Racing of the HKJC, under rule 46.1 and 46.2, when their racing permit was granted.

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Authorship

L. McGlinchey, M. Hurley and C. Riggs were responsible for the objectives and study design. L. McGlinchey performed the case selection and data collection. S. Rosanowski conducted the statistical analyses. All authors were involved in the interpretation of the results, preparing and approving the final manuscript.

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Supplementary Information

Supplementary Item 1: Horses with proximal limb and pelvic fractures.

Figure legend

Fig 1: The incidence of proximal limb and pelvic fractures (PLPF) sustained in 119 injury events by racehorses in training at the Hong Kong Jockey Club (2003-2014), by racing season. (a) the total and during training incidence of PLPF presented per 1000 horses in training; (b) the total and fatalities per 1000 starts. One PLPF resulting in euthanasia occurred during training.

Table legends

Table 1: Description of horses with proximal limb and pelvic fractures sustained in 119 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

Table 2: Description of pre-fracture performance of horses with proximal limb and pelvic fractures sustained in 119 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

Table 3: Description of post-fracture performance of horses with non-fatal proximal limb and pelvic fractures sustained in 110 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

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Table 1: Description of horses with proximal limb and pelvic fractures sustained in 119 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

Fracture location	Number (percentage) of fractures[a]	Median age in years (IQR)	Median time (months) in Hong Kong (IQR)	Time (days) until diagnosis (IQR)
Humerus	59 (49.6)	4 (3 - 5)	13 (3 - 27)	7 (5 - 10)
Pelvis	10 (8.4)	4.5 (4 - 6)	17 (4 - 31)	1.5 (1 - 11)
Radius	17 (14.3)	4 (4 - 5)	20 (12 - 32)	13 (7 - 20)
Tibia	35 (29.4)	4 (3 - 4)	9 (4 - 17)	6 (3 - 9)
Femur	2 (1.7)	2.5 (2 - 3)	4.5 (2 - 7)	8.5 (4 - 13)
Scapula[b]	6 (5.0)	7 (5 - 8)	46.5 (18 - 67)	14
Total	119	4 (3 - 5)	12 (4 - 27)	7 (4 -11)

[a]Percentage greater than 100% as 8 horses sustained more than one type of fracture in one injury event.
[b]Of the 6 scapular fractures, 5 required immediate euthanasia.
IQR = interquartile range

Table 2: Description of pre-fracture performance of horses with proximal limb and pelvic fractures sustained in 119 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

Fracture location	Horses that raced n (%)	Median number of races (IQR)	Number of first placings n (%)[b]	Median number of firsts (IQR)
Humerus	37 (62.7)	16 (3 - 23)	27 (73.0)	1 (1 - 2)
Pelvis	7 (70.0)	19 (3 - 23)	3 (42.9)	5 (2 - 5)
Radius	14 (82.4)	16 (3 - 21)	10 (71.4)	2 (1 - 4.5)
Tibia	17 (48.8)	4.5 (2 - 20)	9 (52.9)	3 (2 - 4)

Scapula	6 (100)	36.5 (5 - 51)	4 (66.7)	4 (3 - 7.5)
Total	74 (62.2)[a]	16 (4 – 23)	48 (64.9)	2 (1 – 4)

[a] The denominator for this percentage is the total number of horses with this fracture type (total = 119)
[b] The denominator for this percentage is the total number of horses with this fracture type that had raced (total = 74)
IQR = interquartile range
Note: no horses with femural fractures had raced prior to fracture.

Table 3: Description of post-fracture performance of horses with non-fatal proximal limb and pelvic fractures sustained in 110 injury events reported at the Hong Kong Jockey Club between 2003 and 2014, stratified by the anatomical location of the fracture.

	Post proximal limb and pelvic fracture					
Fracture location	Horses that raced n (%)[a]	Median time until first race (days)	Median number of races (IQR)	Number of first placings n (%)[b]	Median number of firsts (IQR)	Time (months) until retirement (IQR)[c]
Humerus	42 (71.2)	168.5 (131 - 203)	10.5 (4 - 24)	20 (47.6)	1.5 (1 - 3)	10 (5 - 25)
Pelvis	6 (60.0)	210 (193 - 250)	16 (11 - 20)	3 (50.0)	3 (2 - 5)	14 (3 - 27)
Radius	10 (58.8)	176.5 (168 - 235)	14.5 (3 - 24)	5 (50.0)	4.5 (2 - 5)	10 (6 - 27)
Tibia	27 (77.1)	136 (107 - 194)	16 (10 - 28)	18 (66.7)	1.5 (1 - 4)	22 (6 - 36)
Femur	2 (100)	207.5 (112 - 303)	12.5 (6 - 19)	1 (50.0)	1 (1 - 1)	26 (16 - 36)
Total	81 (73.6)	169 (123 – 204)	14 (6 – 24)	45 (55.6)	2 (1 – 4)	13 (4.5 – 28)

[a] The denominator for this percentage is the total number of injury events with this fracture type (total = 110)
[b] The denominator for this percentage is the total number of injury events with this fracture type that had raced (total = 81)
[c] Including horses that did and did not race post-fracture
IQR = interquartile range