Identifying optimal greyhound track design for greyhound safety and welfare

Phase I Report Jan 2016 to 31 Dec 2016

by A/Prof David Eager, Ms Hasti Hayati and Mr Imam Hossain
for Greyhound Racing NSW

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University of Technology Sydney
PO Box 123
Broadway NSW 2007 Australia
ABN 77 257 686 961

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1.0 INTRODUCTION

PURPOSE OF THIS REPORT[1]

1.1 The purpose of this report (hereafter '**this Report**') is to summarise the work undertaken by UTS during Phase I of the greyhound race track design safety and welfare study.

BACKGROUND

1.2 In early 2016 GRNSW sought proposals from suitably qualified organisations and individuals to investigate factors influencing greyhound race track safety (as defined by incidents and injury risk) and develop best-practice recommendations (see Appendix D) [1].

1.3 Submissions closed on 5 February 2016.

1.4 A research services agreement between GRNSW and UTS was executed on 15 February 2016.

1.5 The term of this research services agreement was for 12 months commencing on 4 April 2016.

1.6 The UTS research team was established reporting to Dr Liz Arnott, Chief Veterinary Officer GRNSW.

1.7 The UTS research team was instructed to focus their resources on non-straight track injury interventions.

1.8 Dr Arnott arranged for Mr Bill Wilson to deliver a familiarisation presentation at UTS to the UTS research team on 11 April 2016.

1.9 A condition of the research services agreement was that UTS obtain appropriate Animal Ethics approval.

1.10 The UTS team formally applied for Animal Ethics approval on 12 May 2016.

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[1] This document shall only be reproduced in full inclusive of the Appendices.

1.11 UTS visited GRV on 15 May 2016 and placed orders for track measurement equipment as recommended by Mr Adam Bailey (moisture meter, penetrometer tester etc.).

1.12 Richmond introduced a 'hoop arm' lure on 1 July 2016.

1.13 Animal Ethics application ETH-0367 approved on 6 July 2016.

1.14 The NSW Government announced on 7 July 2016 that greyhound racing would be banned in NSW from 1 July 2017.

1.15 UTS were instructed to approach other greyhound jurisdictions on 8 July 2016.

1.16 UTS requested injury and track data from GRV and GRSA on 9 July 2016.

1.17 UTS advised by the commercial supplier of inertial measurement units (IMU) that they would not modify software or hardware for greyhound project on 11 July 2016.

1.18 UTS attended Weka data mining technique workshop on 11 July 2016.

1.19 UTS commenced working on the development of a specific greyhound IMU on 1 August 2016 using the InvenSense MilSpec platform.

1.20 UTS presented preliminary findings to GRNSW, GRV and GRSA (at GRV HQ) on 2 August 2016. At this presentation GRV and GRSA agreed to provide injury and track data.

1.21 On 11 August 2016 the Animal Ethics conditions were extended to include that no research shall commence until researchers have completed and obtained an 80% pass grade in an approved Animal Ethics course.

1.22 Dr Liz Arnott resigned on 16 September 2016.

1.23 Tri-axial accelerometer, SloMo video and paw print survey first trialled at Wentworth Park on 4 October 2016.

1.24 The NSW Government reversed the ban on 11 October 2016.

1.25 The NSW Government announced the formation of the Greyhound Industry Reform Panel on 11 October 2016.

1.26 Animal Ethics Annual Report ETH-0367 submitted on 12 December 2016.

1.27 Animal Ethics Annual Report ETH-0367 accepted on 16 December 2016.

1.28 The Greyhound Industry Reform Panel published their recommendations on 18 February 2017.

1.29 UTS has met and/or discussed the project with a number of greyhound industry stakeholders, including but not limited to: Dr Liz Arnott; Ms Ranga Javamanne; Mr Scott Higgins; Mrs Thorsby; Mr Geoff Collins; Dr John Newell; Mr Ivan Akmacic; Mr Dean Degan; Mr Craig Youll; Mr Bob Whitelaw; Mr Bruce Teague; Mr Michael Eberand; Mr John Tracey; Ms Ellen Harris; Mr Brenton Scott; Mr Adam Bailey; Mr Scott Robins; Mr Steve Karamatic; Mr Rob Tyler; Mr Ken Burnett; Mr Scott Wuchatsch; Ms Susan Howard; Mr Tim Whiticker; Mr Brad Adams; Mr Peter Rodgers; Mr Steve Miksic; Dr Gavin Goble; Mr Glenn Midson; Mr Mick Floyd; Grey Miller; Mr Patrick Hallinan; Mr John Gibbons; Ms Sandy Natarajan; and Dr Rick Simons.

1.30 Tracks visited during this reporting period include: Wentworth Park; Richmond; Nowra; Lismore; The Gardens; Healesville; and Sandown.

2.0 LITERATURE REVIEW

2.1 The safety and welfare of racing greyhounds is a concern and has been discussed in literature [2-45].

2.2 In this section, firstly a brief background will be provided. This will be followed by discussion on racetrack design. Finally three frequent types of race related injuries will be discussed.

BACKGROUND

2.3 Human athletes run only half as fast as greyhounds, maintaining constant average running speeds of about 29 km/h versus 65 km/h [46]. This is due to greyhounds' unique body structure that has made them ideal sprinters [45].

2.4 A high rate of acceleration and change of rate of acceleration (jerk) [47] has made the race track a potentially hazardous area for racing greyhounds. Moreover, injuries common on racetracks are unique in racing greyhounds, suggesting specific types of injuries are closely correlated with racetrack design. This observation was previously documented by researchers [6, 7, 11, 12, 17, 20, 24, 25, 40, 43].

2.5 Greyhounds are subjected to centrifugal and gravitational forces while negotiating the bend [8, 44].

2.6 The centrifugal force is calculated using the following equation:

$$F_c = mv^2/r \qquad (1)$$

where F_c represents the centrifugal force, m represents mass of the greyhound, v represents the velocity (speed) of greyhound and r represents the radius of curvature i.e. the track radius [8].

2.7 To maintain speed and dissipate excessive forces a greyhound should 'lean' toward the inside rail [8] as shown in Figure 2.1.

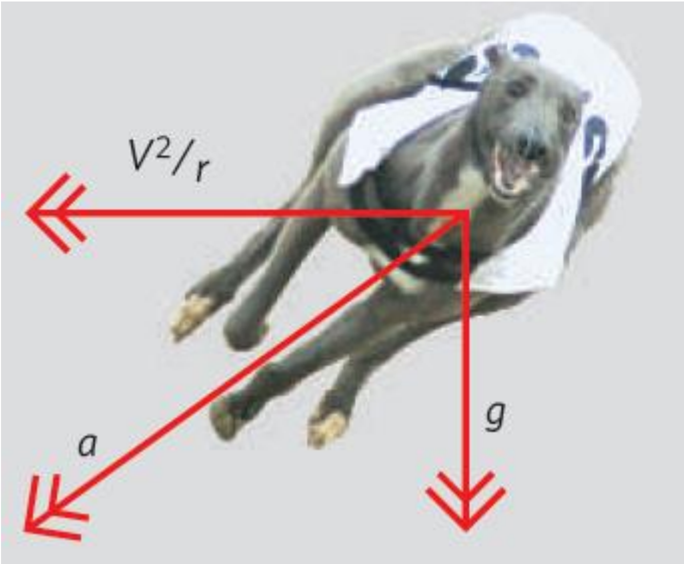

Figure 2.1: Greyhound leaning while negotiating the bend. *g* shows the force due to gravity, v^2/r shows centrifugal acceleration and *a* is the resultant acceleration [44].

2.8 Greyhounds take two protective actions to dissipate the excessive forces acting on their limbs. They either slow down (reduce *v*) or run on a larger radius (increase *r*) [8].

2.9 A slowing down strategy creates an interference or congestion area which is particularly common on tracks with small radius and little banking [8].

2.10 Figure 2.2 illustrates a slowing down scenario.

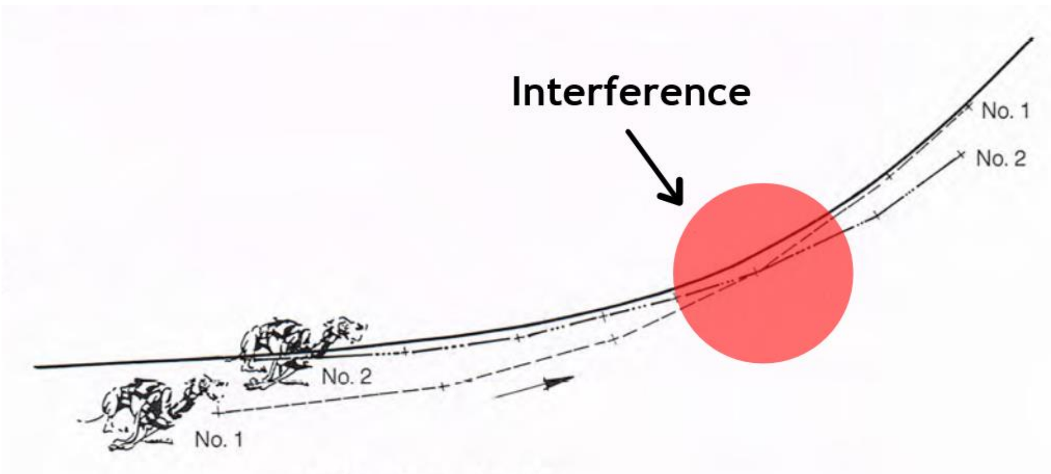

Figure 2.2: Consequence of short track radius and flat banking [8].

2.11 In Figure 2.2 the greyhound labeled No. 2 is in search of a larger radius which results in interference with the greyhound labeled No. 1. The consequence is a higher probability of an interference incident occurring.

2.12 It should be noted that due to the biomechanical difference between car racing and greyhound racing, it is inappropriate to deploy car raceway design strategies in designing greyhound racetracks [8]. For the race car the centre of gravity is fixed in relation to its supports and therefore it cannot balance the forces by leaning.

2.13 The following four issues will now be discussed:

1) Track geometry (track radius and banking);

2) Track surface;

3) Impact of track design on injury rate; and

4) Common types of track-related injuries.

TRACK DESIGN

TRACK GEOMETRY (TRACK RADIUS AND BANKING)

2.14 Analyzing the variation in greyhound maximum speeds on different tracks confirms that the larger the track radius and the steeper the banking, the faster the speed [8]. In other words, the combination of larger track radius and steeper banking (camber) allows for greater speed.

2.15 Faster speed is possible on tracks of a larger radius and steeper banking because these track characteristics reduce the degree to which greyhounds need to 'lean' towards the inside rail [8].

2.16 Usherwood and Wilson, in a paper titled 'No force limits on greyhound sprint speed', noted that no speed reduction has been observed in turning on a banked surface [44].

2.17 The authors of this report suggest that a track radius and surface banking should be designed in a way to reduce excessive limb forces acting on greyhounds while racing (Figure 2.1).

TRACK SURFACE

2.18 According to Ireland in Bloomberg two important factors need to be considered in choosing an appropriate an track surface, namely: the design of track drainage; and track surface materials [8].

2.19 A drainage system is essential in controlling the scour and movement of the surface material in the presence of storms mainly in heavy rainfall regions such as Australia which would imply an excessive cost of maintenance and also safety issues for racing greyhounds [8].

2.20 An example of a drainage system is the Parkland 'grass' track in Queensland, Australia is shown in Figure 2.3 below [8].

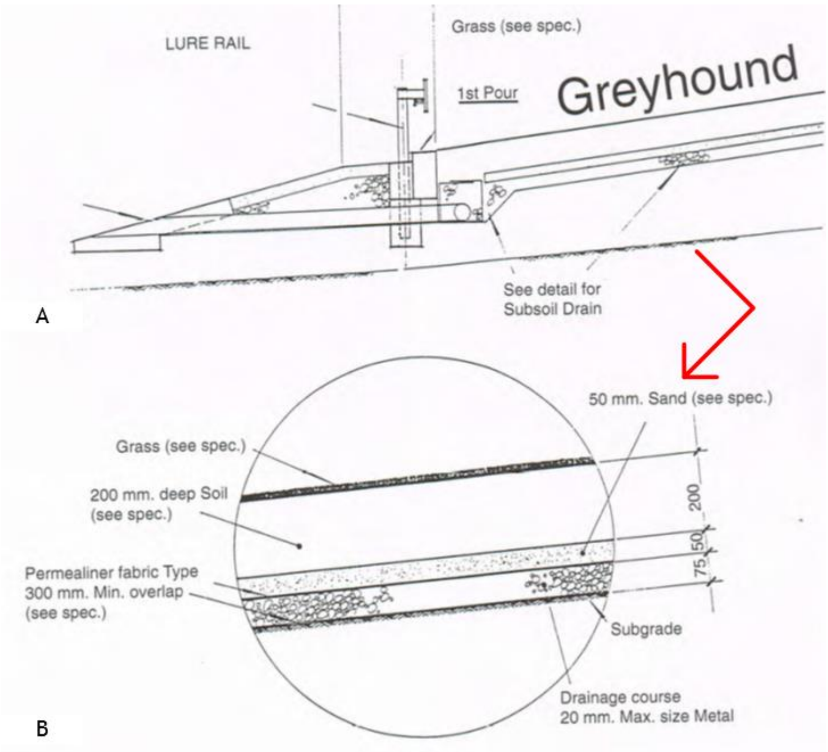

Figure 2.3: (A) Cross-sectional view of the drainage system at the Parkland track in Queensland, Australia. (B) Details of the drainage system at the Parkland track in Queensland, Australia [8].

2.21 The base layer of this track allows for the required drainage. The concrete side-stone (Figure 2.1 (A), 1st pour) is constructed at the inside of the track, supports the pavement materials and maintains the design level for the inside of the track [8].

2.22 Land-based animals exert limb forces on the terrain to move. The magnitude of the forces exerted depends on the selected gait pattern i.e. the faster the speed, the larger the magnitude of the exerted force and the smaller the stance period [48]. Accordingly to prevent the risk of injuries caused by excessive impact forces as induced by locomotion, it is important to know the type and mixture of surface materials.

2.23 In the US, the mixture of the track materials are sand, silt, clay and water. Particles are also defined by their size i.e. Clay (< 0.002 mm), Silt (0.002-0.05 mm), and sand (0.05-0.2 mm) [19].

2.24 The 'ratio' of aforementioned components is important as it determines how the track absorbs impact forces and therefore provides a safer track [19]. For greyhound racing, the materials of the track surface should be resilient and should also have enough moisture content to dissipate the exerted forces [8].

2.25 Ireland in Bloomberg [8] recommends that a mixture of light-colored loam with white sand is an ideal for greyhound race tracks. In order for greyhounds to run with a smooth gait, the track surface should provide enough friction which depends on the compactness and the moisture of the subsurface [8].

2.26 The moisture consistency influences the compressive strength (the strength the surface material required to withstand the force of impact) and the shear strength (the strength of the material that allows propulsion of the support limb). Accordingly, Ireland in Bloomberg notes the moisture should be maintained within ± 2% of the optimal value as moisture level greater than the optimum produces a sloppy track and moisture level lower than the optimum level produces a dry and therefore hard track [8].

2.27 A hard track for instance would exert excessive forces on greyhounds' limbs which would result in injuries and a sloppy track would throw sand into the eyes of following greyhounds [8].

2.28 For a sandy loam track surfaces, the particle triangle depicted in Figure 2.4 shows the accurate mixture of percentage sand, clay and silt and is commonly utilised on US greyhound tracks [19].

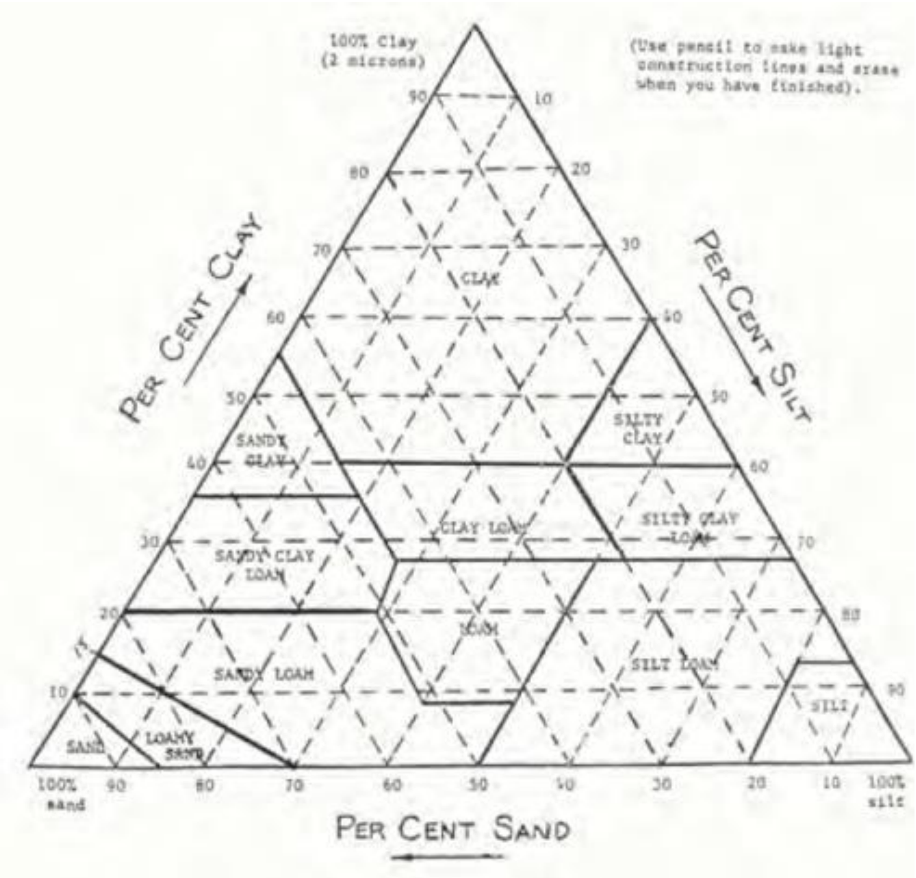

Figure 2.4: A particle triangle showing the percentage mixture of sand, silt and clay [19].

2.29 To analyse the track surface mixture ratio of clay, silt, and sand, samples should be taken from different locations along the track [19].

2.30 Gillette [19] advises a 'sandy loam' or 'loamy sand' mix is the optimum combination for the greyhound track surface.

2.31 He recommends at least 8 samples need to be taken from the following locations of the track to assess the components of track surface:

1) In front of starting boxes;

2) Mid-track of the Home Straight;

3) The rails entering the first turn;

4) Mid-track entering the first turn;

5) The rails at the middle of the first turn;

6) Mid-track of the middle of the first turn;

7) Mid-track of the Back Straight;

8) The rails entering the second turn; and

9) Middle of the second turn.

2.32 Samples should be taken from two different depths in mid-track of the Home Straight, the rails at the middle of the first turn, mid-track at the middle of the first turn, and middle of the second turn as this approach determines composition ratio for the depth of the surface [19].

2.33 Another important characteristic of track surface is its layers. The racing track is divided into two layers (see Figure 2.5), the absorptive layer which is the surface depth that paw goes through until it grips the track and the traction layer is where the paw grasps the track [19].

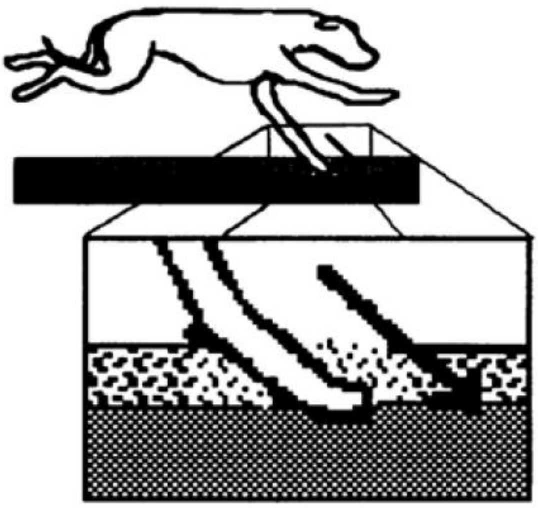

Figure 2.5: The absorptive and traction layers of race track surface [19].

2.34 The absorptive and traction layers should have even depth for the length and depth of the track. Moreover, the traction layer should also be even in straight and bend sections of the track (see Figure 2.6.A). An uneven layer can put the safety of greyhounds at risk (see Figure 2.6.B) [19].

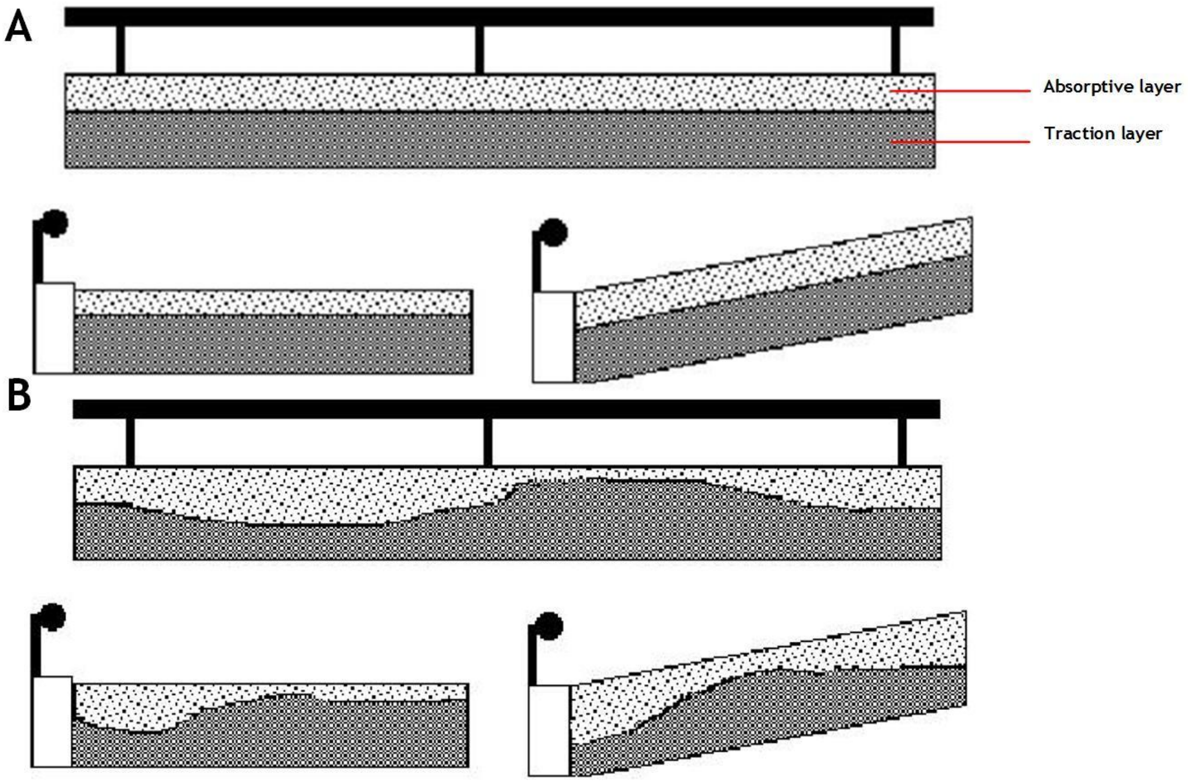

Figure 2.6: (A) The absorptive and traction layers of track surface. (B) An uneven absorptive and traction layers [19].

2.35 Gillette suggested a method to modify an uneven track surface. If the traction layer is uneven, a good approach is cutting the traction layer according to the determined base map (a map which is determined by analyzing the component of the track surface) and repacking the absorptive layer as shown in Figure 2.7 below [19].

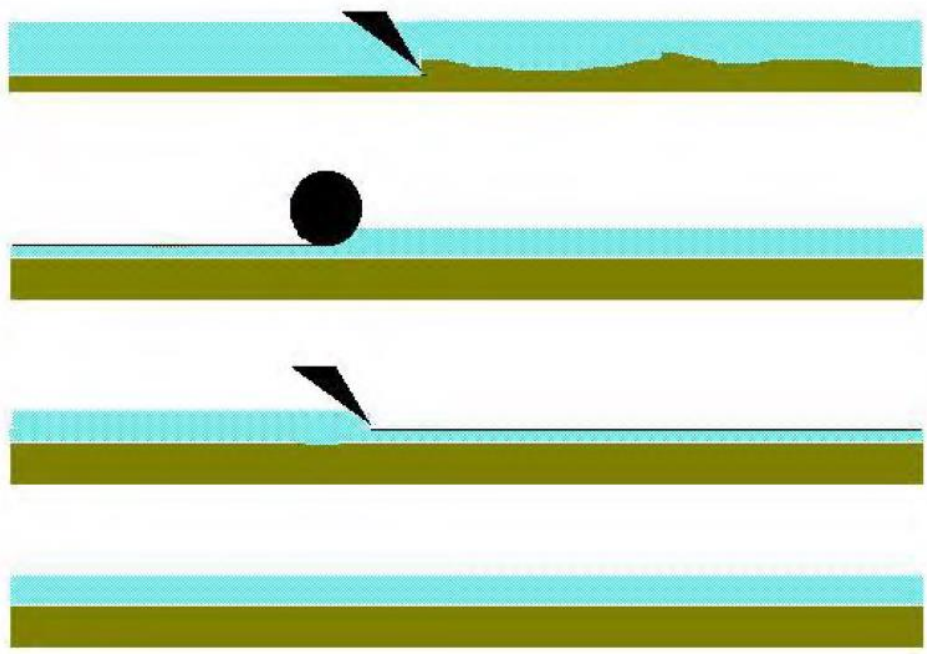

Figure 2.7: Process of modifying a track with uneven traction layer [19].

IMPACT OF TRACK DESIGN ON INJURY RATE

2.36 This section reviews research assessing the impact of track-related parameters on injury rate [25, 40, 43]. It should be noted that the impact of indirect track-related parameters such as the ambient temperature, season of the year and speed of greyhounds are also considered. For example, high ambient temperature would evaporate the moisture of the race track and make the surface drier and therefore harder.

2.37 Track-related parameters make some anatomical sites on greyhounds more prone to injury. As races are run anti-clockwise, most injuries occur in the left foreleg and right hind leg. When negotiating a bend the left foreleg is used as a pivot, with the claws digging into the ground, whilst the right hind leg, moving in an arc, provides the primary propulsive force. The stresses and strains imposed on these two limbs when entering, negotiating and leaving a bend are the most important contributing factors to the specific injuries associated with racing greyhounds [24].

2.38 In a study by Prole et al. in 1976, seasonal effects on the incidence of lameness in racing greyhounds were studied in two greyhound racing tracks in the UK. However, the data were not subjected to statistical analysis. Nevertheless, it was concluded that in drier months, namely August and September, the number of injuries was higher than in other months. They attributed this to the harder surface and associated faster running conditions [40].

2.39 Sicard et al. conducted a survey of five greyhound racing tracks in Wisconsin, USA in 1999, to study the effects of different factors on injury rates. Based on statistical tests (Chi-square, logistic regression analysis and Fisher exact test) they were able to determine that speed, race distance and track design (with emphasis on turn radius of curvature and banking) had significant effects on the rate of musculoskeletal injuries whereas temperature, body weight, race number and type of trauma did not [43].

2.40 Iddon et al. assessed the environmental and management factors which may affect the injury rates in racing greyhounds. By comparing a five year period of injury data on the Rye House track in London, it was found that a grass surface contributed to lower overall injury rates than a sand surface, which was in good agreement with the existing literature. Moreover, a One-way Analysis of Variance (ANOVA) of data from a four year period for the Walthamstow track in London showed that fast track conditions significantly increased the injury [25].

COMMON TYPES OF TRACK-RELATED INJURIES

2.41 In this section, the commonest type of fractures in racing greyhounds reported in the literature are explained. It should be noted that the following information may be different from that in Australia as injuries can be affected by the region, race regulations, individual dogs, etc.

2.42 Racing greyhounds are prone to sustaining fractures. Gannon et al. studied different types of fractures on different anatomical sites of racing greyhounds. They identified four different fracture types, namely: lamellar or cortical shaft fractures; avulsion or chip fracture; simple fracture; and compression fracture [17]. The description of each type is given in Table 2.1.

Table 2.1: Types of fracture in racing greyhounds [17].

Fracture type	Description
Lamellar or cortical shaft fractures	A true fatigue fracture usually associated radio graphically with evidence of progressive re-modeling of bone
Avulsion or chip fracture	When a small chunk of bone attached to a tendon or ligament gets pulled away from the main part of the bone
Simple fracture	A partial or complete loss of continuity of shaft of the bone
Compression fracture	A collapse of a vertebra. It may be due to trauma or due to a weakening of the vertebra

2.43 If the fracture does not have any external trauma it is called a stress fracture. Stress fractures are defined as those that arise without external trauma, and as a direct result of stress within the locomotor system during periods of exertion or fast speed [17].

2.44 Gannon et al. also investigated the relationship between fracture type, anatomical site, and the mechanism of fracture (caused by external trauma or stress fracture) and greyhound age and sex. It was found that age largely determines the state of bone development and the activity to which the greyhound is subjected [17].

2.45 Greyhounds before twelve months of age are prone to have more stress fractures on long bones of the skeleton whereas greyhounds older than twelve months are prone to have stress fractures in vertebral and carpal or tarsals [17]. Those fractures that are varied between greyhounds with different age and sex are tabulated in Table 2.2.

Table 2.2: Type of fracture that varied in greyhounds with different age and sex [17].

Fracture site	Mechanism	Age	Sex
Metacarpal	Stress fracture	young (12-24 months)	male
Tibial	Stress fracture	young (12-24 months)	male
Metatarsal	Stress fracture	young (12-24 months)	male
Vertebral	Stress fracture	mature greyhounds	-
Phalangeal	Stress fracture	young (12-24 months)	male

METACARPAL FRACTURES

2.46 Metacarpal fractures of the left foreleg were found to be the most frequent type of fracture and were more common in young and male greyhounds. Gannon et al. suggested that this was almost certainly because this is the limb closest to the running rail and must therefore carry a greater proportion of weight on each of the bends of the racetrack. Therefore the bad design of the track mainly the radius of curvature may increase the rate of this type of injury. Figure 2.8 shows greyhound metacarpal bones [17].

Figure 2.8: Greyhound forelimb, metacarpal bones [49].

TIBIA FRACTURE

2.47 The next most frequently occurring fractures were tibial fractures. These were avulsion fractures and the mechanism was stress fracture. These fractures were also more common in young greyhounds (12-24 months). The avulsion or spiral fracture is mainly due to a torsional moment caused by a rotational shear force. Figure 2.9 shows the mechanism of the avulsion or spiral fracture [17].

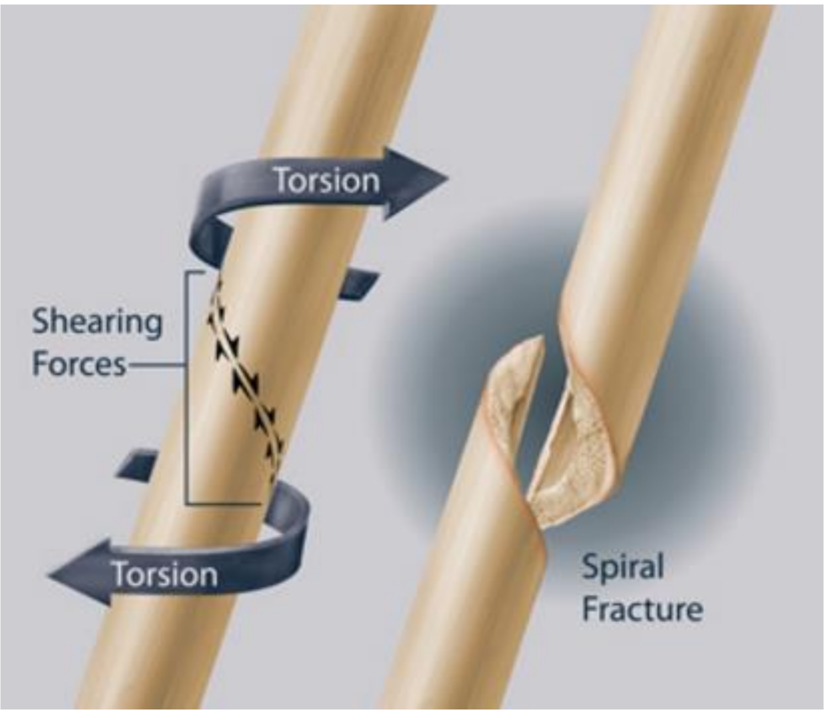

Figure 2.9: Mechanism of spiral/avulsion fracture [50].

METATARSAL FRACTURE

2.48 Another common type of fracture is metatarsal bone fracture on the hind leg which is more frequent in male, and young greyhounds. An interesting aspect of the metatarsal fracture is its fracture type. Unlike the metacarpal fracture which is a lamellar or cortical shaft fracture, the metatarsal fracture is a simple fracture. Figure 2.9 shows the mechanism of lamellar or cortical shaft fractures [17].

2.49 Gannon et al. advise that the driving and thrusting action of the hind limb is associated with the relatively less mobile tarsal joint and therefore is more conducive to the production of a lateral force resulting in a clear-cut simple fracture. On the other hand, the pivoting action of the forelimb, which is coupled with the more mobile carpal joint, is conducive to the production of a shearing force in an axial plane resulting in a range of fatigue and torsion fractures, that present as lamellar and compression fractures[17].

Figure 2.10: Mechanism of Metatarsal fracture [51].

3.0 INJURY GRAPHS

INTRODUCTION

3.1 In this section the injury graphs generated from a twelve-month injury data set are presented.

3.2 Only the 'post-race' and 'race-related' injuries are considered for data analysis i.e. injuries due to disease, dehydration etc. are not considered.

CATEGORIES THE SEVERITY OF INJURY

3.1 Throughout the Report the categories of injuries contained within Table 3.1 will be used.

Table 3.1: Categories of injuries.

Rating	Incapacitation period	Typical injury types
Minor injuries-1 (MINa)	0 days	Mild skin abrasion/grazes
Minor injuries-2 (MINb)	1-10 days	Grade 1 muscle injury Mild skin laceration
Medium injuries (MED)	11-21 days	Joint/ligament sprain skin laceration Grade 2 muscle injury
Major injuries (MAJ)	Greater than 21 days	Grade 3 muscle injury Bone fracture
Catastrophic (CATb)	Euthanased post-race	Euthanased post-race, unable to be retired or unable to race NB: may not include all data (deaths)
Catastrophic (CATa)	Deceased or euthanased on race day	Severe skull or spinal trauma complex/open/join fracture

3.2 It is worth noting that UTS was only supplied access to retirement reports for the period 1 Jan 2016 to 30 June 2016 so the CATb does not include all the data.

INJURY LEVEL

3.3 Throughout the Report the following levels of injury will be used:

3.4 Level 1 = CATa + CATb

3.5 Level 2 = CATa + CATb + MAJ

3.6 Level 3 = CATa + CATb + MAJ + MED

3.7 Level 4 = CATa + CATb + MAJ + MED + MINa + MINb

Absolute and normalised injuries for all NSW tracks in 2016

3.8 Figures 3.1 to 3.4 present histograms of the absolute injuries on a track-by-track basis for both TAB and non-TAB tracks within NSW.

3.9 The *absolute* number of injuries histograms provide the magnitudes of the number of injuries while the *normalised* histograms present the same data adjusted per number of 1000 starts at each track. Both the *absolute* and the *normalised* data are presented herein as they provide different perspectives and information.

3.10 The *absolute* histograms depict the raw total number of injuries for each track.

3.11 The *normalised* histograms depict the same data for each track after it has been adjusted to account for the number of 1000 starts held at each track. This is important as tracks such as Wentworth Park, where many races are held, will have more injuries on average than tracks that have fewer races but may be more dangerous.

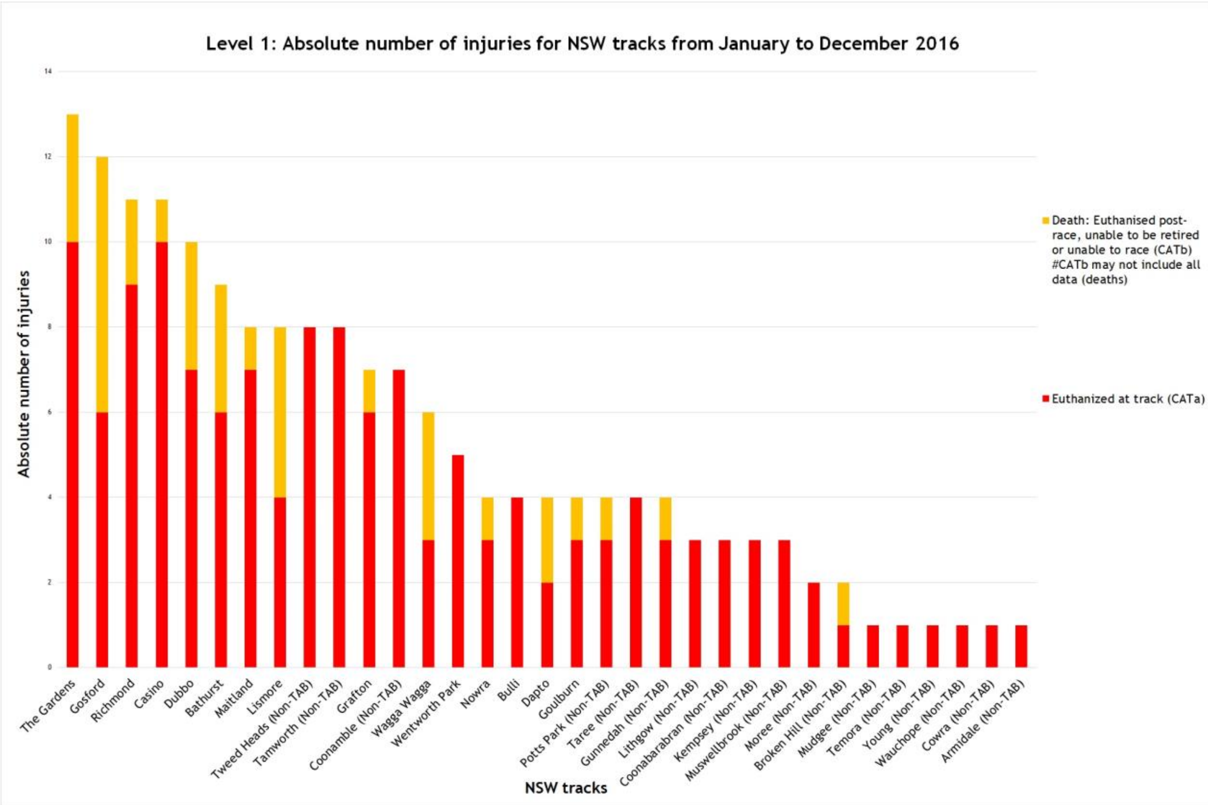

Figure 3.1: NSW Level 1 *absolute* injury rates – 1 Jan to 31 Dec 2016.

3.12 Figure 3.1 depicts the *absolute* Level 1 injury rates ranked from worst to best for 2016.

3.13 The worst five NSW tracks were: The Gardens; Gosford; Richmond; Casino; and Dubbo.

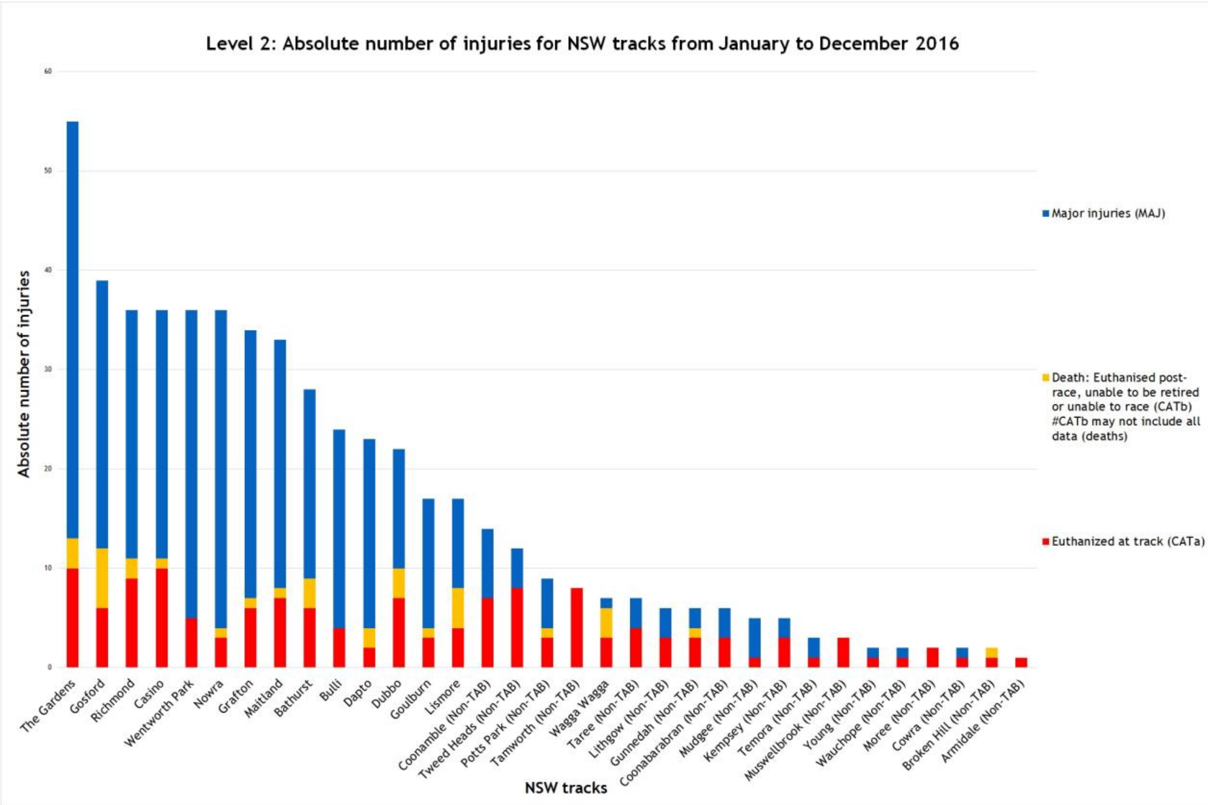

Figure 3.2: NSW Level 2 *absolute* injury rates – 1 Jan to 31 Dec 2016.

3.14 Figure 3.2 depicts the *absolute* Level 2 injury rates ranked from worst to best for 2016.

3.15 The worst five NSW tracks were: The Gardens; Gosford; Richmond; Casino and Wentworth Park.

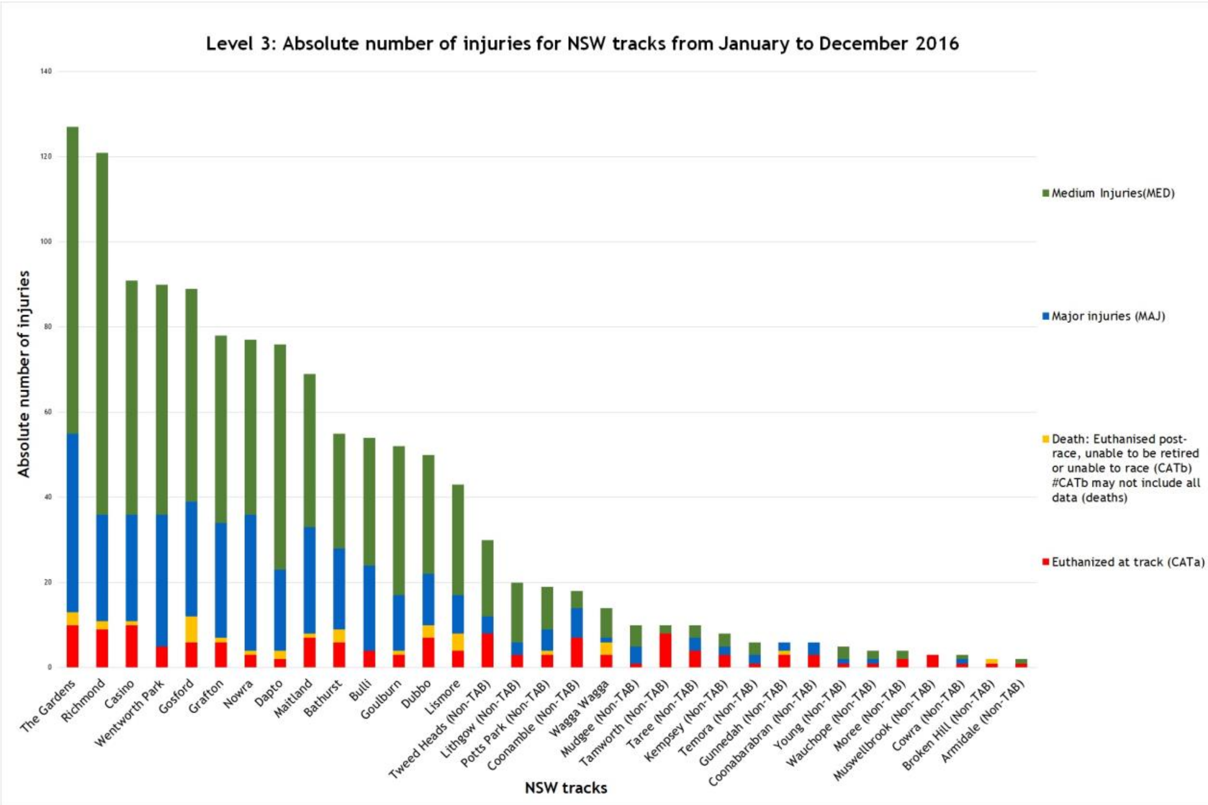

Figure 3.3: NSW Level 3 *absolute* injury rates – 1 Jan to 31 Dec 2016.

3.16 Figure 3.3 depicts the *absolute* Level 3 injury rates ranked from worst to best for 2016.

3.17 The worst five NSW tracks were: The Gardens; Richmond; Casino; Wentworth Park and Gosford.

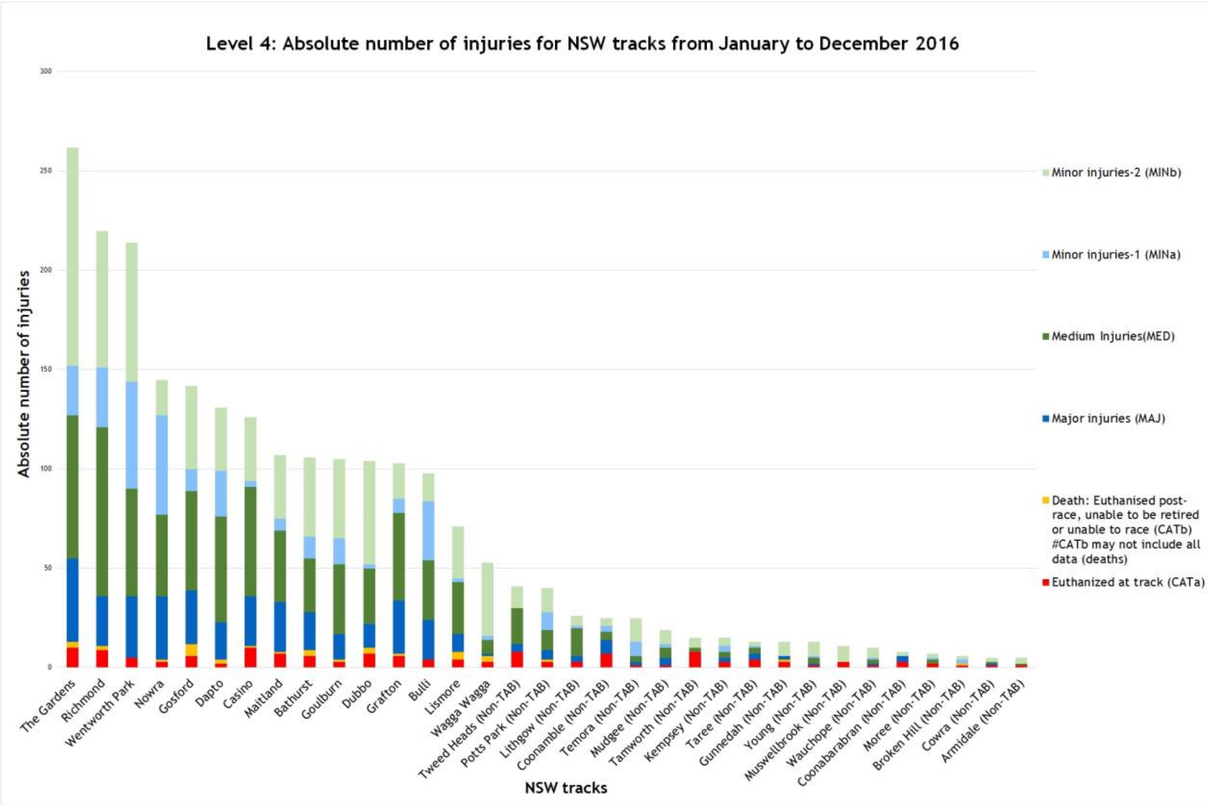

Figure 3.4: NSW Level 4 *absolute* injury rates – 1 Jan to 31 Dec 2016.

3.18 Figure 3.4 depicts the *absolute* Level 4 injury rates ranked from worst to best for 2016.

3.19 The worst five NSW tracks were: The Gardens; Richmond; Wentworth Park; Nowra; and Gosford.

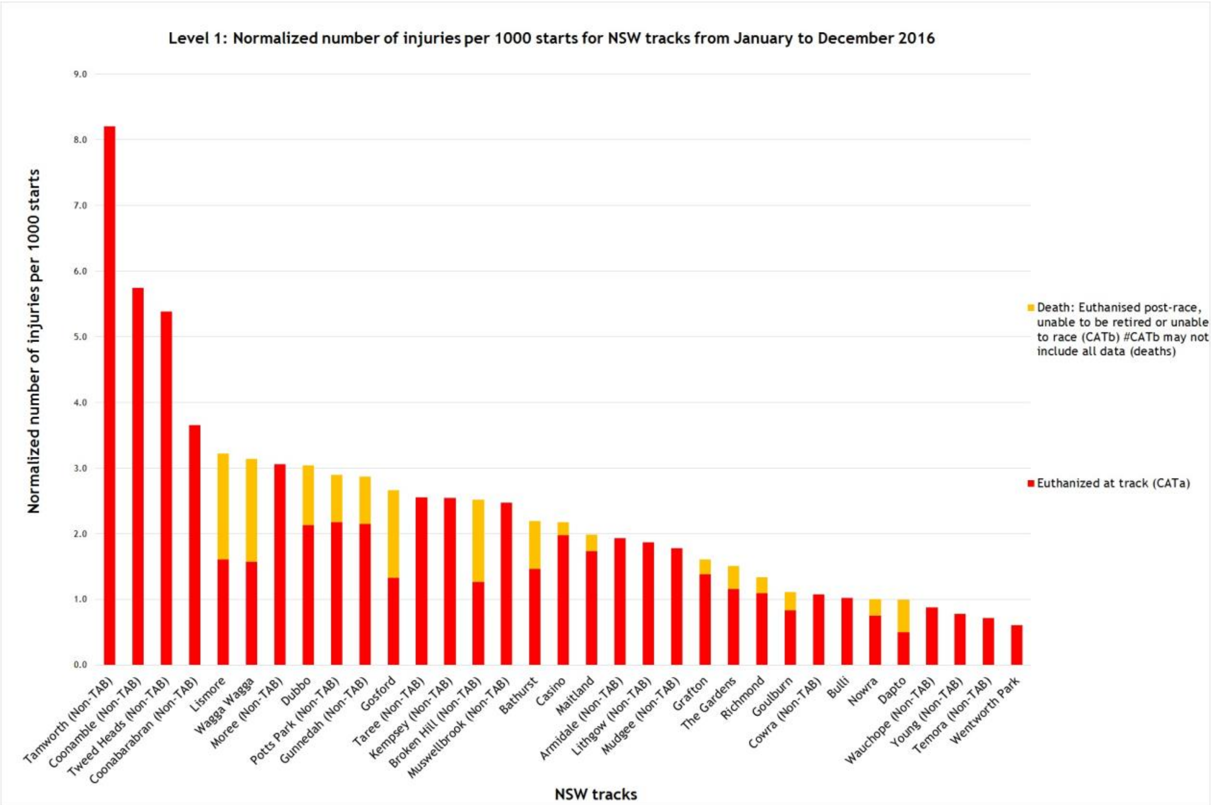

Figure 3.5: NSW Level 1 *normalised* injury rates – 1 Jan to 31 Dec 2016.

3.20 Figure 3.5 depicts the *normalised* Level 1 injury rates ranked from worst to best for 2016.

3.21 The worst five NSW tracks were: Tamworth (non-TAB); Coonamble (non-TAB); Tweed Heads (non-TAB); Coonabarabran (non-TAB) and Lismore.

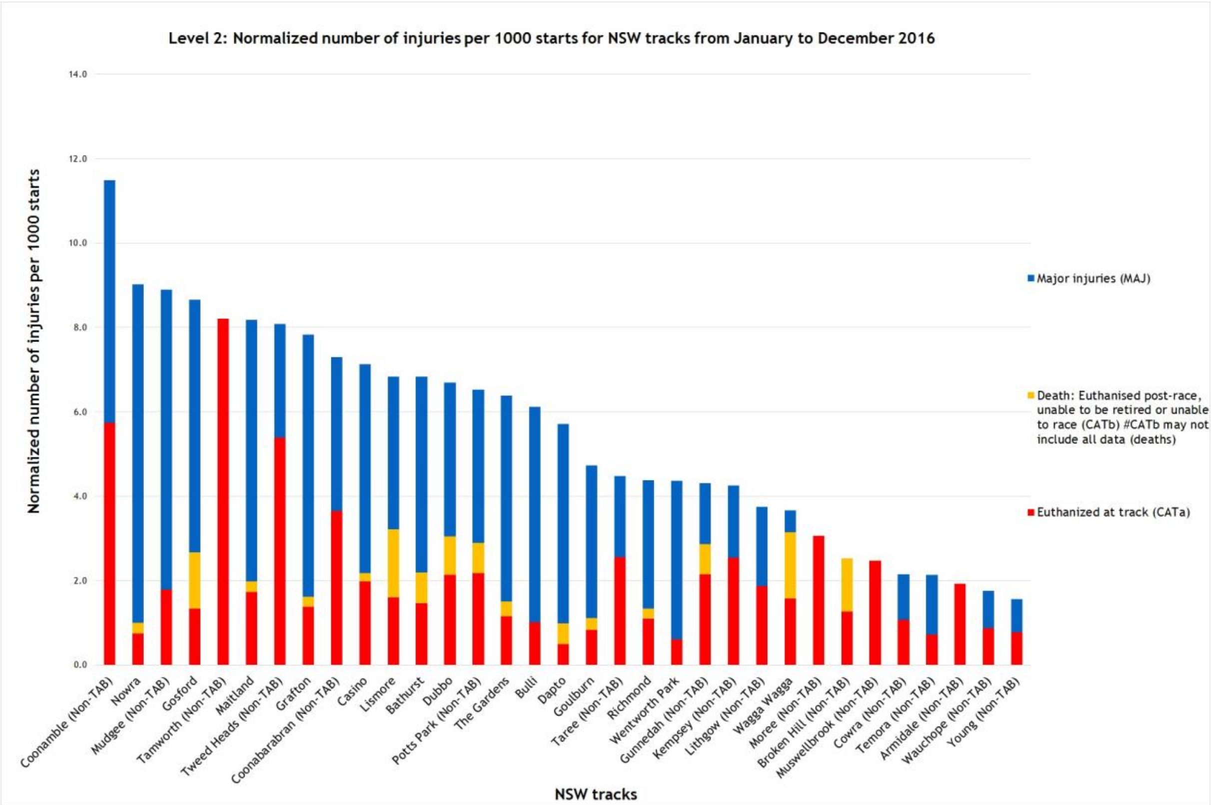

Figure 3.6: NSW Level 2 *normalised* injury rates – 1 Jan to 31 Dec 2016.

3.22 Figure 3.6 depicts the *normalised* Level 2 injury rates ranked from worst to best for 2016.

3.23 The worst five NSW tracks were: Coonamble (non-TAB); Nowra; Mudgee (non-TAB); Gosford; and Tamworth (non-TAB).

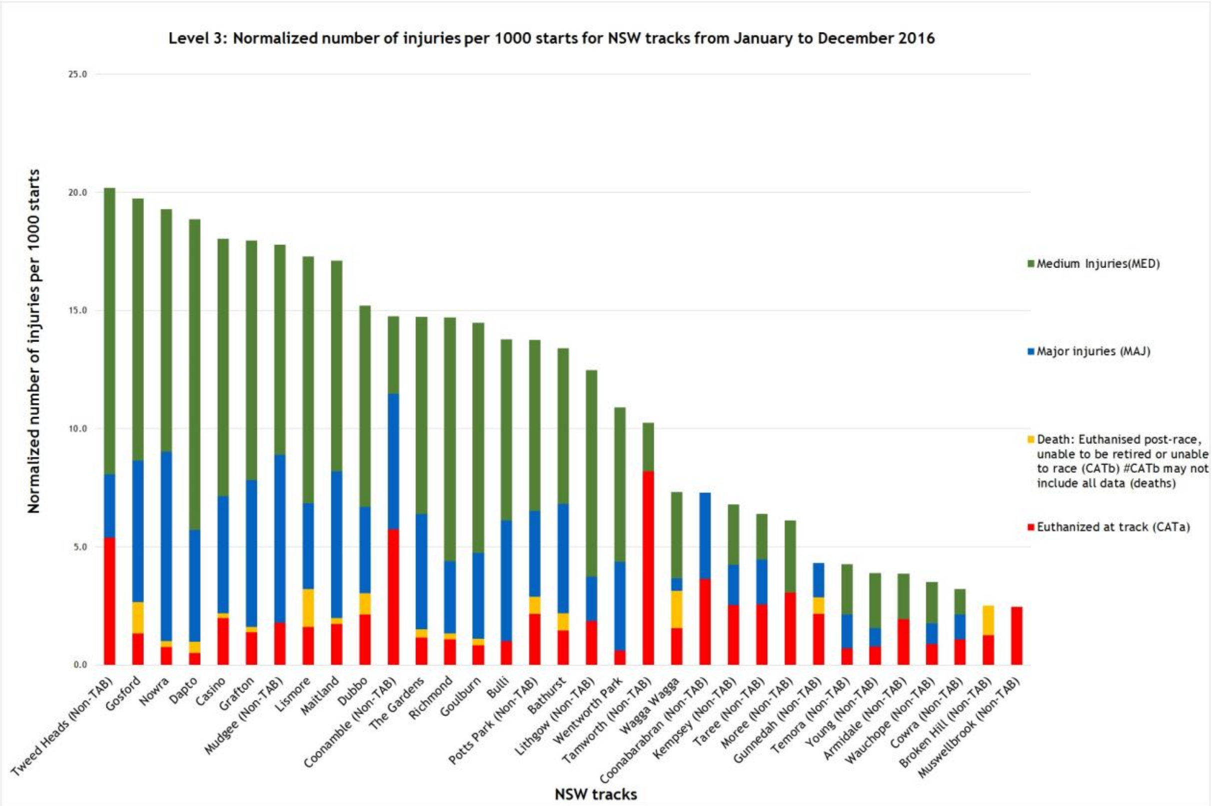

Figure 3.7: NSW Level 3 *normalised* injury rates – 1 Jan to 31 Dec 2016.

3.24 Figure 3.7 depicts the *normalised* Level 3 injury rates ranked from worst to best for 2016.

3.25 The worst five NSW tracks were: Tweed Heads (non-TAB); Gosford; Nowra; Dapto; and Casino.

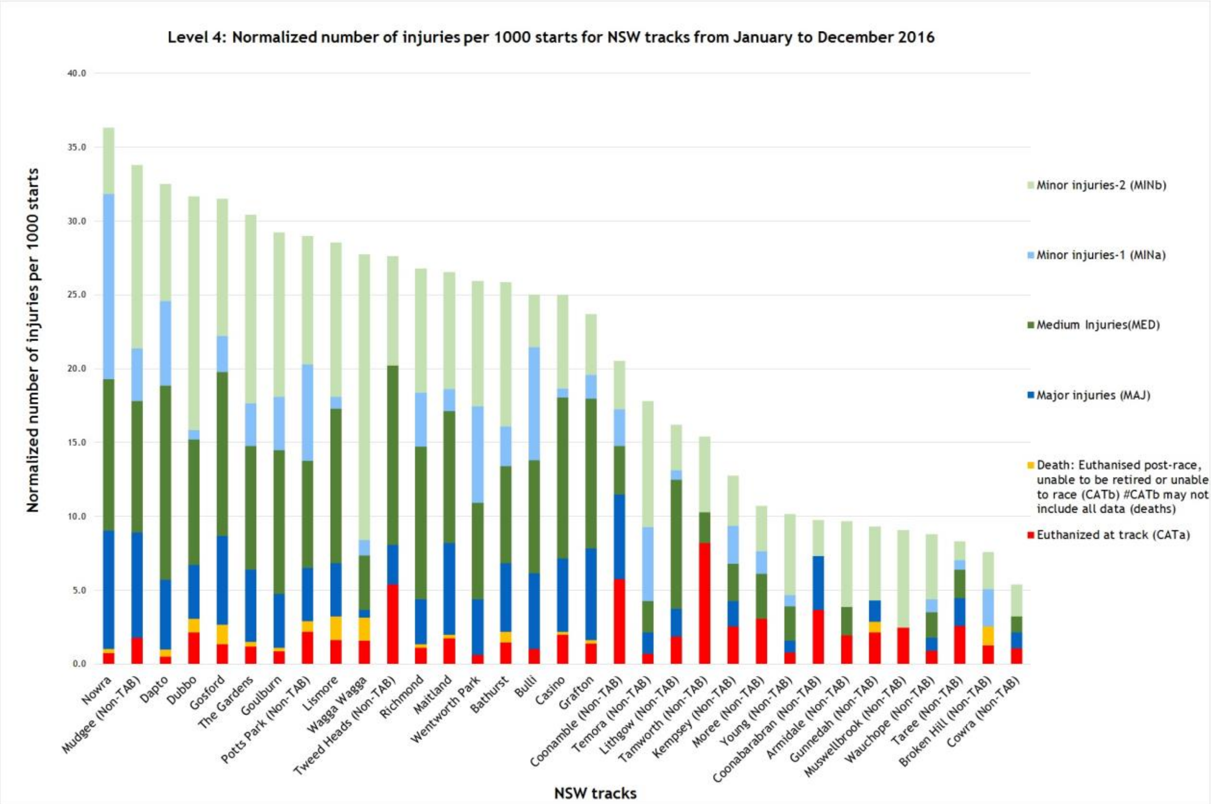

Figure 3.8: NSW Level 4 *normalised* injury rates – 1 Jan to 31 Dec 2016.

3.3 Figure 3.8 depicts the *normalised* Level 4 injury rates ranked from worst to best for 2016.

3.4 The worst five NSW tracks were: Nowra; Mudgee (non-TAB); Dapto; Dubbo and Gosford.

3.5 Figure 3.8 highlights a lack of reporting in MINa and MINb injury categories.

4.0 TRACK INVESTIGATIONS

INTRODUCTION

4.1 This section contains a review of each NSW track.

4.2 It should be noted that the following injury location graphs may not include all the injuries as the location of some of the injuries been uncertain.

GOSFORD

GOSFORD - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.3 Figures 4.1 to 4.4 contain the Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016.

4.4 Absolute Level 1 injury rates for Gosford are shown in Figure 4.1.A.

4.5 January has the highest absolute Level 1 injury rate with 2 CATa and 3 CATb injuries followed by February (1 CATa and 1 CATb).

4.6 No Level 1 injury is reported in March, June, September, October and November.

4.7 Normalized Level 1 injury rates for Gosford are shown in Figure 4.1.B.

4.8 January has the highest normalized Level 1 injury rate followed by February.

4.9 Absolute Level 2 injury rates for Gosford are shown in Figure 4.2.A.

4.10 January and February have the highest absolute Level 2 injury rate with 7 injuries each.

4.11 August and October had the lowest absolute Level 2 injury rate with 2 injuries each.

4.12 Normalized Level 2 injury rates for Gosford are shown in Figure 4.2.B.

4.13 February has the highest normalized Level 2 injury rate followed by April and December.

4.14 August has the lowest normalized Level 2 injury followed by October.

4.15 Absolute Level 3 injury rates for Gosford are shown in Figure 4.3.A.

4.16 February has the highest absolute Level 3 injury rate with 13 injuries.

4.17 July and December have the lowest absolute Level 3 injury rate with 3 injuries.

4.18 Normalized Level 3 injury rates for Gosford are shown in Figure 4.3.B.

4.19 April has the highest normalized Level 3 injury rate followed by February.

4.20 October has the lowest normalized Level 3 injuries followed by December.

4.21 Absolute Level 4 injury rates for Gosford are shown in Figure 4.4.A.

4.22 January and February have the highest absolute Level 4 injury rate with 20 injuries followed by April with 17 injuries each.

4.23 July, October and December have the lowest absolute Level 4 injury rate with 7 injurie.

4.24 Normalized Level 4 injury rates for Gosford are shown in Figure 4.4.B.

4.25 April has the highest normalized Level 4 injury rate followed by February.

4.26 August has the lowest normalized Level 4 injury.

4.27 CATb does not include all the data.

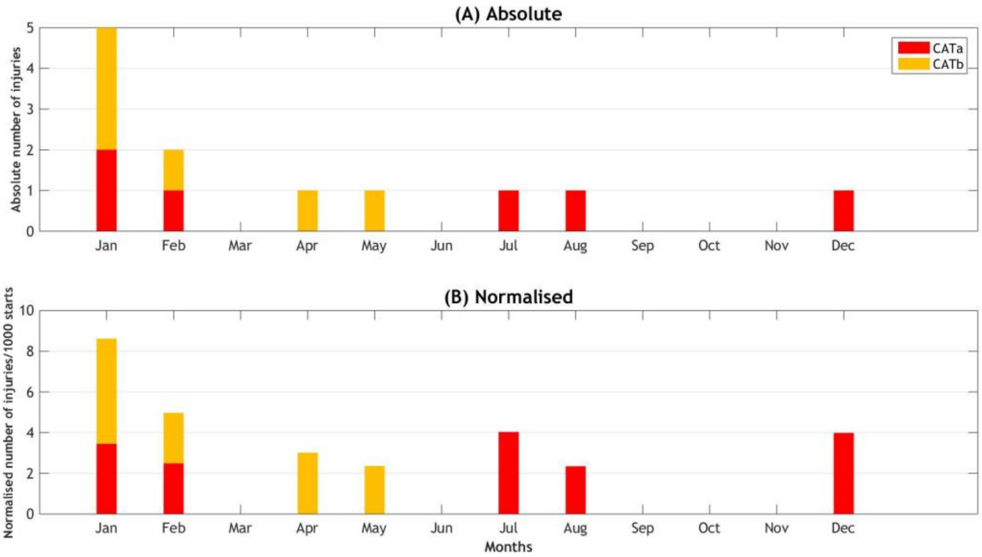

Figure 4.1: Gosford track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

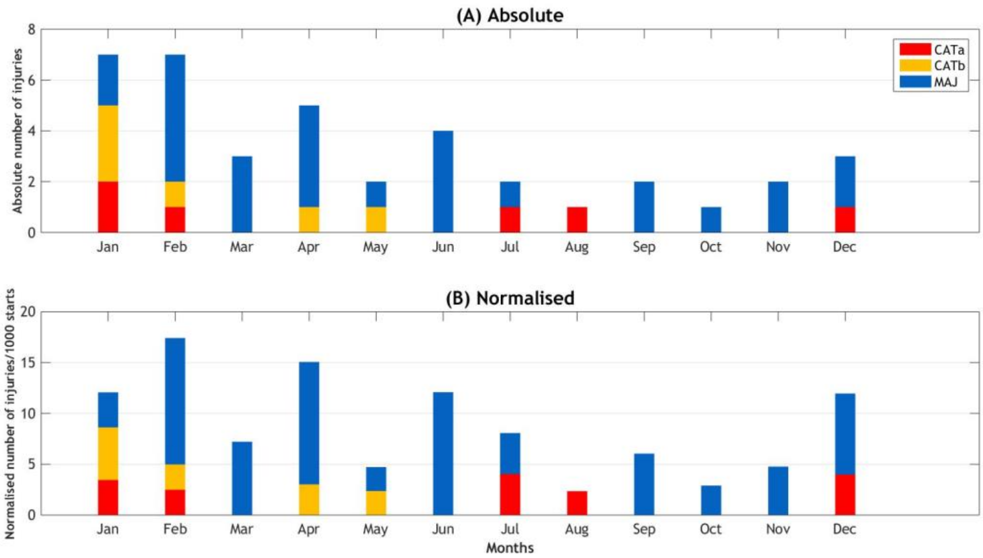

Figure 4.2: Gosford track Level 2 *absolute* (A) and *normalized* (B) Injury rates – 1 Jan to 31 Dec 2016.

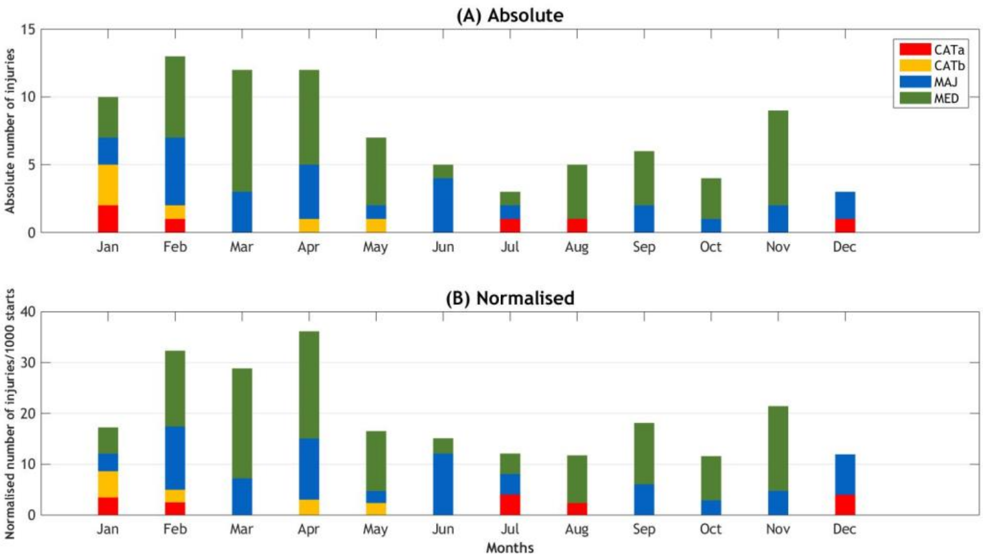

Figure 4.3: Gosford track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

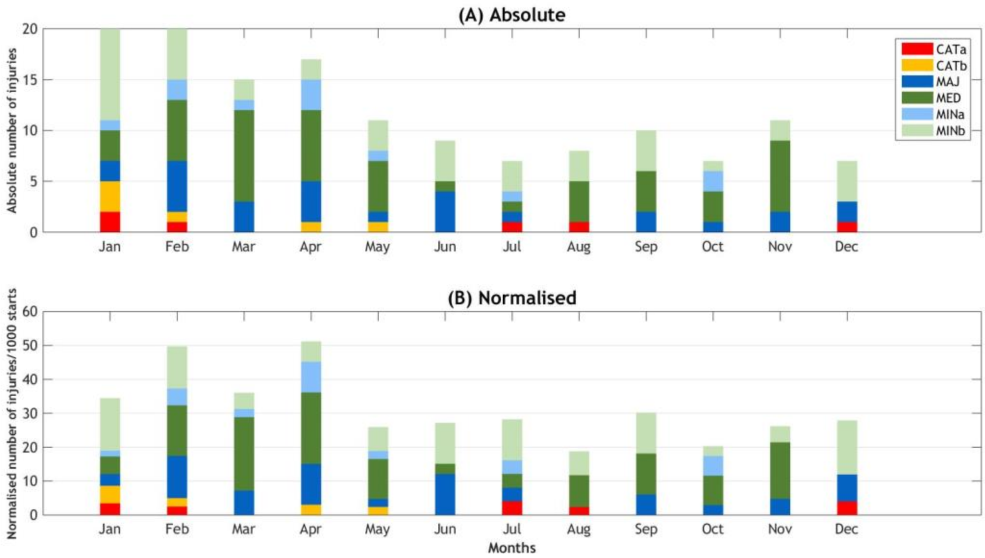

Figure 4.4: Gosford track Level 4 *absolute* (A) and *normalized* (B) Injury rates – 1 Jan to 31 Dec 2016.

GOSFORD - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.28 There were 228 races and 1758 starts from 1 January to 31 December 2016 at the 400 m distance.

4.29 Most of the injuries occurred shortly after the start at Northern Turn (turn into Back Straight).

4.30 There were 6 Level 2 injuries with 2 occurring at Back Straight and 4 at Northern Turn.

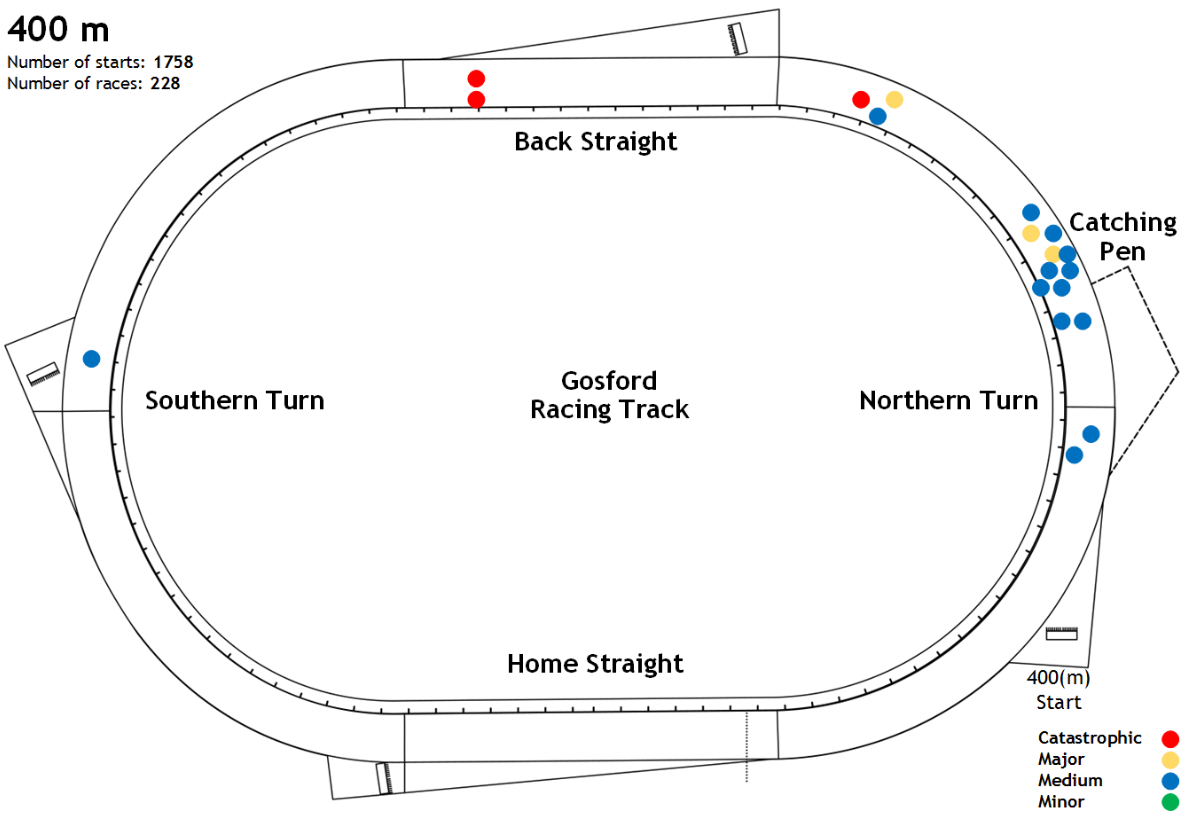

Figure 4.5: Gosford track location of injuries for the 400 m distance - 1 Jan to 31 Dec 2016.

GOSFORD - LOCATION OF INJURIES 515 M - 1 JAN TO 31 DEC 2016

4.31 There were 277 races and 2130 starts from 1 January to 31 December 2016 at the 515 m distance.

4.32 Most of the injuries occurred shortly after the start at the beginning of Northern Turn (turn out of Home Straight).

4.33 There were 15 Level 2 injuries with 10 occurring at the beginning of Northern Turn, adjacent to the 400 m starting boxes.

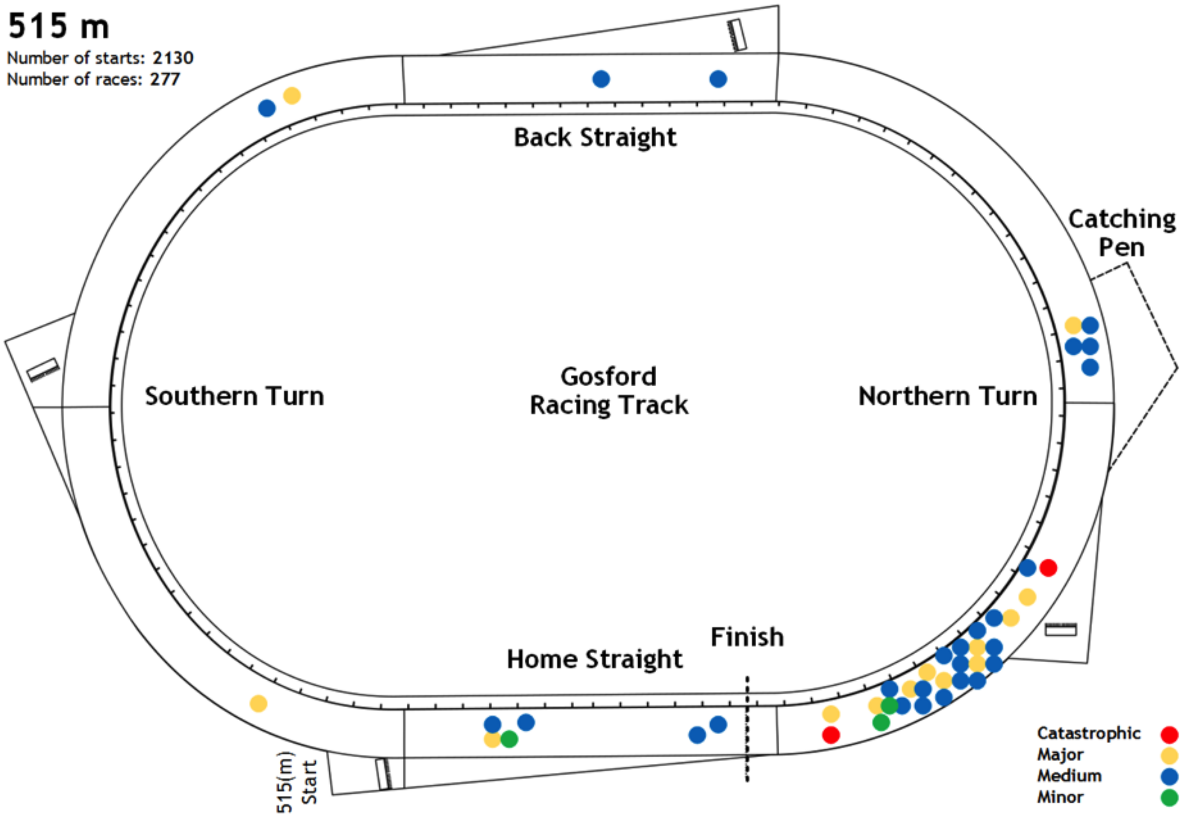

Figure 4.6: Gosford track location of injures for the 515 m distance – 1 Jan to 31 Dec 2016.

GOSFORD - LOCATION OF INJURIES 600 M - 1 JAN TO 31 DEC 2016

4.34 There were 75 races and 541 starts from 1 January to 31 December 2016 at the 600 m distance.

4.35 There were insufficient data to determine the worst locations of the track for races started at the 600 m distance.

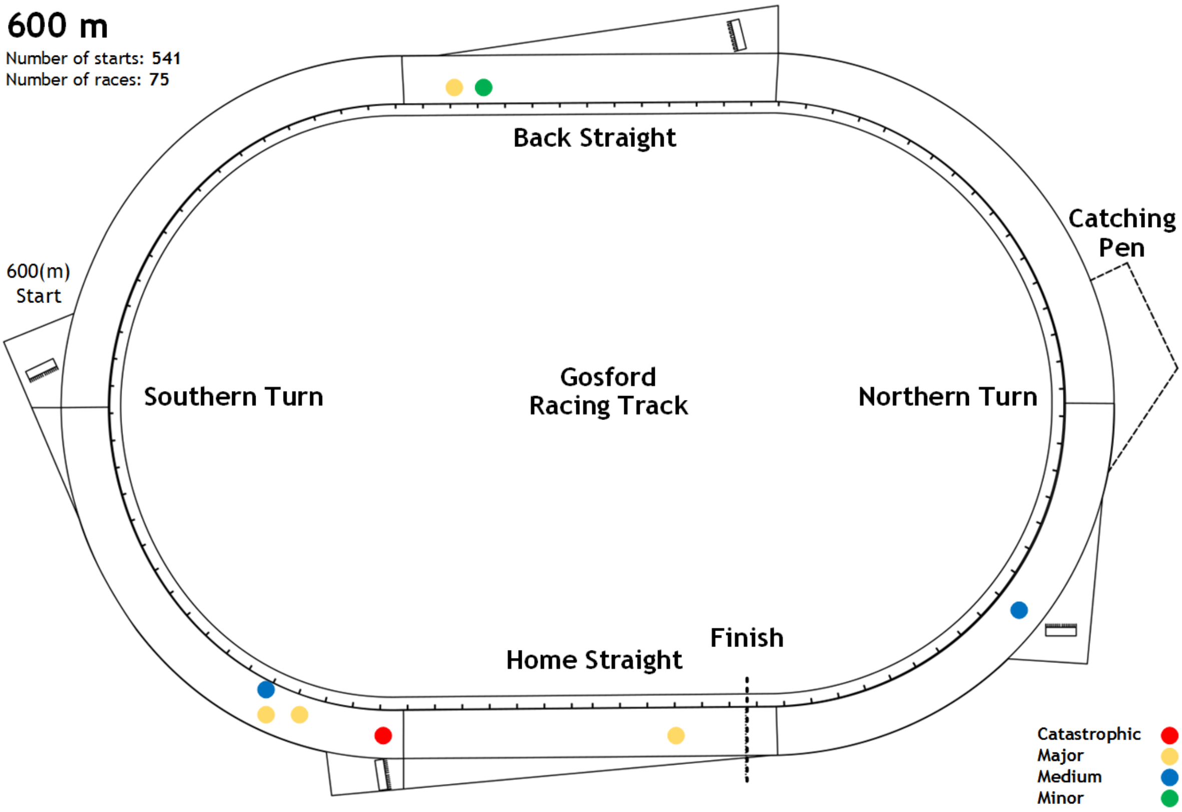

Figure 4.7: Gosford track location of injuries for the 600 m distance – 1 Jan to 31 Dec 2016.

The Gardens

The Gardens - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.36 Figures 4.8 to 4.111 contain The Gardens Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016.

4.37 Absolute Level 1 injury rates for The Gardens are shown in Figure 4.8.A.

4.38 June, September and December has have the highest absolute Level 1 injury rate with 2 injuries.

4.39 No Level 1 injury was reported in January and March.

4.40 Normalized Level 1 injury rates for The Gardens are shown in Figure 4.8.B.

4.41 June and September has the highest normalized Level 1 injury rate followed by December.

4.42 Absolute Level 2 injury rates for The Gardens are shown in Figure 4.9.A.

4.43 December has the highest absolute Level 2 injury rate with 10 injuries.

4.44 July has the lowest absolute Level 2 injury rate with 1 injury.

4.45 Normalized Level 2 injury rates for The Gardens are shown in Figure 4.9.B.

4.46 December has the highest normalized Level 2 Injury rate followed by April and June.

4.47 July has the lowest normalized Level 2 injury followed by March.

4.48 Absolute Level 3 injury rates for The Gardens track are shown in Figure 4.10.A.

4.49 October has the highest absolute Level 3 injury rate with 17 injuries followed by December with 16 injuries.

4.50 March has the lowest absolute Level 3 rate injury with 5 injuries.

4.51 Normalized Level 3 injury rates for The Gardens track are shown in Figure 4.10.B.

4.52 January has the highest normalized Level 3 injury rate followed by October.

4.53 March has the lowest normalized Level 3 injury followed by July.

4.54 Absolute Level 4 injury rates for The Gardens are shown in Figure 4.11.A.

4.55 October has the highest absolute Level 4 injury rate with 31 injuries followed by December with 27 injuries.

4.56 January and November have the lowest absolute Level 4 injury rate with 15 injuries.

4.57 Normalized Level 4 injury rates for The Gardens are shown in Figure 4.11.B.

4.58 October has the highest normalized Level 4 injury rate followed by July.

4.59 November has the lowest normalized Level 4 injury rate followed by June.

4.60 CATb does not include all the data.

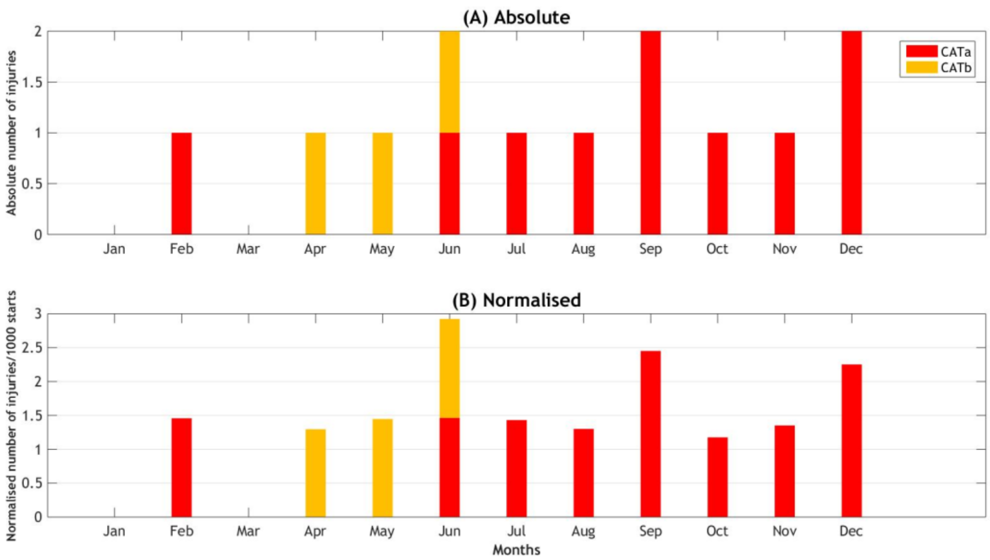

Figure 4.8: The Gardens track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

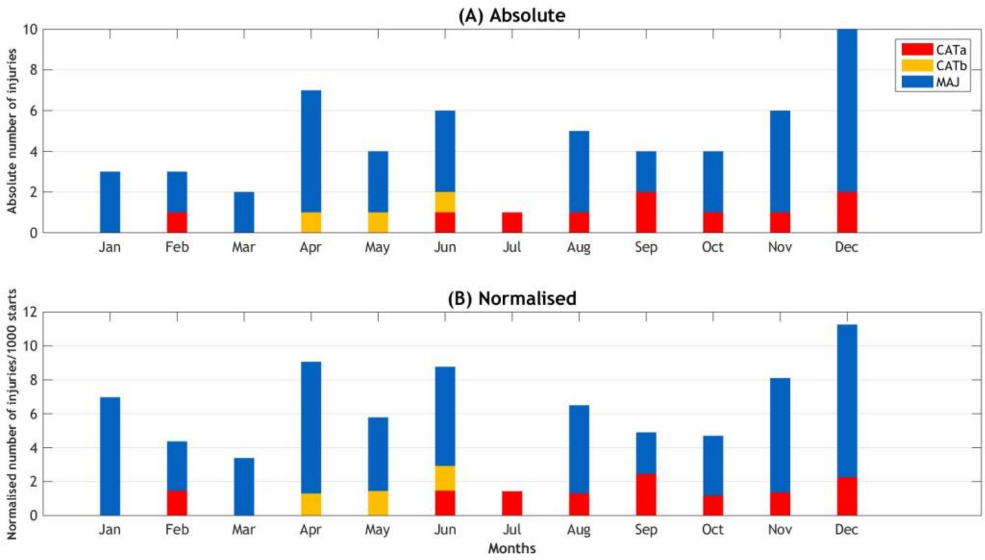

Figure 4.9: The Gardens track Level 2 *absolute* (A) and *normalized* (B) Injury rates – 1 Jan to 31 Dec 2016.

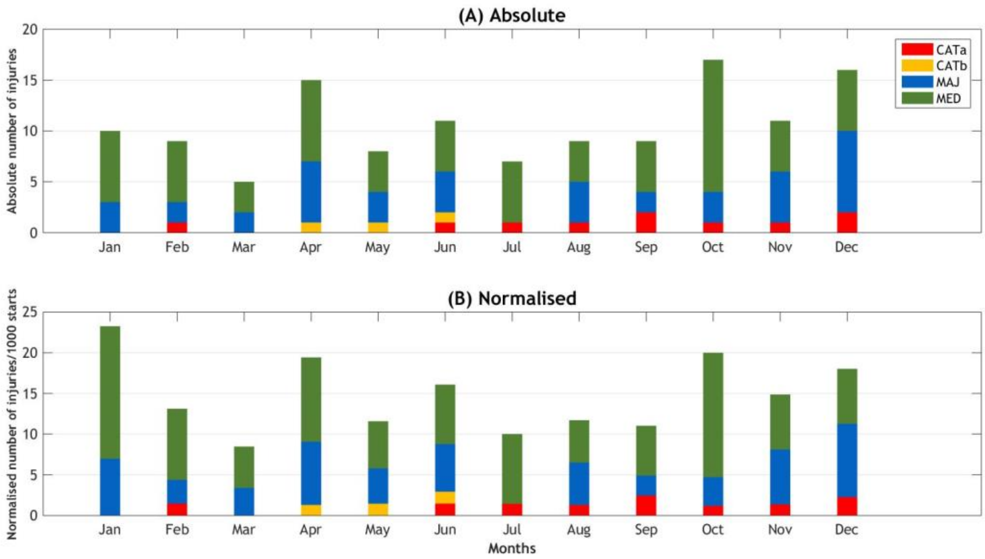

Figure 4.10: The Gardens track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

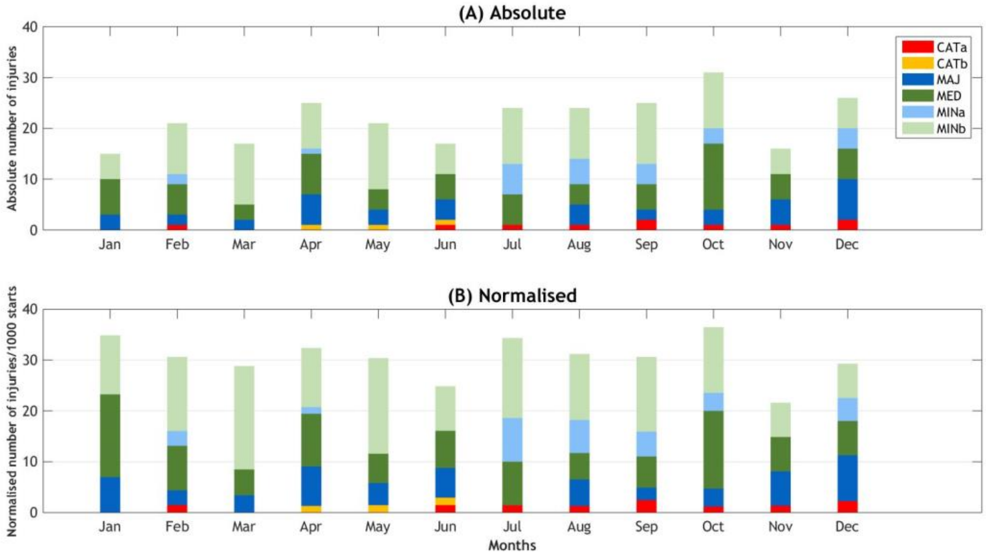

Figure 4.11: The Gardens track Level 4 *absolute* (A) and *normalized* (B) Injury rates – 1 Jan to 31 Dec 2016.

THE GARDENS - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.61 For The Gardens 400 m distance race the locations of injuries are illustrated in Figure 4.12.

4.62 There were 596 races and 4664 starts from 1 January to 31 December 2016 at the 400 m distance.

4.63 Most of the injuries occurred shortly after the start at Northern Turn (turn into Back Straight).

4.64 There were 16 Level 2 injuries with 13 occurring at Northern Turn.

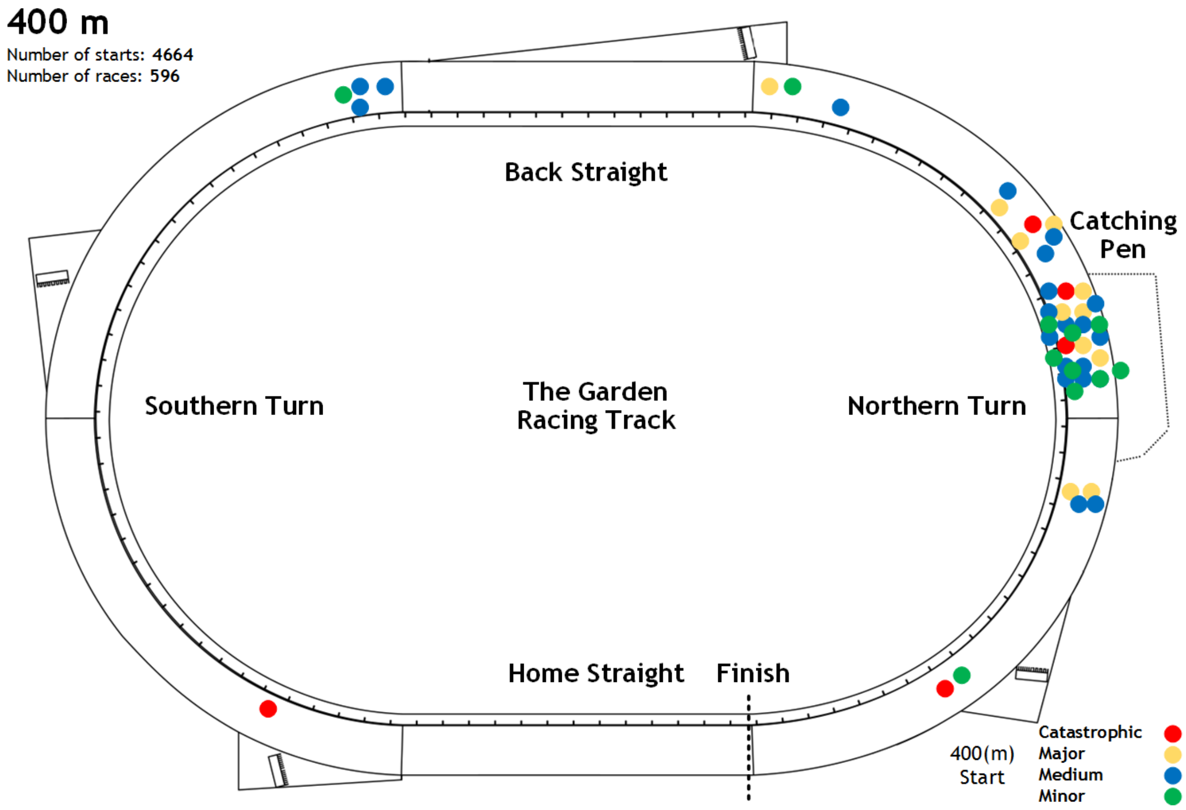

Figure 4.12: The Gardens track location of injuries for the 400 m distance - 1 Jan to 31 Dec 2016.

The Gardens - Location of injuries 515 m - 1 Jan to 31 Dec 2016

4.65 For The Gardens the 515 m distance race the locations of injuries for races are illustrated in Figure 4.13.

4.66 There were 441 races and 3435 starts from 1 January to 31 December 2016 at the 515 m distance.

4.67 Most of the injuries occurred at the beginning of Northern Turn (turn out of Home Straight).

4.68 For the 515 m distance there were 14 Level 2 injuries with 8 occurring at the beginning of Northern Turn, adjacent to the 400 m starting boxes.

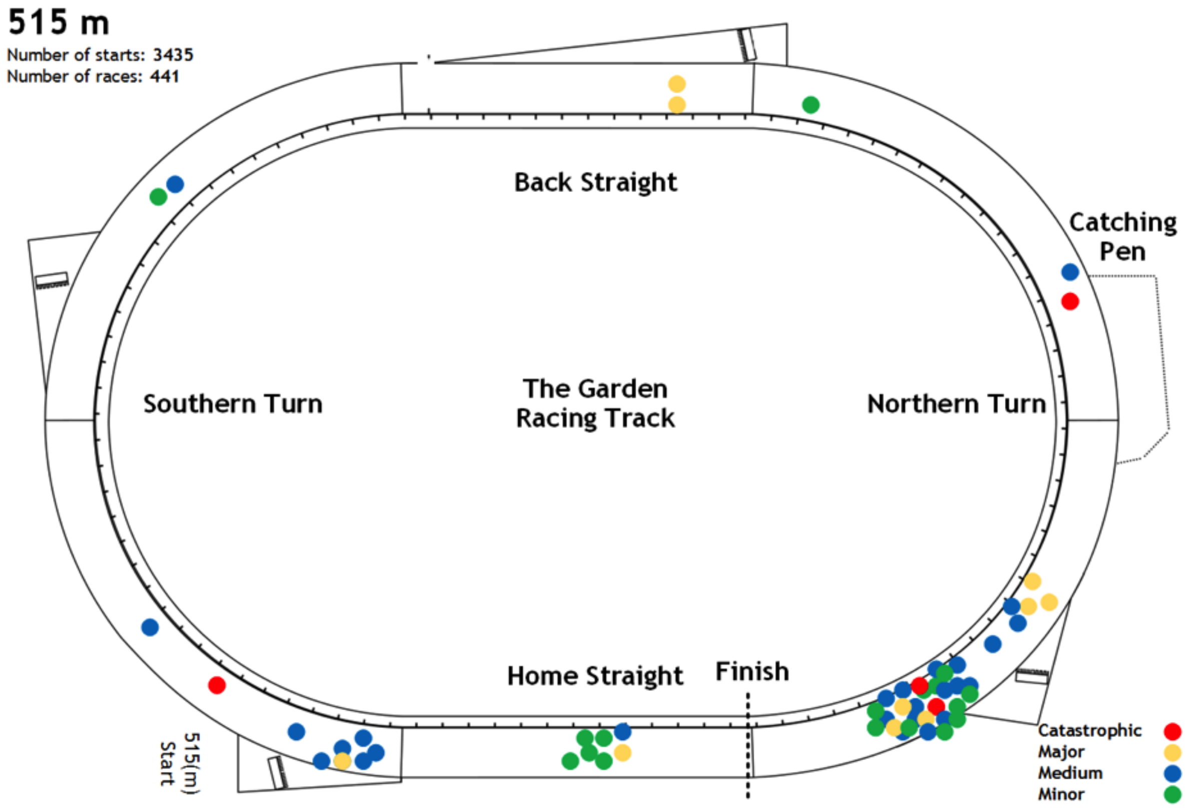

Figure 4.13: The Gardens track location of injuries for the 515 m distance - 1 Jan to 31 Dec 2016.

The Gardens - Location of injuries 600 m - 1 Jan to 31 Dec 2016

4.69 For The Gardens the 600 m distance race the locations of injuries for races are illustrated in Figure 4.14.

4.70 There were 67 races and 502 starts from 1 January to 31 December 2016 at the 600 m distance.

4.71 There are not sufficient data to determine the worst location of the track for races started at the 600 m distance though most of the injuries occurred shortly after the start at Southern Turn.

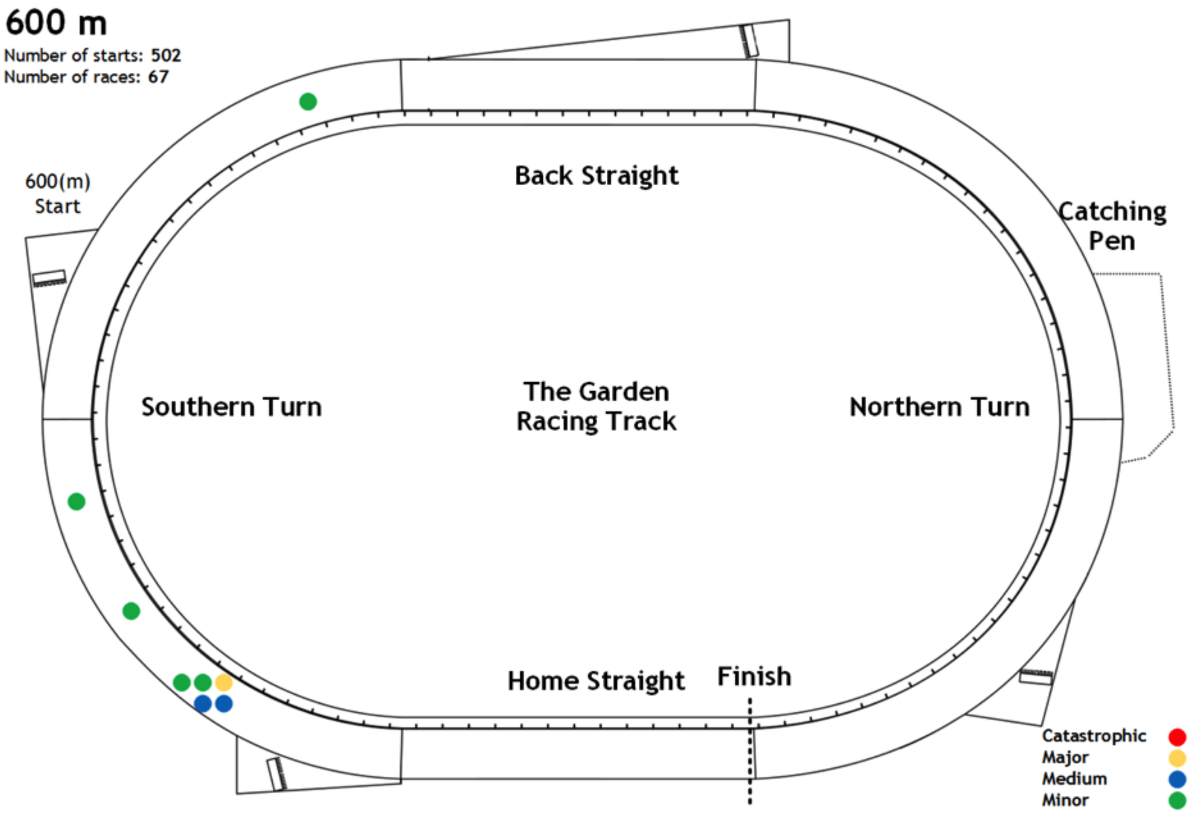

Figure 4.14: The Gardens track location of injuries for the 600 m distance - 1 Jan to 31 Dec 2016.

NOWRA

NOWRA - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.72 Figures 4.15 to 4.18 contain Nowra Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.73 Absolute Level 1 injury rates for Nowra are shown in Figure 4.15.A.

4.74 July has the highest absolute Level 1 injury rate with 2 injuries.

4.75 Normalized Level 1 injury rates for Nowra are shown in Figure 4.15.B.

4.76 July has the highest normalized Level 1 injury rate.

4.77 Absolute Level 2 injury rates for Nowra are shown in Figure 4.16.A.

4.78 October has the highest absolute Level 2 injury rate with 6 injuries.

4.79 August and September have the lowest absolute Level 2 Injury rate with 1 injury.

4.80 Normalized Level 2 injury rates for Nowra are shown in Figure 4.16.B.

4.81 June, July and October have the highest normalized Level 2 injury rate.

4.82 August has the lowest normalized Level 2 injury followed by September.

4.83 Absolute Level 3 injury rates for Nowra are shown in Figure 4.17.A.

4.84 October has the highest absolute Level 3 injury rate with 13 injuries.

4.85 August has the lowest absolute Level 3 injuries rate with 2 injuries.

4.86 Normalized Level 3 injury rates for Nowra track are shown in Figure 4.17.B.

4.87 October has the highest normalized Level 3 injury rate followed by June.

4.88 August has the lowest normalized Level 3 injury followed by September.

4.89 Absolute Level 4 injury rates for Nowra track are shown in Figure 4.18.A.

4.90 June has the highest absolute Level 4 injury rate with 18 injuries.

4.91 January has the lowest absolute Level 4 injury rate with 7 injuries.

4.92 Normalized Level 4 injury rates for Nowra track are shown in Figure 4.18.B.

4.93 June has the highest normalized Level 4 injury rate.

4.94 August has the lowest normalized Level 4 injury rate followed by January.

4.95 CATb does not include all the data.

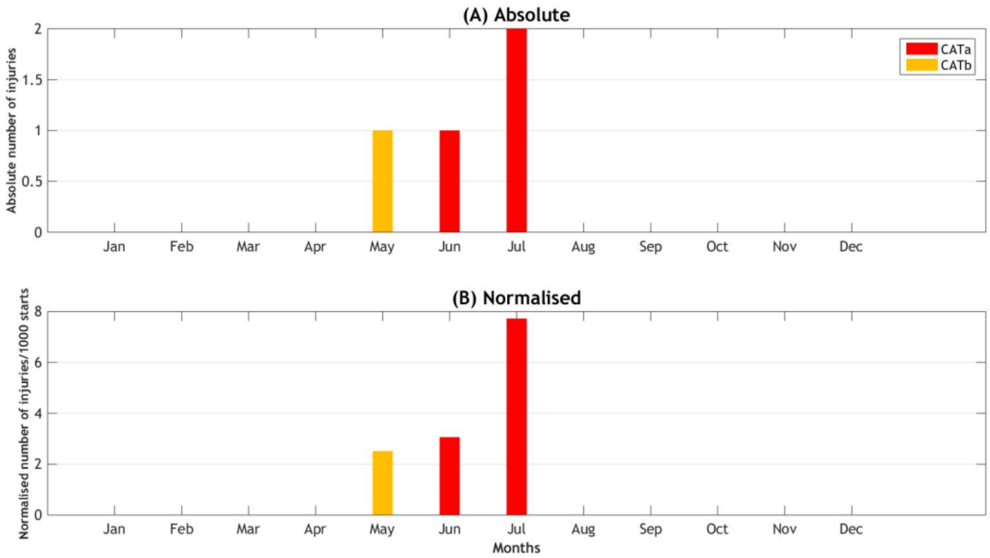

Figure 4.15: The Nowra track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

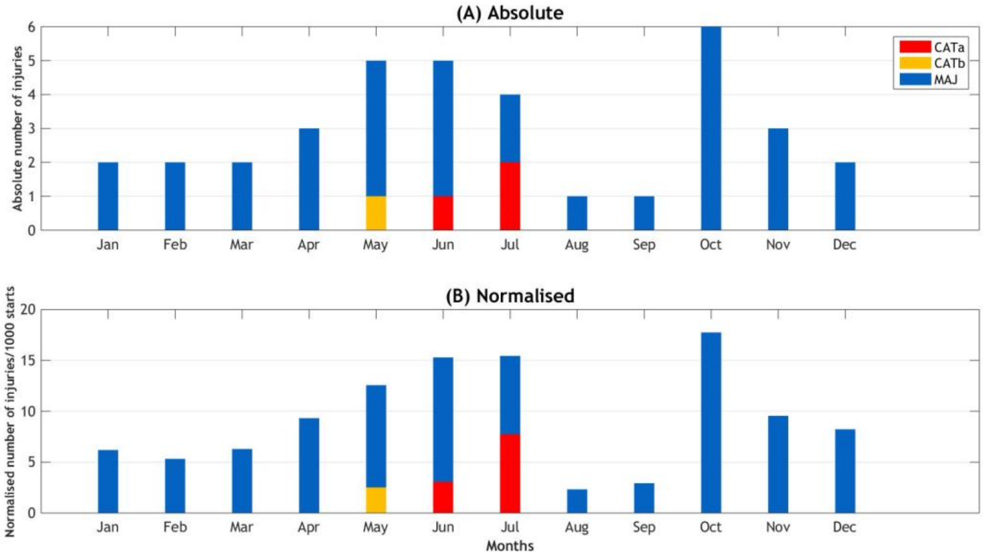

Figure 4.16: The Nowra track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

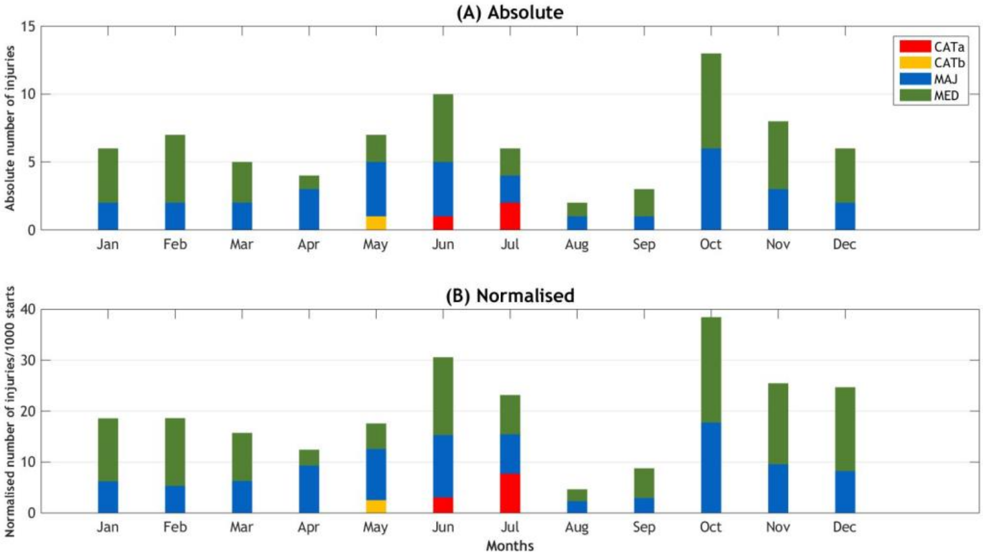

Figure 4.17: The Nowra track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

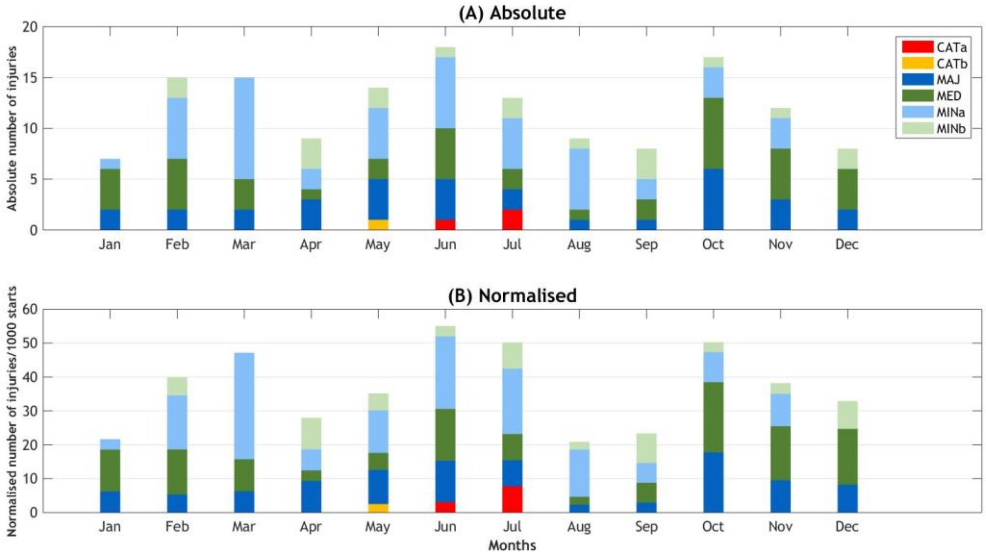

Figure 4.18: The Nowra track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

NOWRA - LOCATION OF INJURIES 365 M - 1 JAN TO 31 DEC 2016

4.96 For the Nowra 365 m distance race the locations of injuries are illustrated in Figure 4.19.

4.97 There were 311 races and 2396 starts from 1 January to 31 December 2016 at the 365 m distance.

4.98 Most of the injuries occurred shortly after the start and in the Back Straight.

4.99 There were 22 Level 2 injuries for races started at the 365 m distance with 13 occurring shortly after the start and at Back Straight.

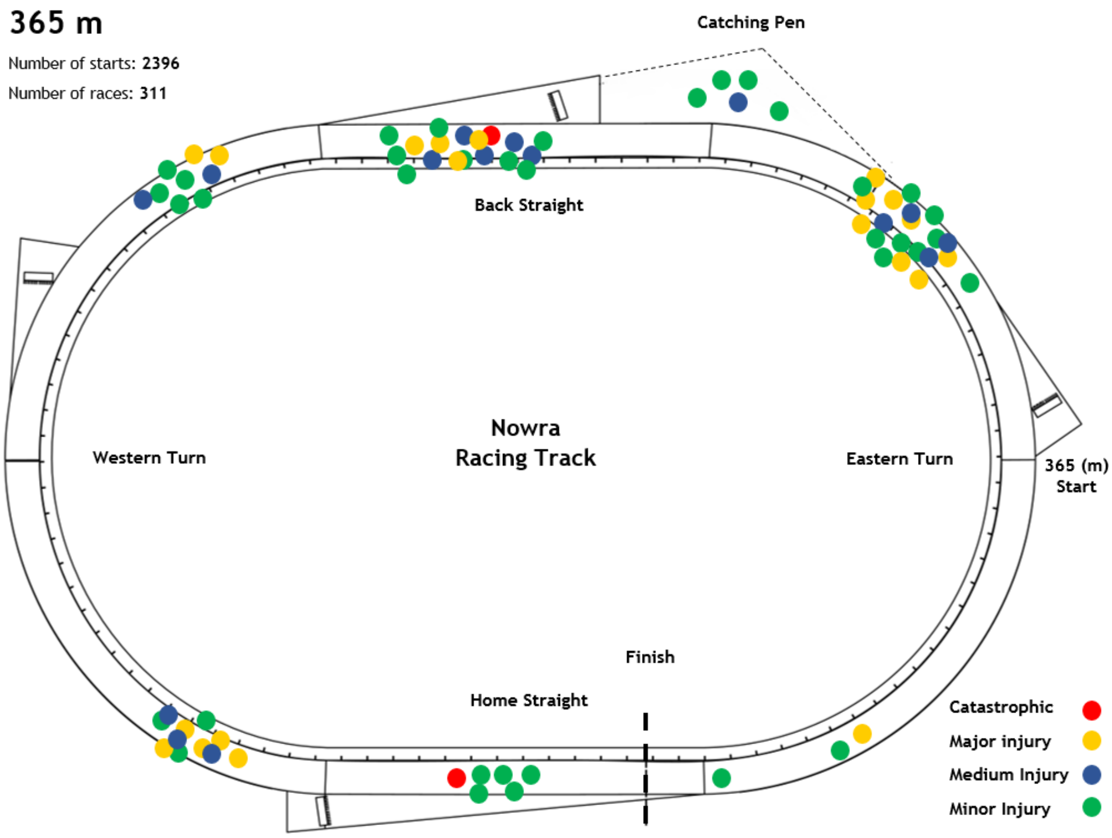

Figure 4.19: Nowra track location of injuries for the 365 m distance - 1 Jan to 31 Dec 2016.

NOWRA - LOCATION OF INJURIES 520 M - 1 JAN TO 31 DEC 2016

4.100 For the Nowra 520 m distance race the location of injuries are illustrated in Figure 4.20.

4.101 There were 183 races and 1782 starts from 1 January to 31 December 2016 at the 520 m distance.

4.102 Most of the injuries occurred at the beginning of Easter Turn.

4.103 There were 12 Level 2 injuries for races started at the 520 m distance with 7 occurring shortly after the start and at Back Straight.

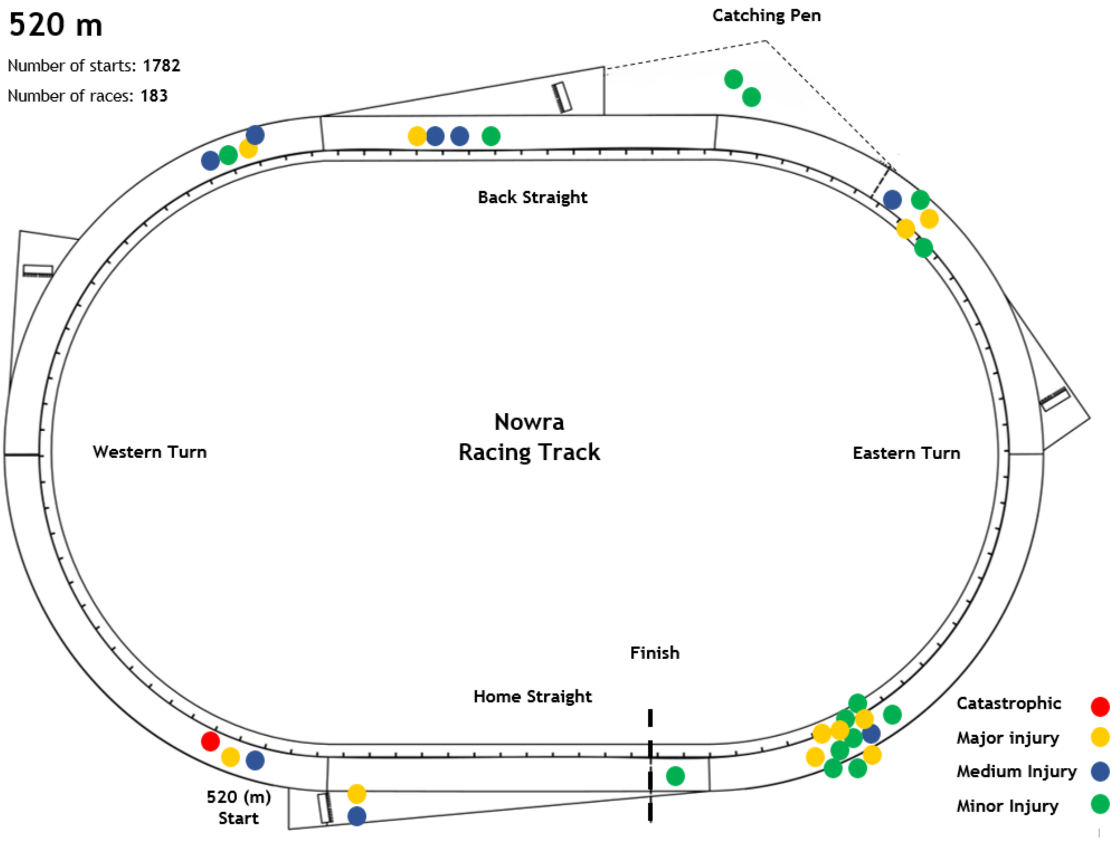

Figure 4.20: Nowra track location of injuries for the 520 m distance – 1 Jan to 31 Dec 2016.

Richmond

Richmond - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.104 Figures 4.21 to 4.24 contain Richmond Level 1 injury data for each month in the period 1 Jan to 31 Dec 2016.

4.105 Absolute Level 1 injury rates for Richmond are shown in Figure 4.21.A.

4.106 January, May and August have the highest absolute Level 1 injury rate with 2 injuries each.

4.107 Normalized Level 1 injury rates for Richmond are shown in Figure 4.21.B.

4.108 May has the highest normalized Level 1 injury rate.

4.109 Absolute Level 2 injury rates for Richmond are shown in Figure 4.22.A.

4.110 January and June had the highest absolute Level 2 injury rate with 5 injuries each.

4.111 September has the lowest absolute Level 2 Injury rate with 0 injuries.

4.112 Normalized Level 2 injury rates for Richmond are shown in Figure 4.22.B.

4.113 January and June have the highest normalized Level 2 Injury rate.

4.114 Absolute Level 3 injury rates for Richmond are shown in Figure 4.23.A.

4.115 March has the highest absolute Level 3 injury rate with 15 injuries followed by February with 14 injuries.

4.116 April, October and December have the lowest absolute Level 3 injury rate with 7 injuries, each.

4.117 Normalized Level 3 injury rates for Richmond are shown in Figure 4.23.B.

4.118 February has the highest normalized Level 3 injury rate.

4.119 April has the lowest normalized Level 3 injury followed by October.

4.120 Absolute Level 4 injury rates for Richmond are shown in Figure 4.24.A.

4.121 March has the highest absolute Level 4 injury rate with 27 injuries.

4.122 October has the lowest absolute Level 4 injury rate with 10 injuries.

4.123 Normalized Level 4 injury rates for Richmond are shown in Figure 4.24.B.

4.124 March has the highest normalized Level 4 injury rate followed by February.

4.125 October has the lowest normalized Level 4 injury rate.

4.126 CATb does not include all the data.

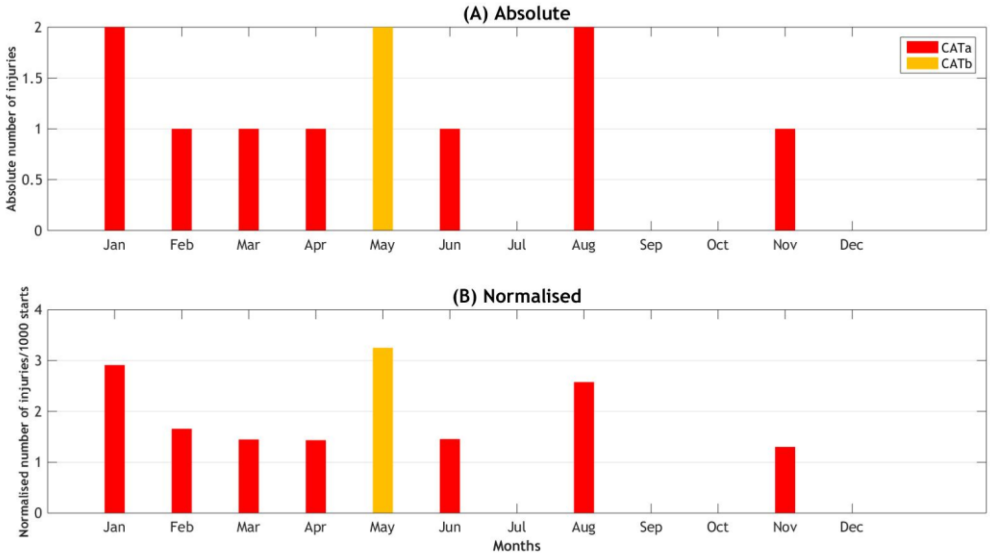

Figure 4.21: Richmond track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

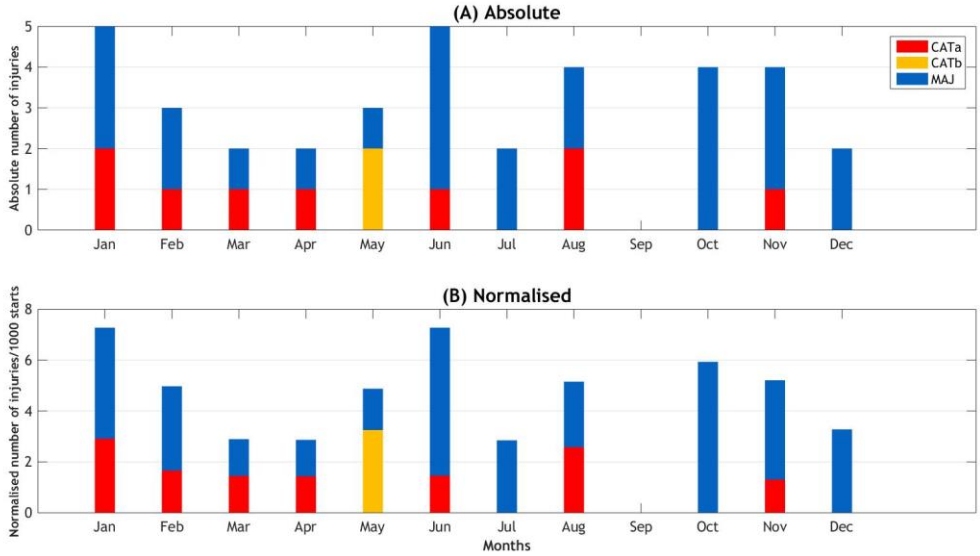

Figure 4.22: Richmond track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

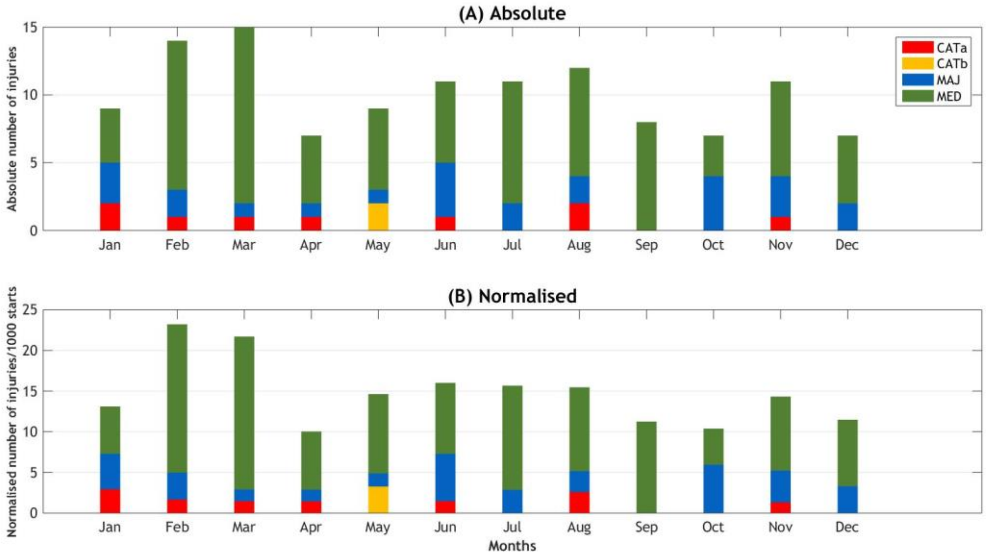

Figure 4.23: Richmond track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

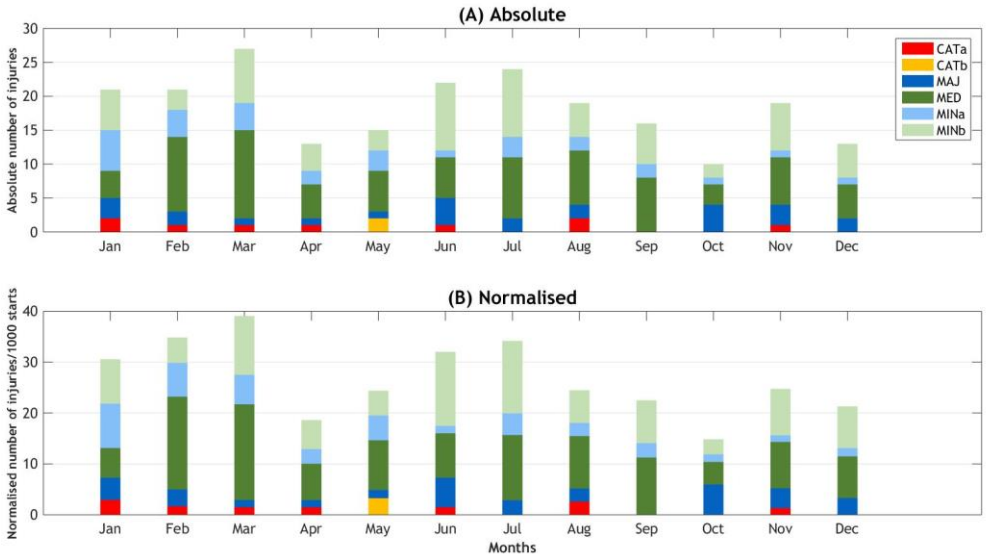

Figure 4.24: Richmond track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

RICHMOND - LOCATION OF INJURIES 330 M - 1 JAN TO 31 DEC 2016

4.127 For the Richmond 330 m distance race the locations of injuries are illustrated in Figure 4.25.

4.128 There were 114 races and 891 starts from 1 January to 31 December 2016 at the 330 m distance.

4.129 The data are not sufficient to determine the hazardous locations for this distance.

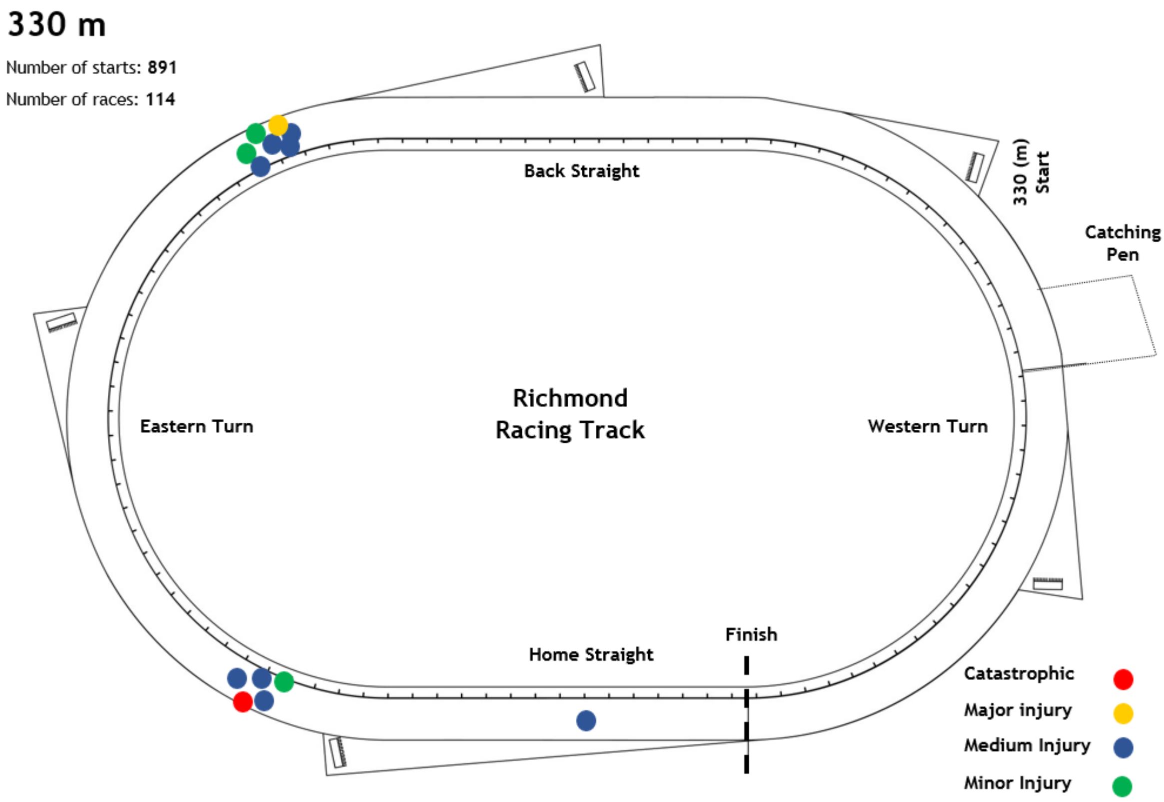

Figure 4.25: Richmond track location of injuries for the 330 m distance – 1 Jan to 31 Dec 2016.

RICHMOND - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.130 For the Richmond 400 m distance race the locations of injuries are illustrated in Figure 4.26.

4.131 There were 498 races and 3866 starts from 1 January to 31 December 2016 at the 400 m distance.

4.132 Most of the injuries occurred shortly after the start approaching the Back Straight.

4.133 There were 18 Level 2 injuries for races started at the 400 m distance with 7 occurring shortly after the start approaching the Back Straight.

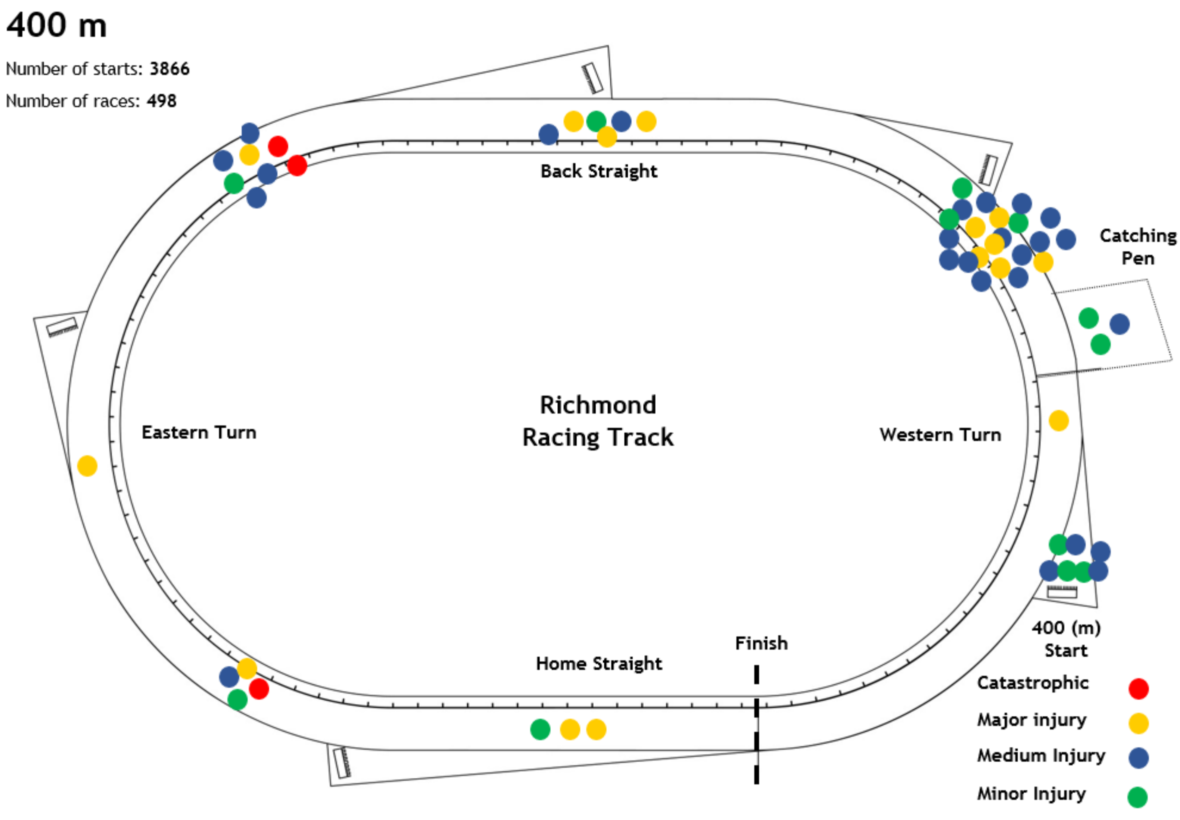

Figure 4.26: Richmond track location of injuries for the 400 m distance - 1 Jan to 31 Dec 2016.

Richmond - Location of injuries 535 m - 1 Jan to 31 Dec 2016

4.134 For the Richmond 535 m distance race the locations of injuries are illustrated in Figure 4.27.

4.135 There were 371 races and 2833 starts from 1 January to 31 December 2016 at the 535 m distance.

4.136 Most of the level 2 injuries occurred at the beginning of Eastern Turn.

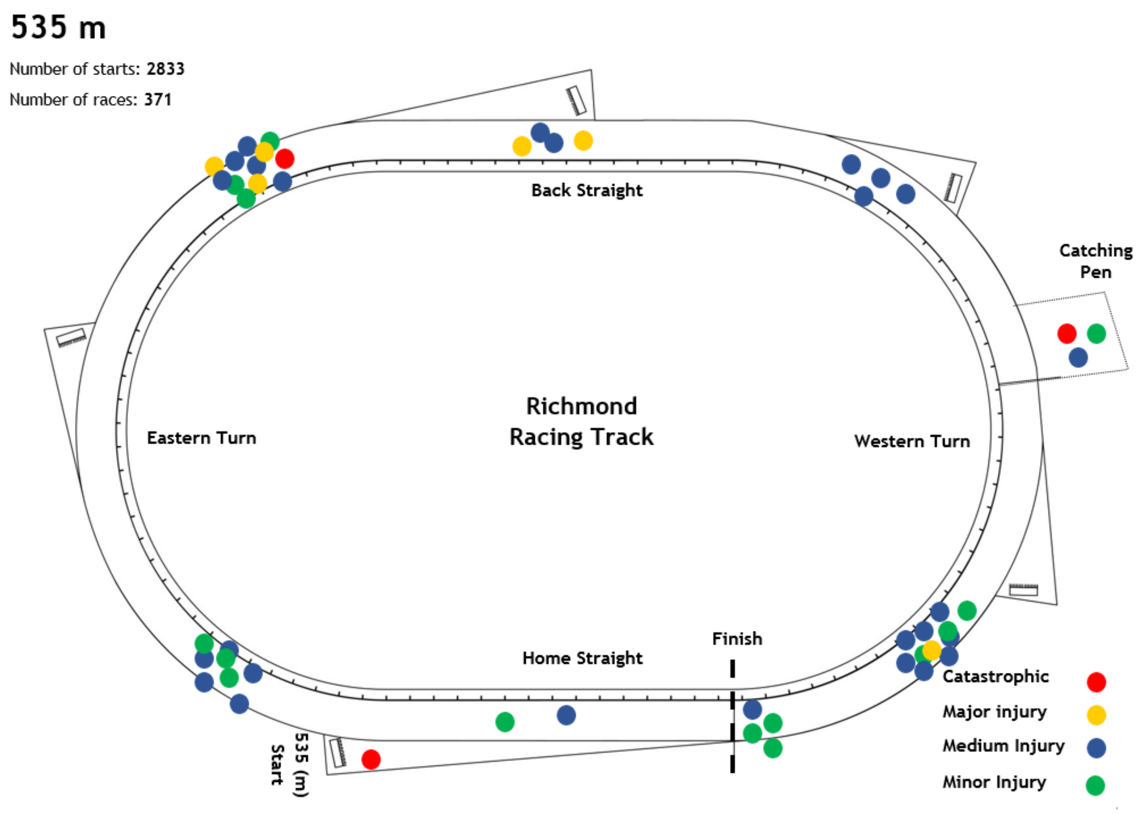

Figure 4.27: Richmond track location of injuries for the 535 m distance – 1 Jan to 31 Dec 2016.

RICHMOND - LOCATION OF INJURIES 618 M - 1 JAN TO 31 DEC 2016

4.137 For the Richmond 618 m distance race the locations of injuries are illustrated in Figure 4.28.

4.138 There were 82 races and 595 starts from 1 January to 31 December 2016 at the 618 m distance.

4.139 The data are not sufficient to determine the hazardous locations for this distance.

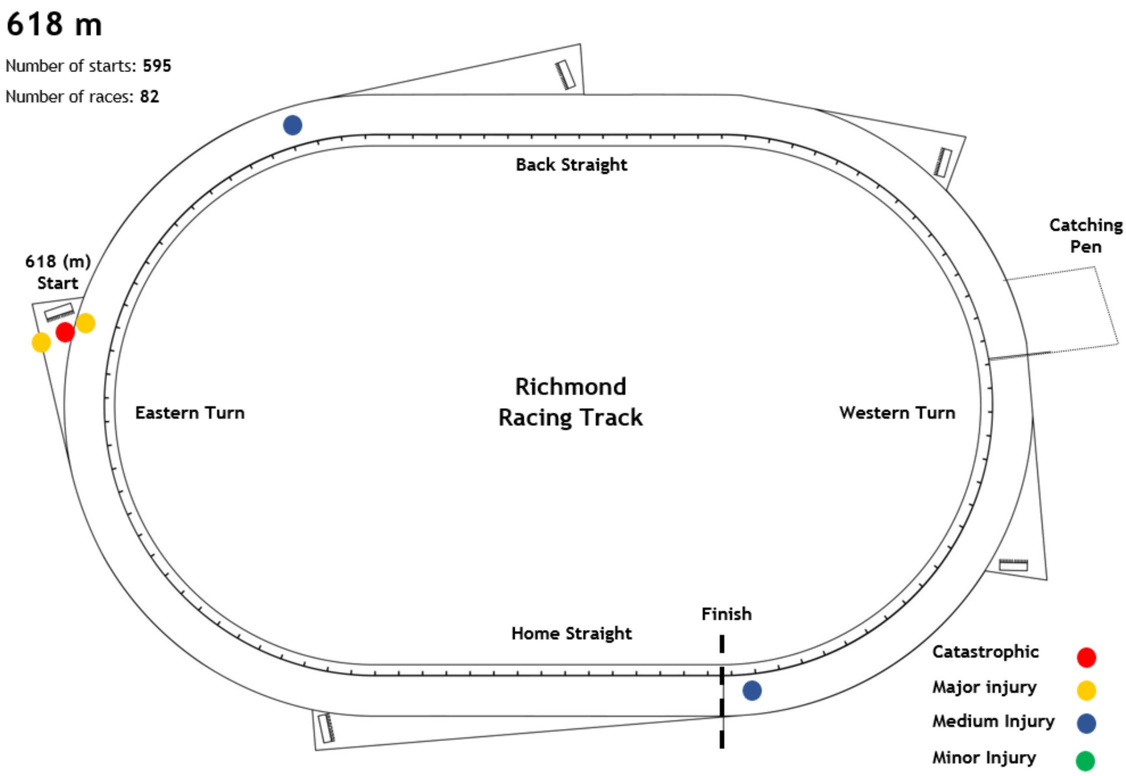

Figure 4.28: Richmond track location of injuries for the 618 m distance - 1 Jan to 31 Dec 2016.

Wentworth Park

Wentworth Park - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.140 Figures 4.29 to 4.32 contain Wentworth Park Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.141 Absolute Level 1 injury rates for Wentworth Park are shown in Figure 4.29.A.

4.142 January, April, May, June and October are the only months with Level 1 injuries i.e. the number of injuries apart from the mentioned months are 0.

4.143 Normalized Level 1 injury rates for Wentworth Park are shown in Figure 4.29.B.

4.144 June has the highest normalized Level 1 injury rate.

4.145 Absolute Level 2 injury rates for Wentworth Park are shown in Figure 4.30.A.

4.146 April has the highest absolute Level 2 injury rate with 7 injuries.

4.147 July has the lowest absolute Level 2 Injury rate with 0 injuries.

4.148 Normalized Level 2 injury rates for Wentworth Park are shown in Figure 4.30.B.

4.149 April has the highest normalized Level 2 Injury rate followed by January.

4.150 July has the lowest normalized Level 2 injury followed by August.

4.151 Absolute Level 3 injury rates for Wentworth Park are shown in Figure 4.31.A.

4.152 March and April have the highest absolute Level 3 injury rate with 11 injuries.

4.153 July has the lowest absolute Level 3 injury rate with 2 injuries.

4.154 Normalized Level 3 injury rates for Wentworth Park are shown in Figure 4.31.B.

4.155 April has the highest normalized Level 3 injury rate followed by May.

4.156 July has the lowest normalized Level 3 injury rate.

4.157 Absolute Level 4 injury rates for Wentworth Park are shown in Figure 4.32.A.

4.158 March has the highest absolute Level 4 injury rate with 27 injuries.

4.159 September has the lowest absolute Level 4 injury rate with 11 injuries.

4.160 Normalized Level 4 injury rates for Wentworth Park are shown in Figure 4.32.B.

4.161 January has the highest normalized Level 4 injury rate.

4.162 October has the lowest normalized Level 4 injury rate followed by January.

4.163 CATb does not include all the data.

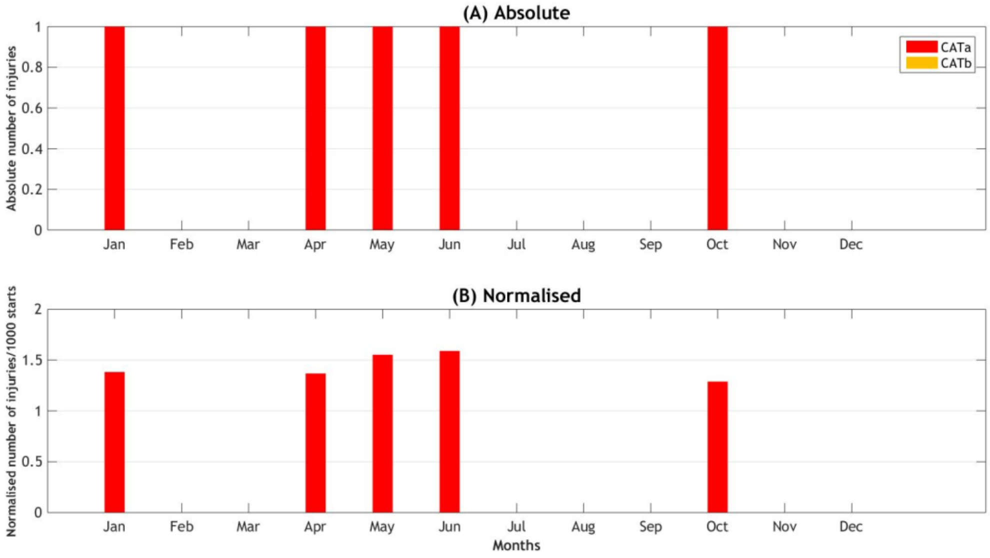

Figure 4.29: Wentworth Park track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

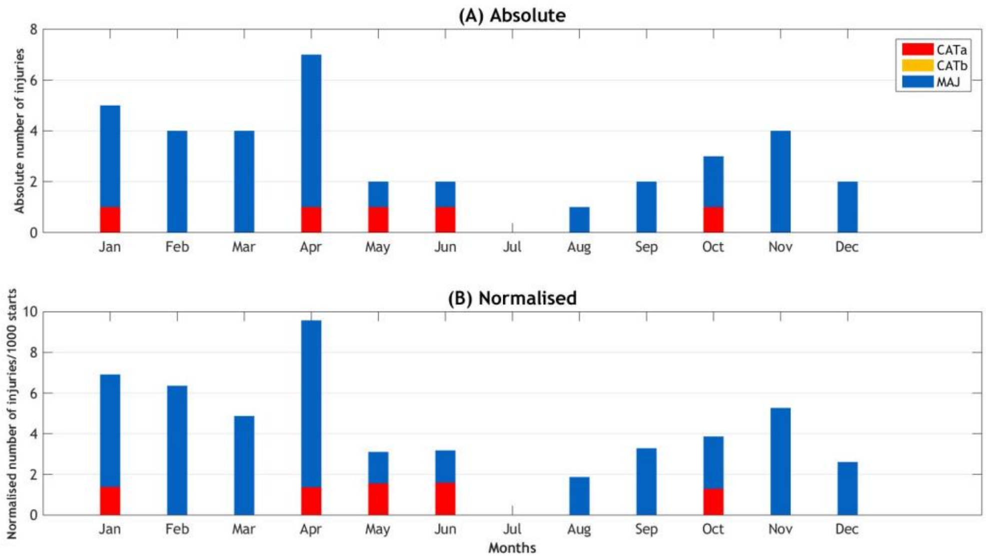

Figure 4.30: Wentworth Park track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

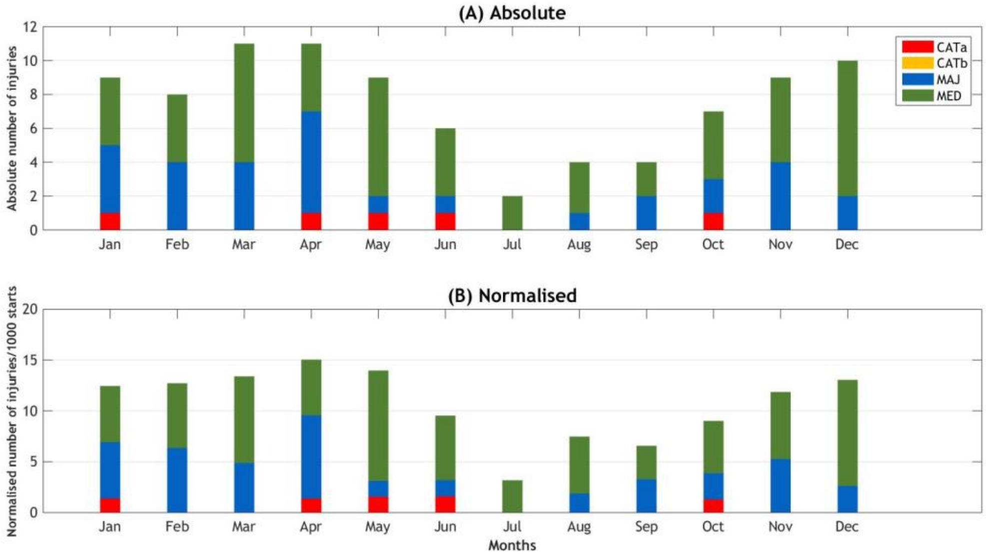

Figure 4.31: Wentworth Park track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

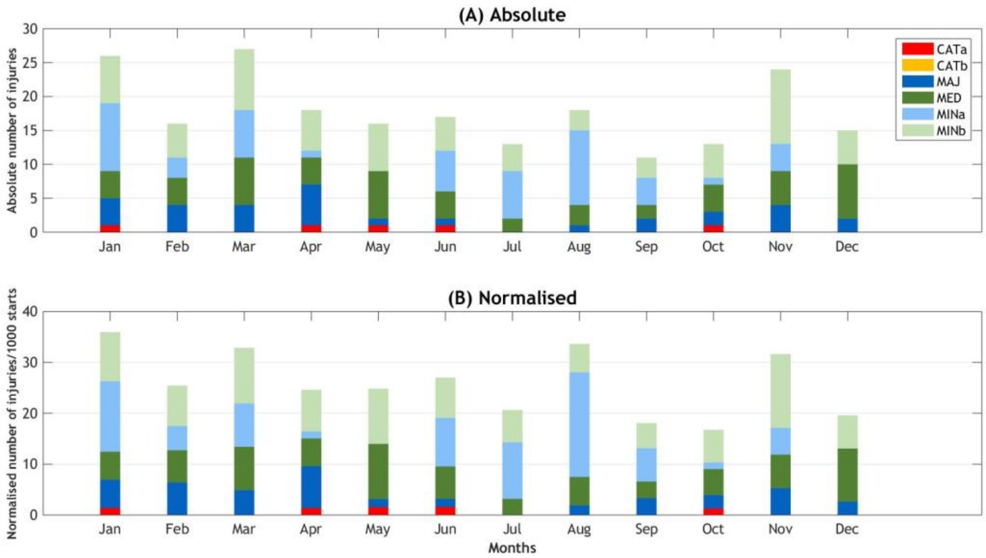

Figure 4.32: Wentworth Park track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

WENTWORTH PARK - LOCATION OF INJURIES 520 M - 1 JAN TO 31 DEC 2016

4.164 For the Wentworth Park 520 m distance race the locations of injuries are illustrated in Figure 4.33.

4.165 There were 953 races and 7352 starts from 1 January to 31 December 2016 at the 520 m distance.

4.166 Most of the injuries occurred at the beginning of the Southern Turn.

4.167 There were 26 Level 2 injuries for races started at the 520 m distance with 14 occurring at the beginning of the Southern Turn.

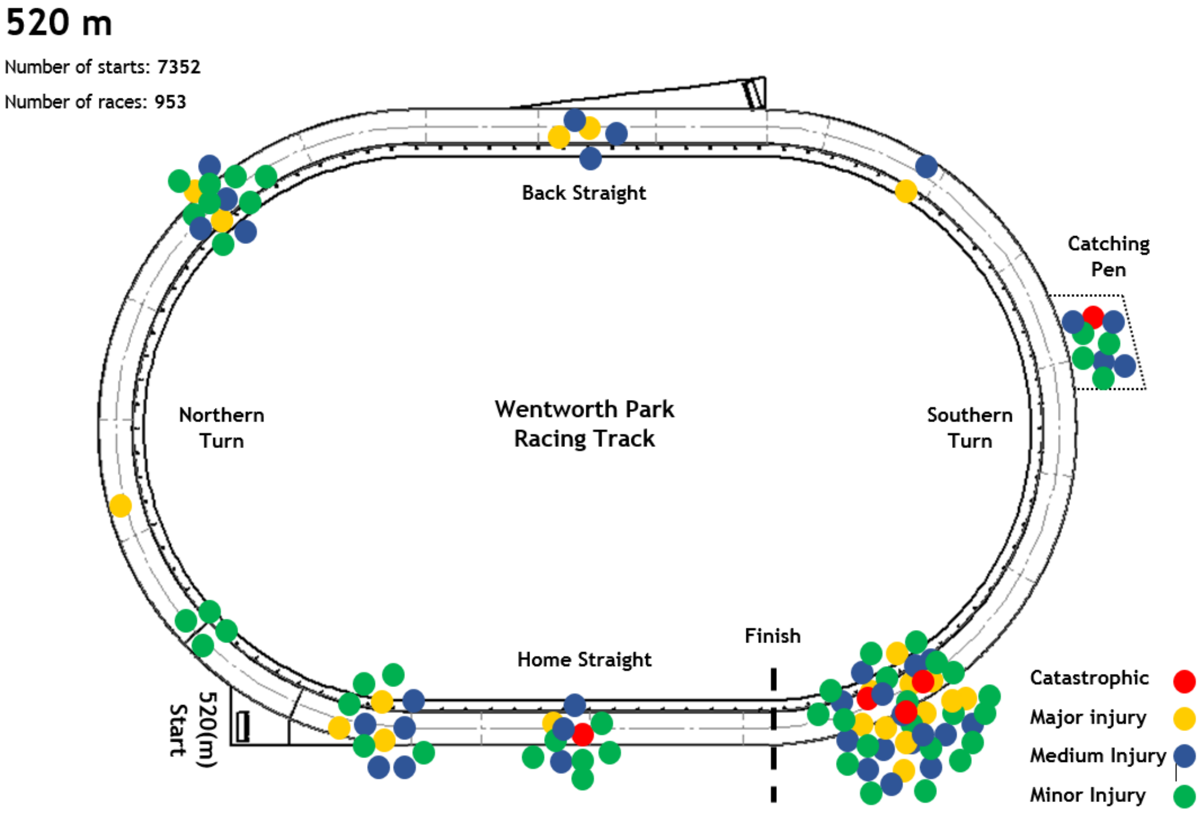

Figure 4.33: Wentworth Park track location of injuries for the 520 m distance – 1 Jan to 31 Dec 2016.

WENTWORTH PARK - LOCATION OF INJURIES 720 M - 1 JAN TO 31 DEC 2016

4.168 For the Wentworth Park 720 m distance race the locations of injuries are illustrated in Figure 4.34.

4.169 There were 111 races and 778 starts from 1 January to 31 December 2016 at the 720 m distance.

4.170 Most of the injuries occurred at the beginning of the Northern Turn.

4.171 There were only two injuries for 280 m starts.

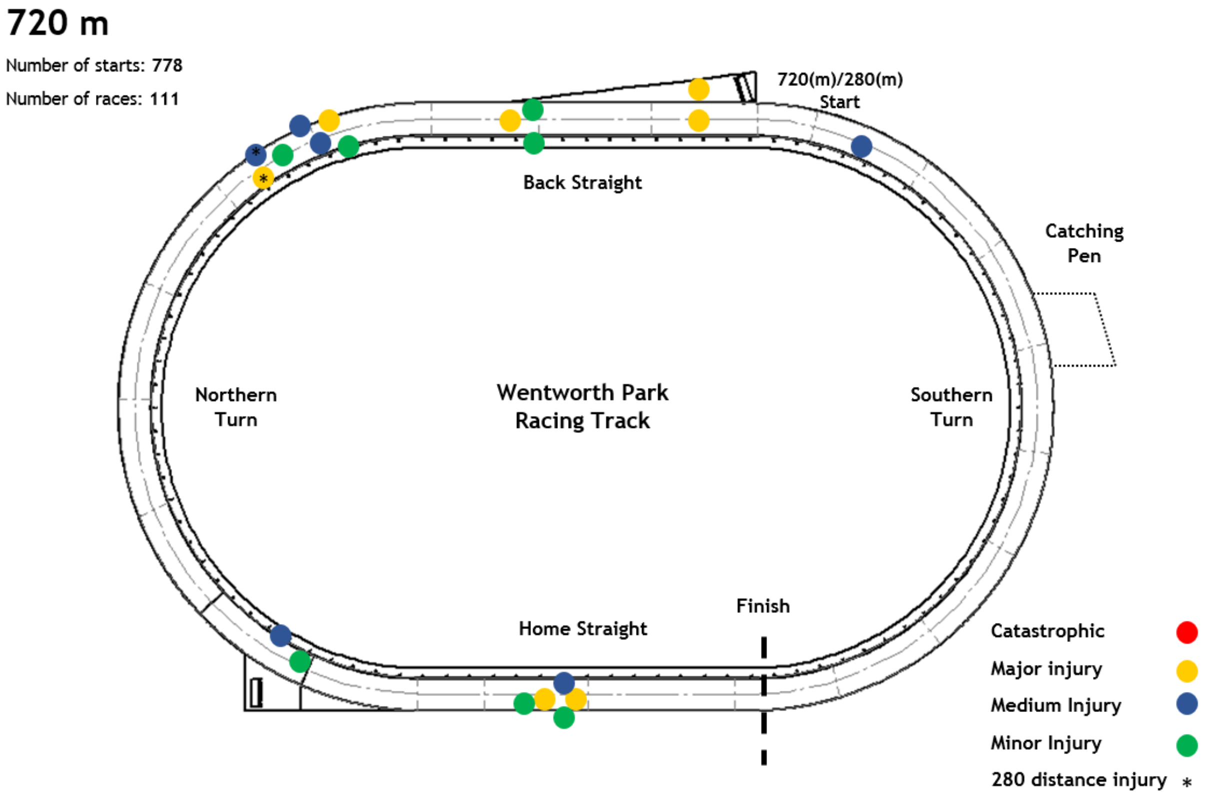

Figure 4.34: Wentworth Park track location of injuries for the 720 m distance – 1 Jan to 31 Dec 2016.

Grafton track

Grafton - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.172 Figures 4.35 to 4.38 contain Grafton Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.173 Absolute Level 1 injury rates for Grafton are shown in Figure 4.35.A.

4.174 May has the highest Level 1 injury with 2 injuries.

4.175 Normalized Level 1 injury rates for Grafton are shown in Figure 4.35.B.

4.176 April has the highest normalized Level 1 injury rate.

4.177 Absolute Level 2 injury rates for Grafton are shown in Figure 4.36.A.

4.178 September has the highest absolute Level 2 injury rate with 7 injuries.

4.179 February, March, June and October have the lowest absolute Level 2 Injury rate with 1 injury each.

4.180 Normalized Level 2 injury rates for Grafton are shown in Figure 4.36.B.

4.181 September has the highest normalized Level 2 injury rate.

4.182 June has the lowest normalized Level 2 injury.

4.183 Absolute Level 3 injury rates for Grafton are shown in Figure 4.37.A.

4.184 December and May have the highest absolute Level 3 injury rate with 11 injuries.

4.185 October and November have the lowest absolute Level 3 injuries rate with 3 injuries.

4.186 Normalized Level 3 injury rates for Grafton are shown in Figure 4.37.B.

4.187 April has the highest normalized Level 3 injury rate.

4.188 June has the lowest normalized Level 3 injury rate.

4.189 Absolute Level 4 injury rates for Grafton are shown in Figure 4.38.A.

4.190 July has the highest absolute Level 4 injury rate with 15 injuries.

4.191 November has the lowest absolute Level 4 injury rate with 4 injuries.

4.192 Normalized Level 4 injury rates for Grafton are shown in Figure 4.38.B.

4.193 April has the highest normalized Level 4 injury rate.

4.194 November has the lowest normalized Level 4 injury rate.

4.195 CATb does not include all the data.

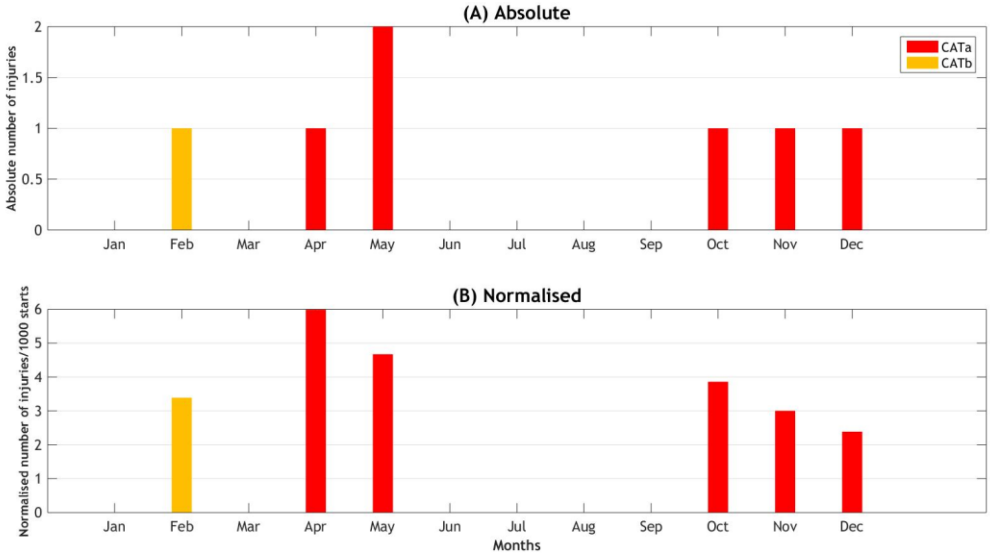

Figure 4.35: Grafton track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

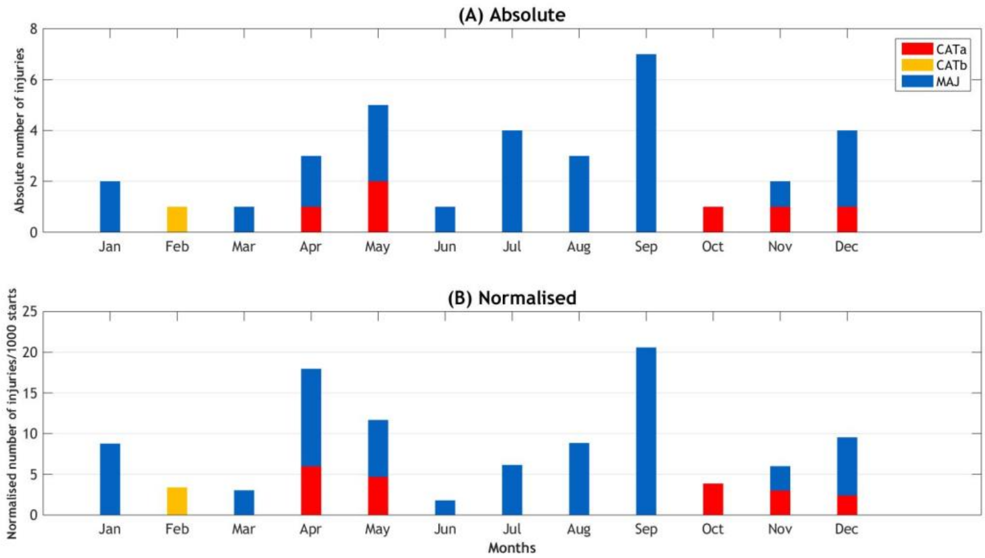

Figure 4.36: Grafton track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

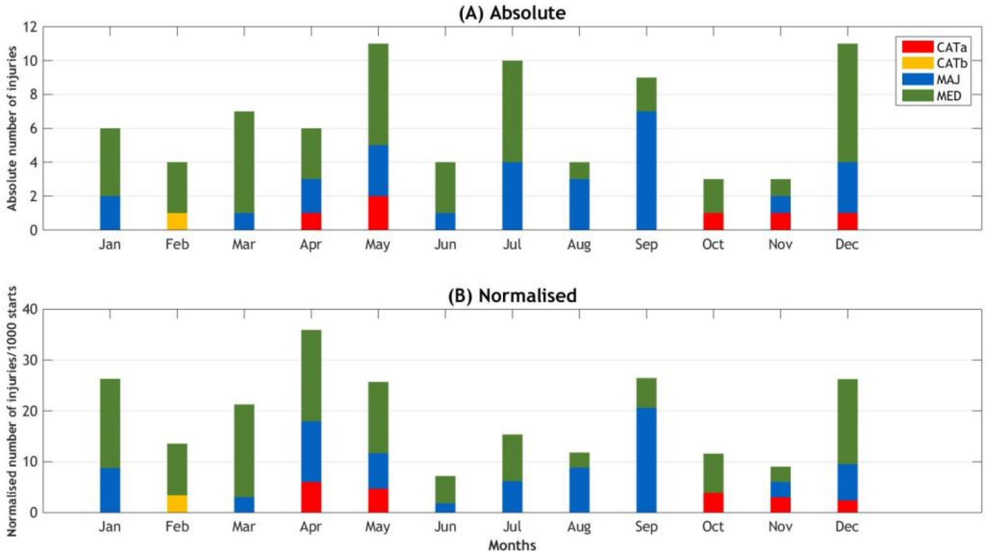

Figure 4.37: Grafton track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

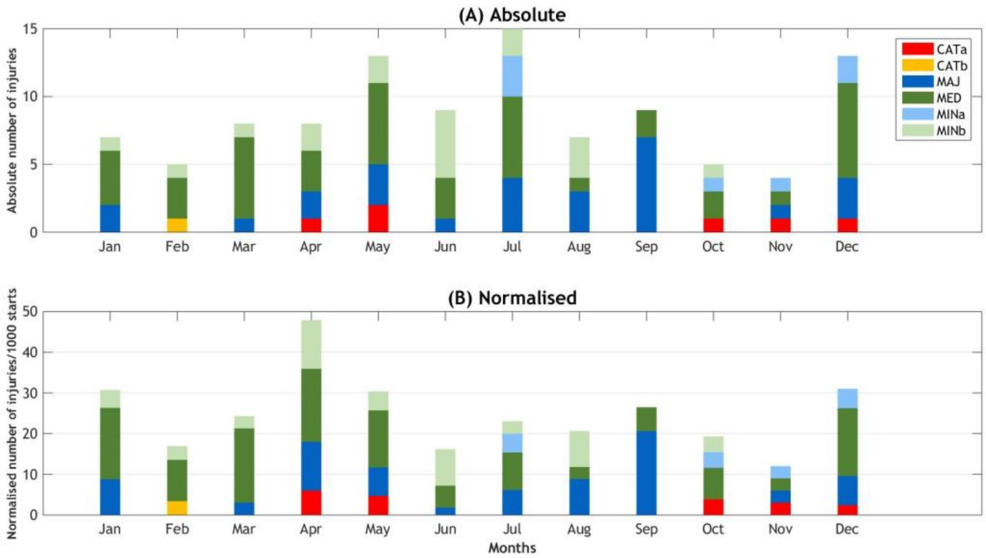

Figure 4.38: Grafton track Level 4 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

Grafton - Location of injuries 305 m - 1 Jan to 31 Dec 2016

4.196 For the Grafton 305 m distance race the locations of injuries are illustrated in Figure 4.39.

4.197 There were 138 races and 1071 starts from 1 January to 31 December 2016 at the 305 m distance.

4.198 Most of the injuries occurred shortly after the start at Northern Turn.

4.199 There were 4 Level 2 injuries for races started at the 305 m distance and all occurred at the Northern Turn.

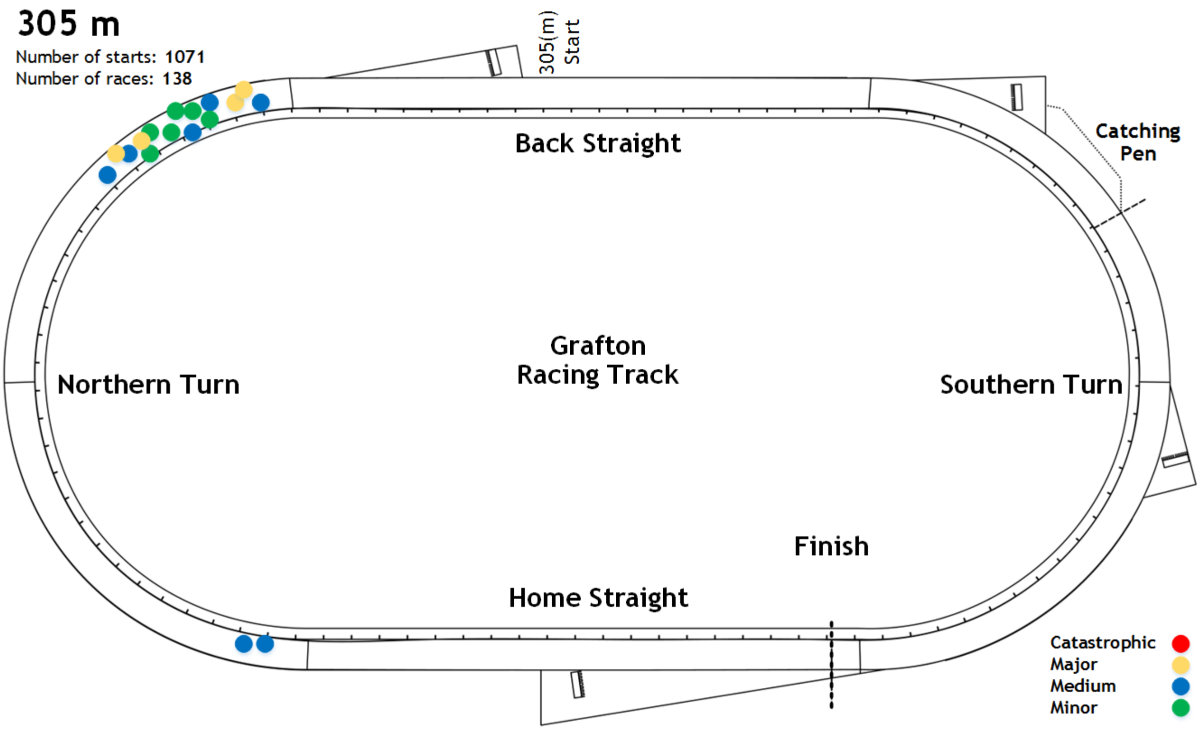

Figure 4.39: Grafton track location of injuries for the 305 m distance – 1 Jan to 31 Dec 2016.

GRAFTON - LOCATION OF INJURIES 407 M - 1 JAN TO 31 DEC 2016

4.200 For the Grafton 407 m distance race the locations of injuries are illustrated in Figure 4.40.

4.201 There were 286 races and 2220 starts from 1 January to 31 December 2016 at the 407 m distance.

4.202 Most of the injuries occurred at the beginning of the Northern Turn.

4.203 There were 4 level 2 injuries that occurred at Catching Pen.

4.204 There were 12 Level 2 injuries for races started at the 407 m distance with 5 occurring at the beginning of the Northern Turn.

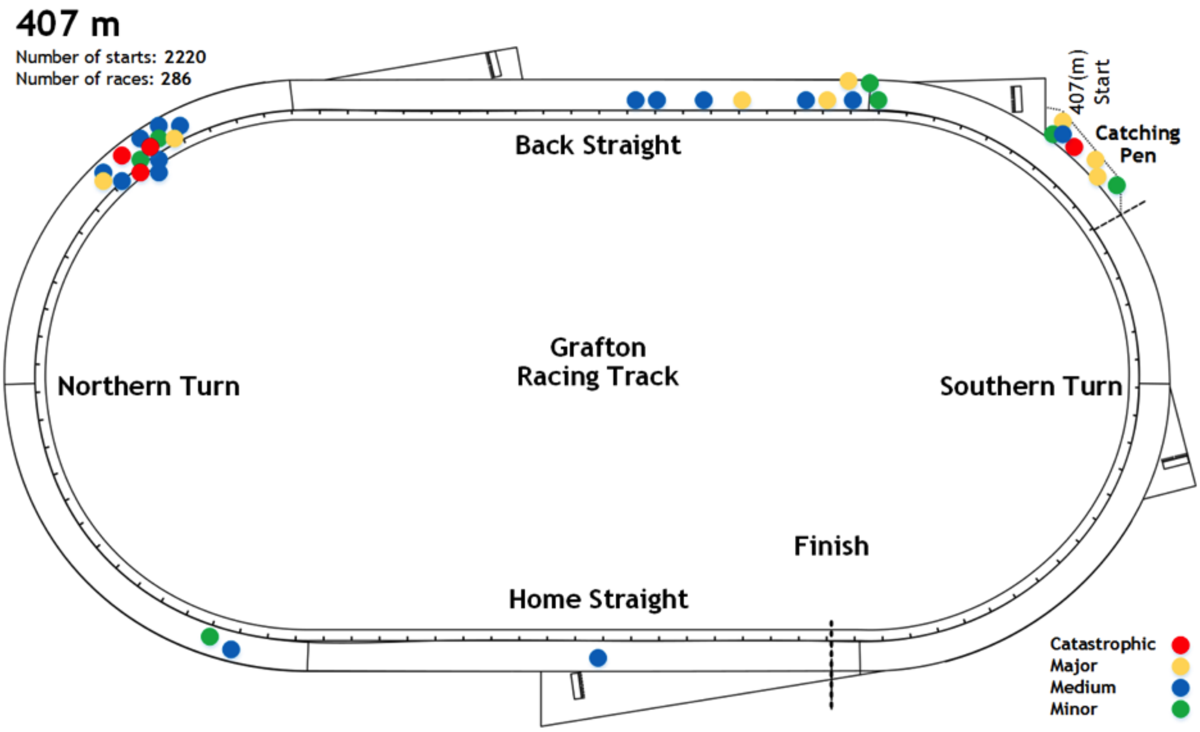

Figure 4.40: Grafton track location of injuries for the 407 m distance - 1 Jan to 31 Dec 2016.

GRAFTON - LOCATION OF INJURIES 480 M - 1 JAN TO 31 DEC 2016

4.205 For the Grafton 480 m distance race the locations of injuries are illustrated in Figure 4.41.

4.206 There were 111 races and 847 starts from 1 January to 31 December 2016 at the 480 m distance.

4.207 Most of the injuries occurred shortly after the start at Southern Turn.

4.208 There were 9 Level 2 injuries for races started at the 480 m distance and all occurred at the Southern Turn.

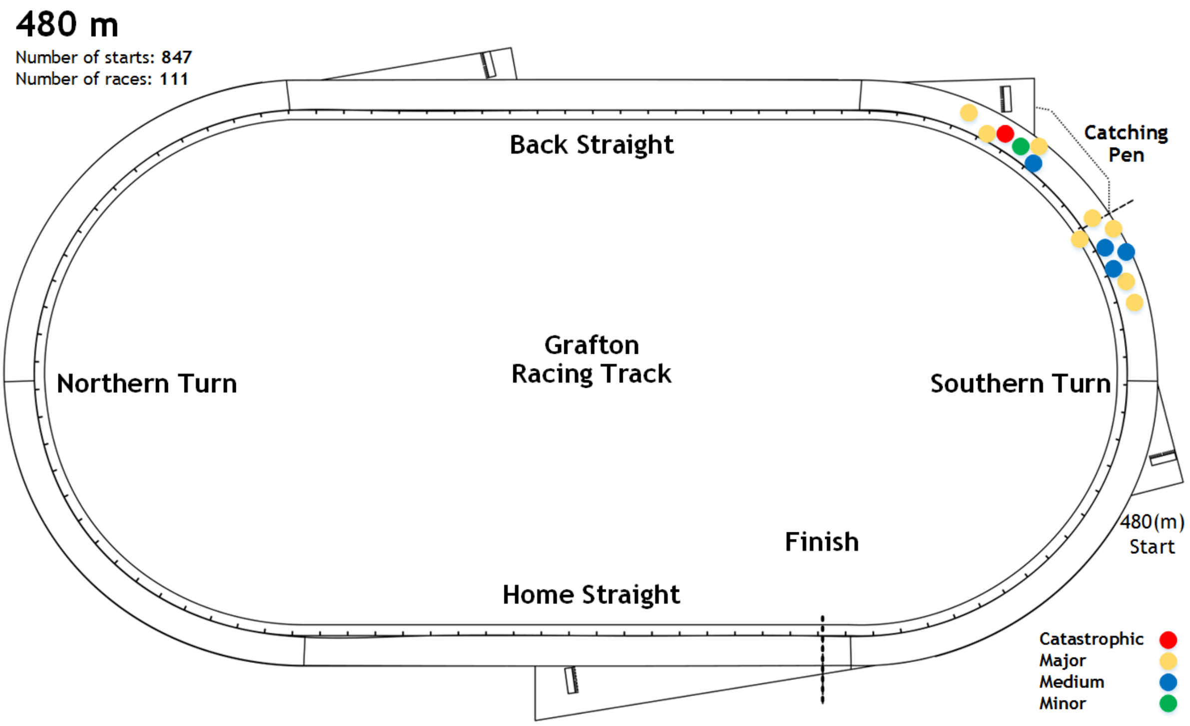

Figure 4.41: Grafton track location of injuries for the 480 m distance - 1 Jan to 31 Dec 2016.

Casino

Casino - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.209 Figures 4.42 to 4.45 contain Casino Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.210 Absolute Level 1 injury rates for Casino are shown in Figure 4.42.A.

4.211 September and October and December have the highest Level 1 injury with 2 injuries.

4.212 Normalized Level 1 injury rates for Casino are shown in Figure 4.42.B.

4.213 October has the highest normalized Level 1 injury rate.

4.214 Absolute Level 2 injury rates for Casino are shown in Figure 4.43.A.

4.215 August has the highest absolute Level 2 injury rate with 6 injuries.

4.216 March and November have the lowest absolute Level 2 Injury rate with 1 injury each.

4.217 Normalized Level 2 injury rates for Casino are shown in Figure 4.43.B.

4.218 December has the highest normalized Level 2 Injury rate.

4.219 November has the lowest normalized Level 2 injury.

4.220 Absolute Level 3 injury rates for Casino are shown in Figure 4.44.A.

4.221 August has the highest absolute Level 3 injury rate with 17 injuries.

4.222 January, March and April have the lowest absolute Level 3 injury rate with 3 injuries.

4.223 Normalized Level 3 injury rates for Casino are shown in Figure 4.44.B.

4.224 December has the highest normalized Level 3 injury rate followed by June.

4.225 April has the lowest normalized Level 3 injury rate followed by September.

4.226 Absolute Level 4 injury rates for Casino are shown in Figure 4.45.A.

4.227 August has the highest absolute Level 4 injury rate with 26 injuries.

4.228 April and January has the lowest absolute Level 4 injury rate with 4 injuries.

4.229 Normalized Level 4 injury rates for Casino are shown in Figure 4.46.B.

4.230 August has the highest normalized Level 4 injury rate followed by December.

4.231 April has the lowest normalized Level 4 injury rate.

4.232 CATb does not include all the data.

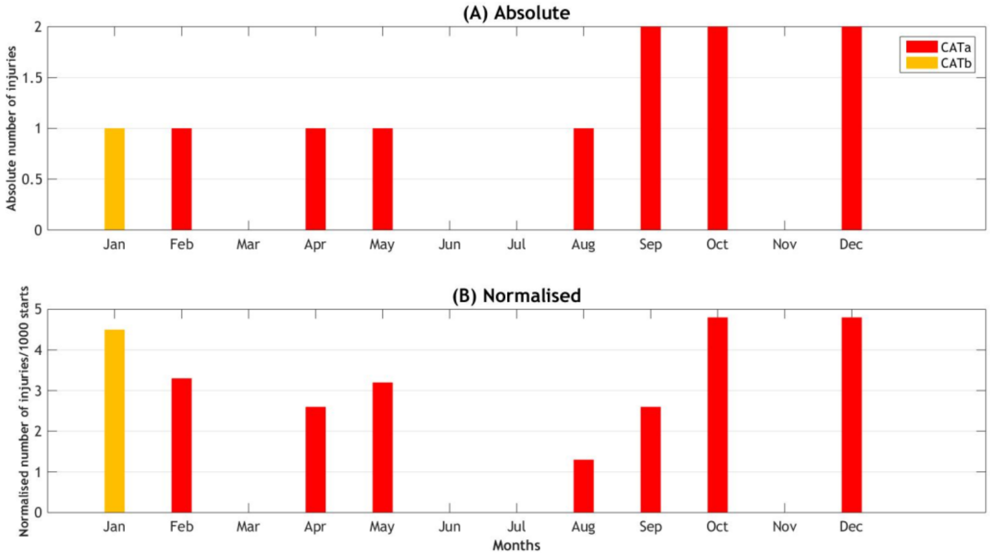

Figure 4.42: Casino track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

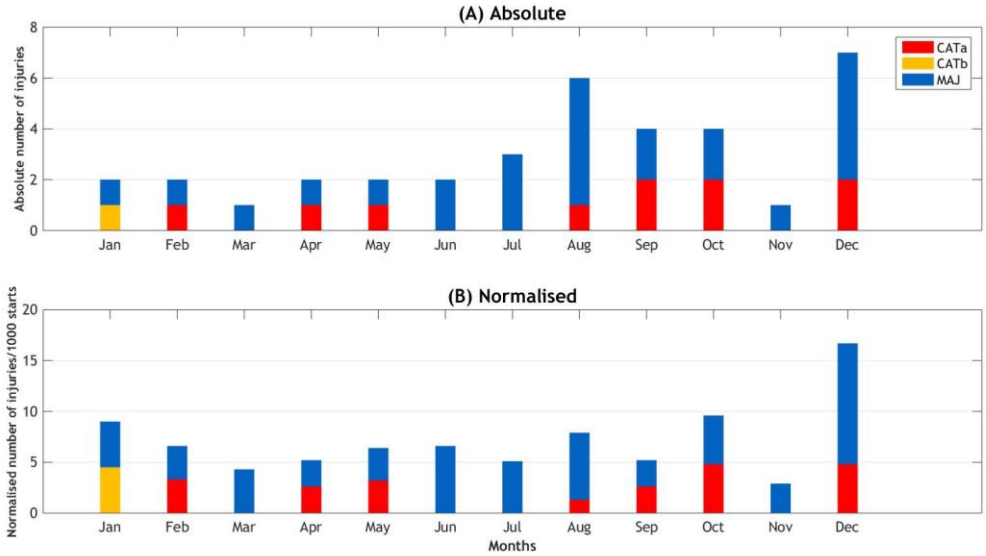

Figure 4.43: Casino track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

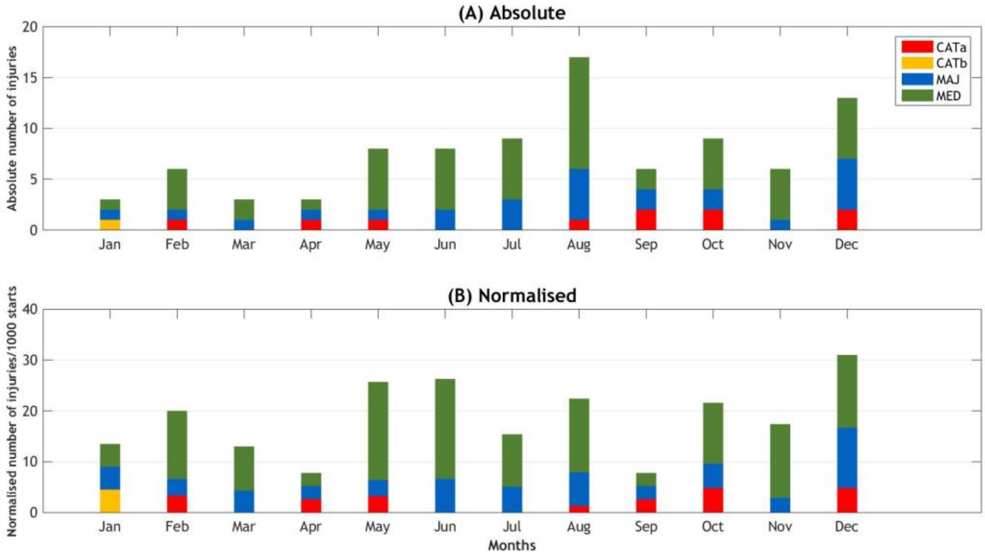

Figure 4.44: Casino track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

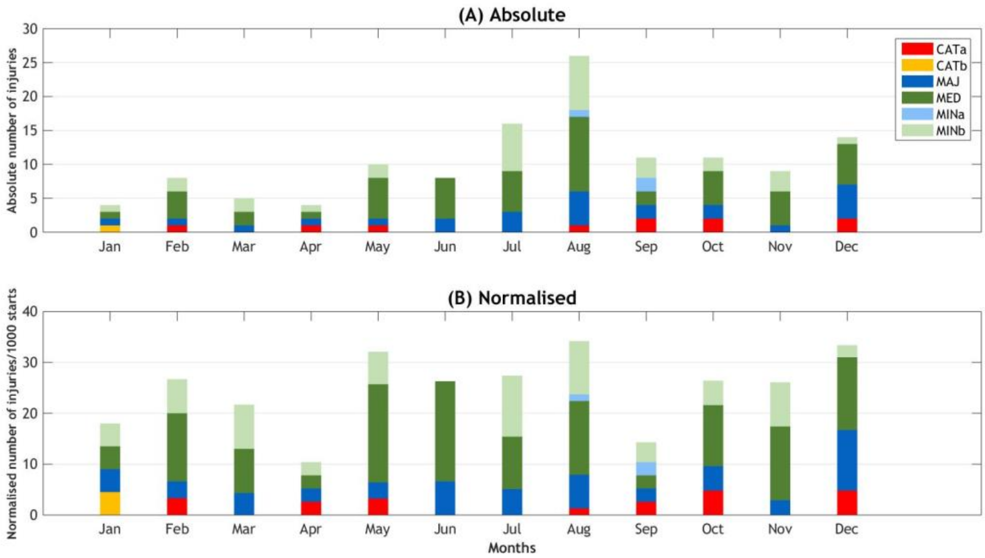

Figure 4.45: Casino track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

CASINO - LOCATION OF INJURIES 411 M - 1 JAN TO 31 DEC 2016

4.233 For the Casino 411 m distance race the locations of injuries are illustrated in Figure 4.46.

4.234 There were 349 races and 2701 starts from 1 January to 31 Decembers 2016 at the 411 m distance.

4.235 Most of the injuries occurred shortly after the start at Southern Turn.

4.236 There were 10 Level 2 injuries for races started at the 411 m distance with 9 occurring at the Southern Turn.

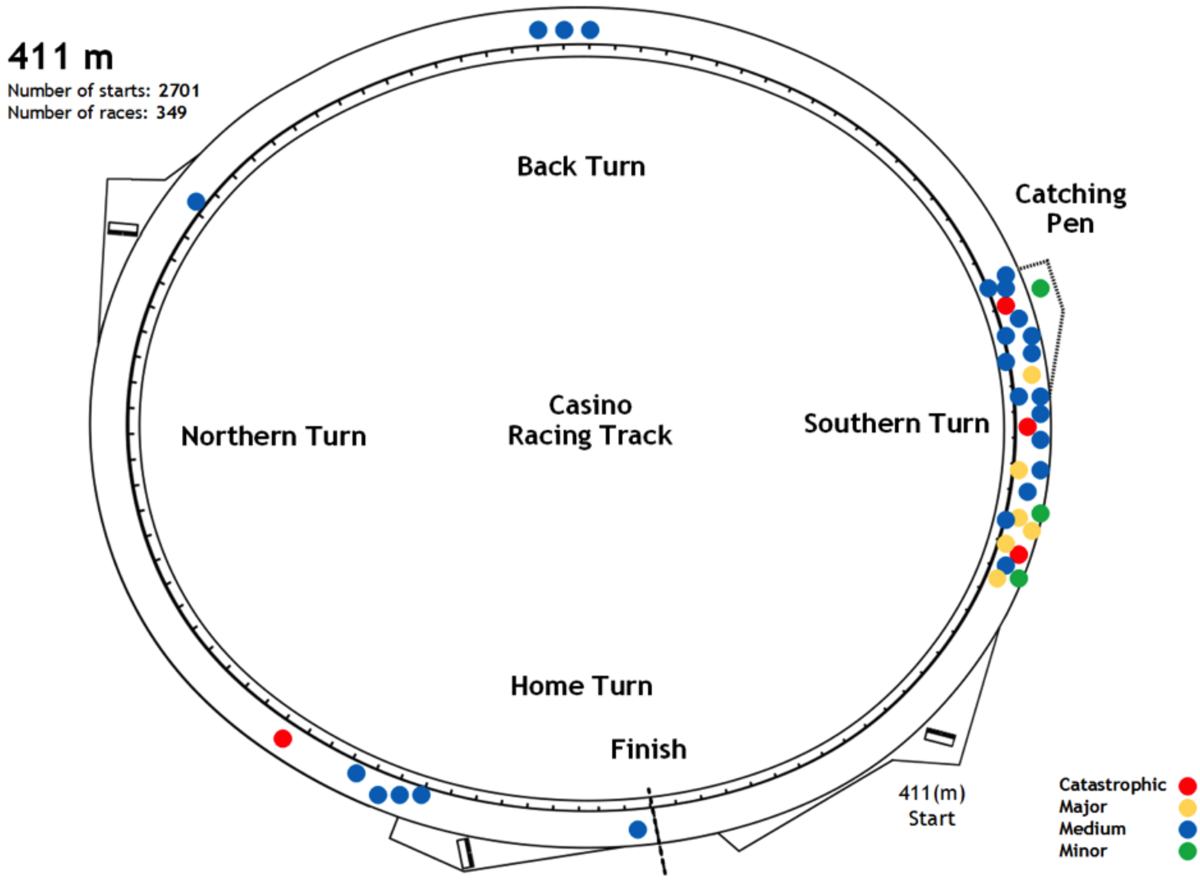

Figure 4.46: Casino track location of injuries for the 411 m distance – 1 Jan to 31 Dec 2016.

CASINO - LOCATION OF INJURIES 484 M - 1 JAN TO 31 DEC 2016

4.237 For the Casino 484 m distance race the locations of injuries are illustrated in Figure 4.47.

4.238 There were 252 races and 1943 starts from 1 January to 31 December 2016 at the 484 m distance.

4.239 Most of the injuries occurred shortly after the start at the beginning of Southern Turn.

4.240 There were 13 Level 2 injuries for races started at the 484 m distance with 10 occurring at the Southern Turn.

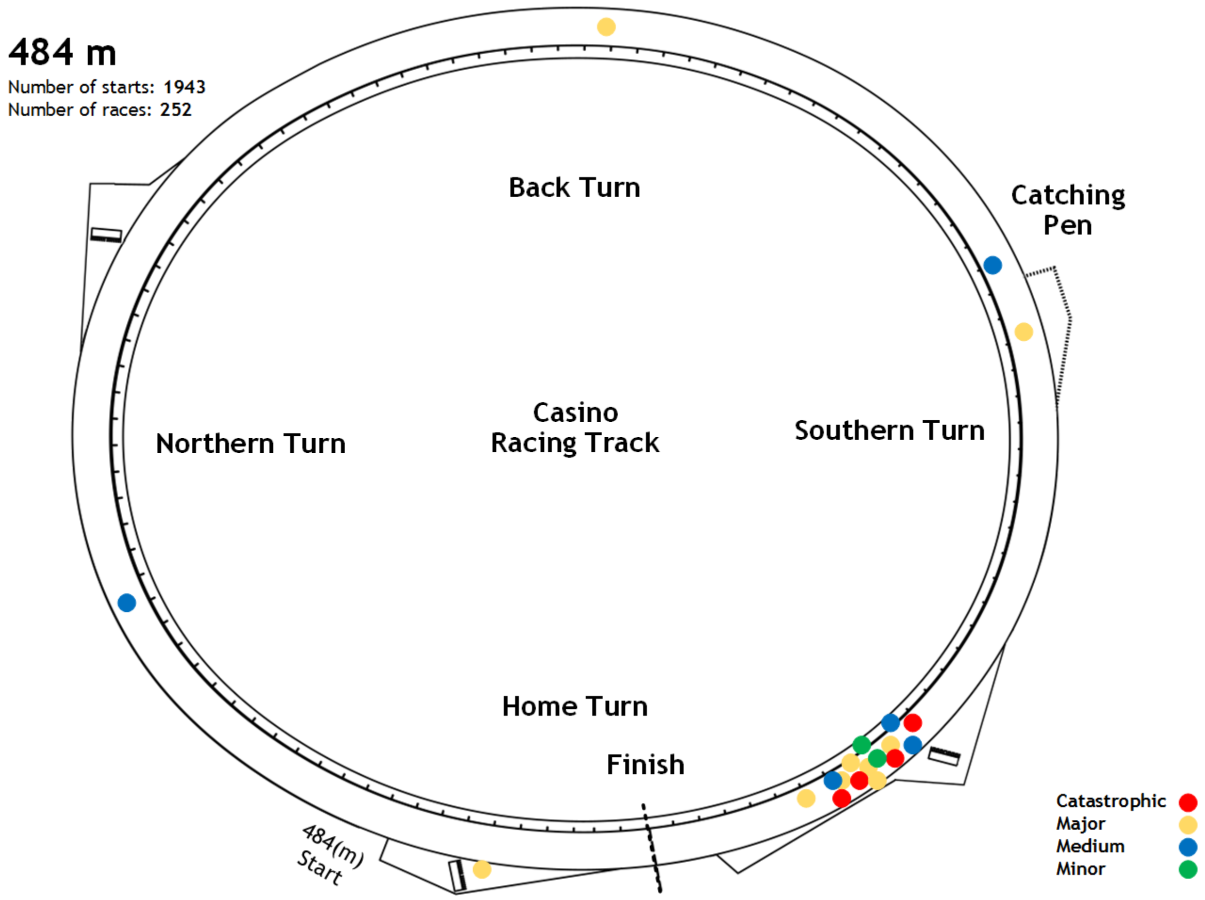

Figure 4.47: Casino track location of injuries for the 484 m distance – 1 Jan to 31 Dec 2016.

CASINO - LOCATION OF INJURIES 600 M - 1 JAN TO 31 DEC 2016

4.241 For the Casino 600 m distance race the locations of injuries are illustrated in Figure 4.48.

4.242 The data are not sufficient enough to determine the hazardous locations for this distance.

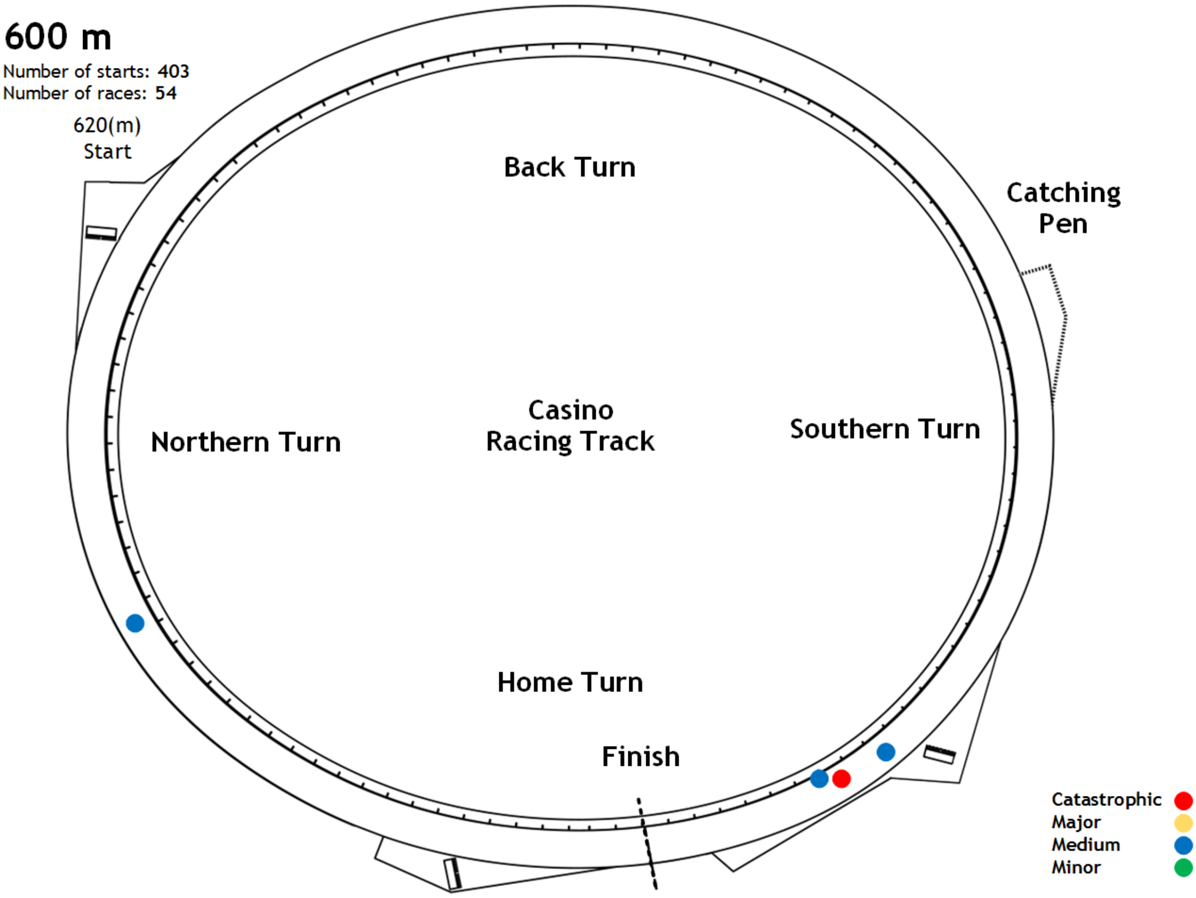

Figure 4.48: Casino track location of injuries for the 620 m distance – 1 Jan to 31 Dec 2016.

MAITLAND

MAITLAND - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.243 Figures 4.49 to 4.52 contain Maitland Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.244 Absolute Level 1 injury rates for Maitland are shown in Figure 4.49.A.

4.245 April has the highest Level 1 injury with 3 injuries.

4.246 Normalized Level 1 injury rates for Maitland are shown in Figure 4.49.B.

4.247 April has the highest normalized Level 1 injury rate.

4.248 Absolute Level 2 injury rates for Maitland are shown in Figure 4.50.A.

4.249 March has the highest absolute Level 2 injury rate with 6 injuries.

4.250 January, February, June and July have the lowest absolute Level 2 Injury rate with 1 injury each.

4.251 Normalized Level 2 injury rates for Maitland are shown in Figure 4.50.B.

4.252 December has the highest normalized Level 2 Injury rate.

4.253 June has the lowest normalized Level 2 injury.

4.254 Absolute Level 3 injury rates for Maitland are shown in Figure 4.51.A.

4.255 March has the highest absolute Level 3 injury rate with 12 injuries.

4.256 February has the lowest absolute Level 3 injuries rate with 2 injuries.

4.257 Normalized Level 3 injury rates for Maitland are shown in Figure 4.51.B.

4.258 March has the highest normalized Level 3 injury rate.

4.259 February has the lowest normalized Level 3 injury rate followed by September.

4.260 Absolute Level 4 injury rates for Maitland are shown in Figure 4.52.A.

4.261 March has the highest absolute Level 4 injury rate with 16 injuries.

4.262 January and February have the lowest absolute Level 4 injury rate with 4 injuries each.

4.263 Normalized Level 4 injury rates for Maitland are shown in Figure 4.52.B.

4.264 March has the highest normalized Level 4 injury rate.

4.265 June has the lowest normalized Level 4 injury rate.

4.266 CATb does not include all the data.

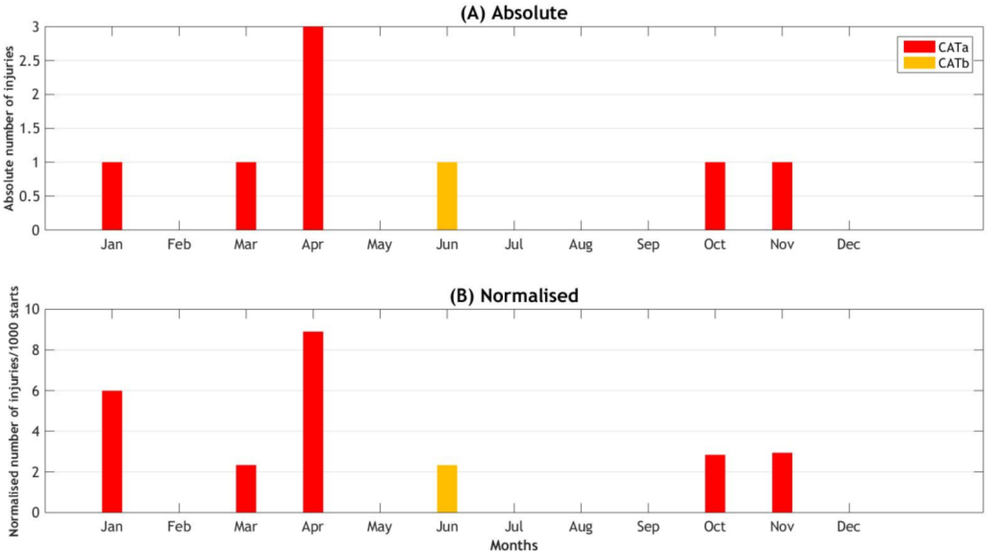

Figure 4.49: Maitland track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

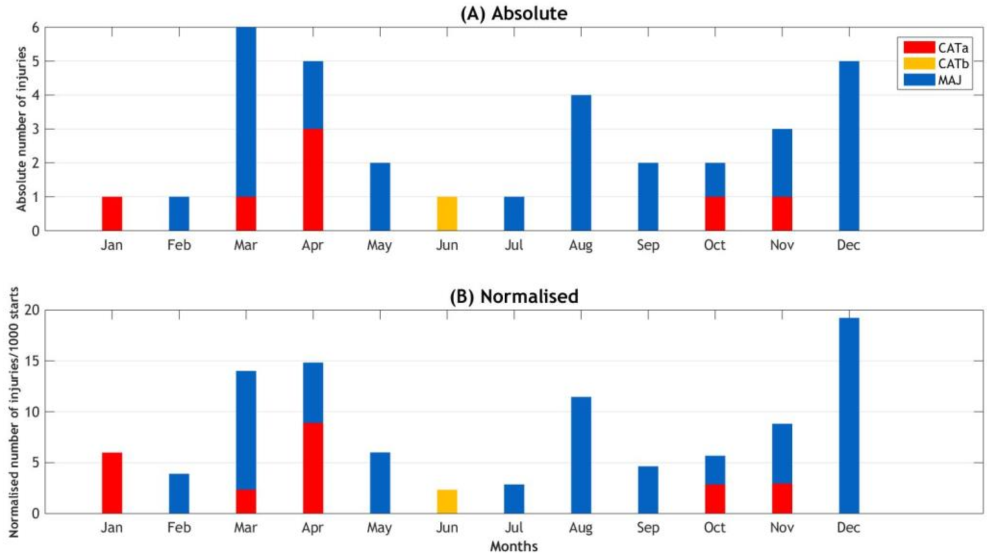

Figure 4.50: Maitland track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

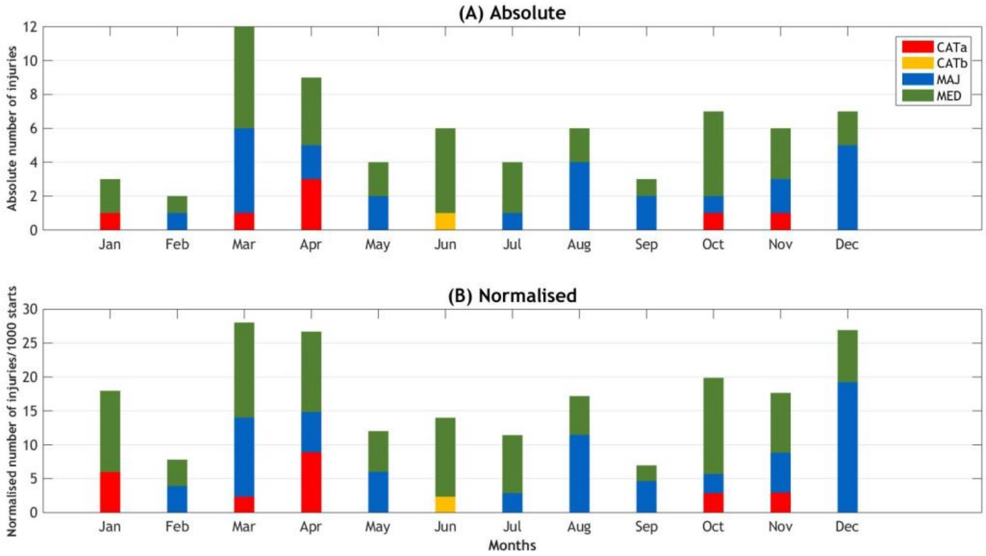

Figure 4.51: Maitland track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

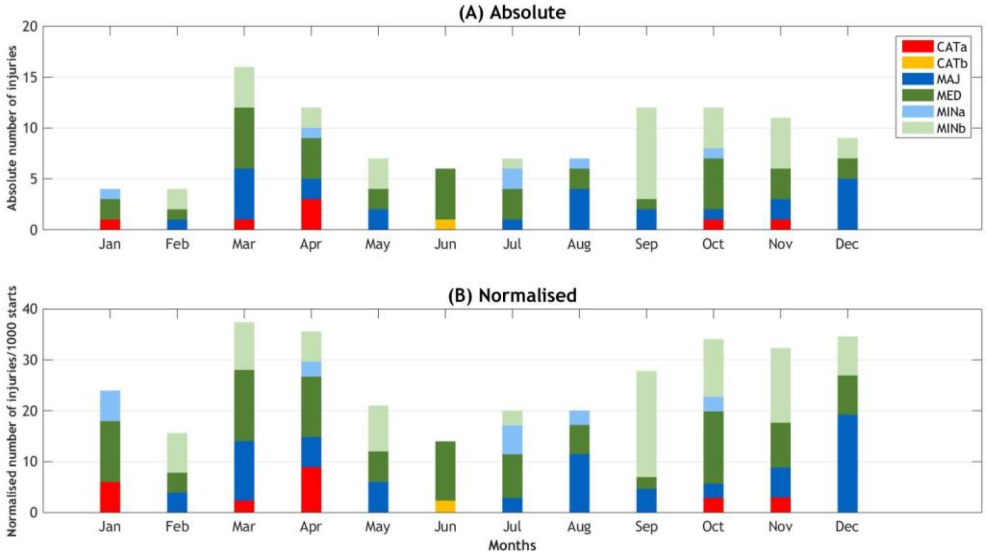

Figure 4.52: Maitland track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

MAITLAND - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.267 For the Maitland 400 m distance race the locations of injuries are illustrated in Figure 4.53.

4.268 There were 264 races and 2084 starts from 1 January to 31 December 2016 at the 400 m distance.

4.269 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.270 There were 14 Level 2 injuries for races started at the 400 m distance with 11 occurring at the Northern Turn.

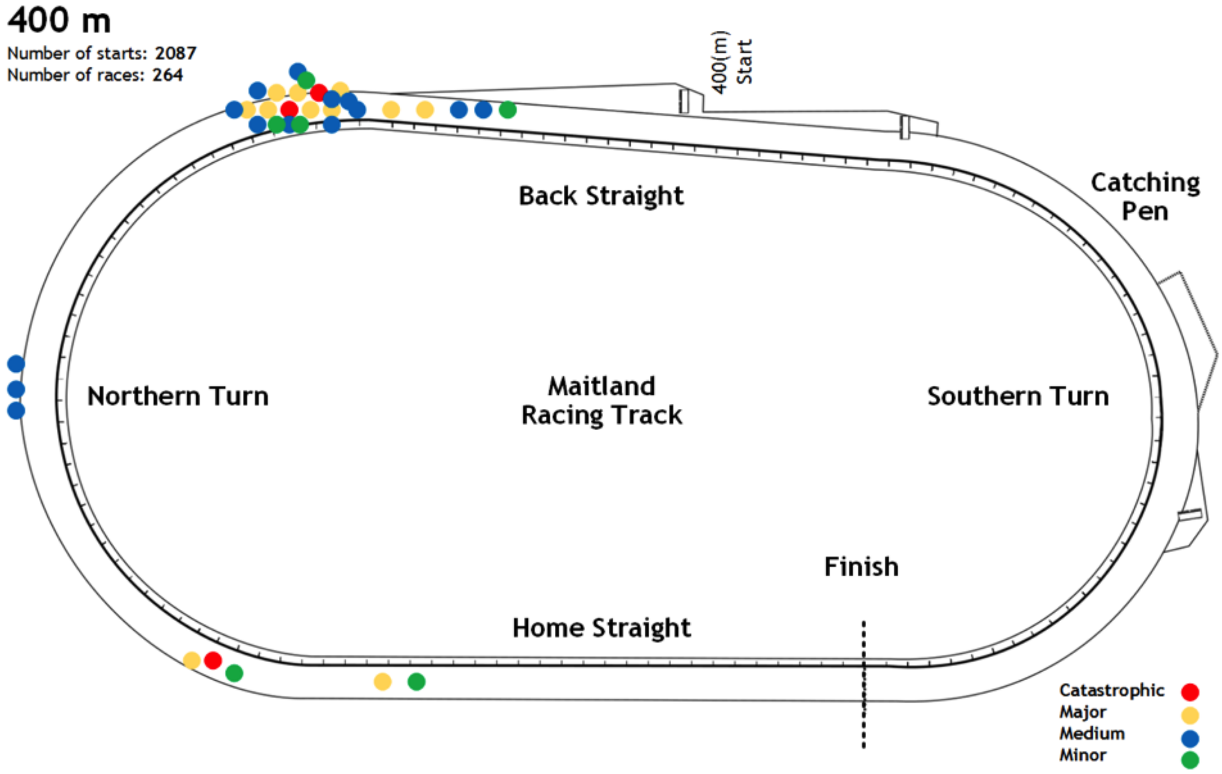

Figure 4.53: Maitland track location of injuries for the 400 m distance – 1 Jan to 31 Dec 2016.

Maitland - Location of injuries 450 m - 1 Jan to 31 Dec 2016

4.271 For the Maitland 450 m distance race the locations of injuries are illustrated in Figure 4.54.

4.272 There were 215 races and 1678 starts from 1 January to 31 December 2016 at the 450 m distance.

4.273 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.274 There were 13 Level 2 injuries for races started at the 450 m distance and all occurred at the Northern Turn.

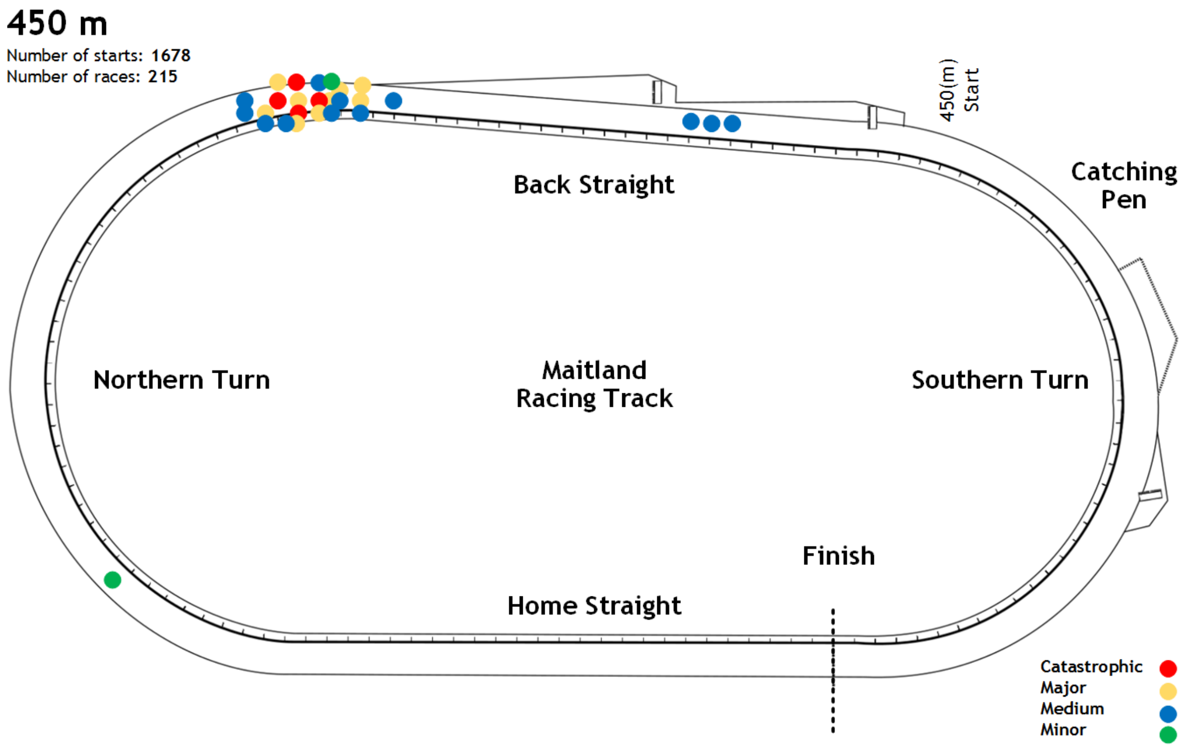

Figure 4.54: Maitland track location of injuries for the 450 m distance - 1 Jan to 31 Dec 2016.

Bathurst

Bathurst - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.275 Figures 4.55 to 4.58 contain Bathurst Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.276 Absolute Level 1 injury rates for Bathurst are shown in Figure 4.55.A.

4.277 February has the highest Level 1 injury with 3 injuries.

4.278 Normalized Level 1 injury rates for Bathurst are shown in Figure 4.55.B.

4.279 April has the highest normalized Level 1 injury rate.

4.280 Absolute Level 2 injury rates for Bathurst are shown in Figure 4.56.A.

4.281 January has the highest absolute Level 2 injury rate with 6 injuries.

4.282 March and December have the lowest absolute Level 2 Injury rate with 0 injuries.

4.283 Normalized Level 2 injury rates for Bathurst are shown in Figure 4.56.B.

4.284 January has the highest normalized Level 2 Injury rate.

4.285 March and December have the lowest normalized Level 2 injury.

4.286 Absolute Level 3 injury rates for Bathurst are shown in Figure 4.57.A.

4.287 January has the highest absolute Level 3 injury rate with 8 injuries.

4.288 March has the lowest absolute Level 3 injuries rate with 0 injuries.

4.289 Normalized Level 3 injury rates for Bathurst are shown in Figure 4.57.B.

4.290 May has the highest normalized Level 3 injury rate followed by October.

4.291 March has the lowest normalized Level 3 injury rate.

4.292 Absolute Level 4 injury rates for Bathurst are shown in Figure 4.58.A.

4.293 October has the highest absolute Level 4 injury rate with 16 injuries.

4.294 November and December has the lowest absolute Level 4 injury rate with 4 injuries.

4.295 Normalized Level 4 injury rates for Bathurst are shown in Figure 4.58.B.

4.296 June has the highest normalized Level 4 injury rate.

4.297 November and December have the lowest normalized Level 4 injury rate.

4.298 CATb does not include all the data.

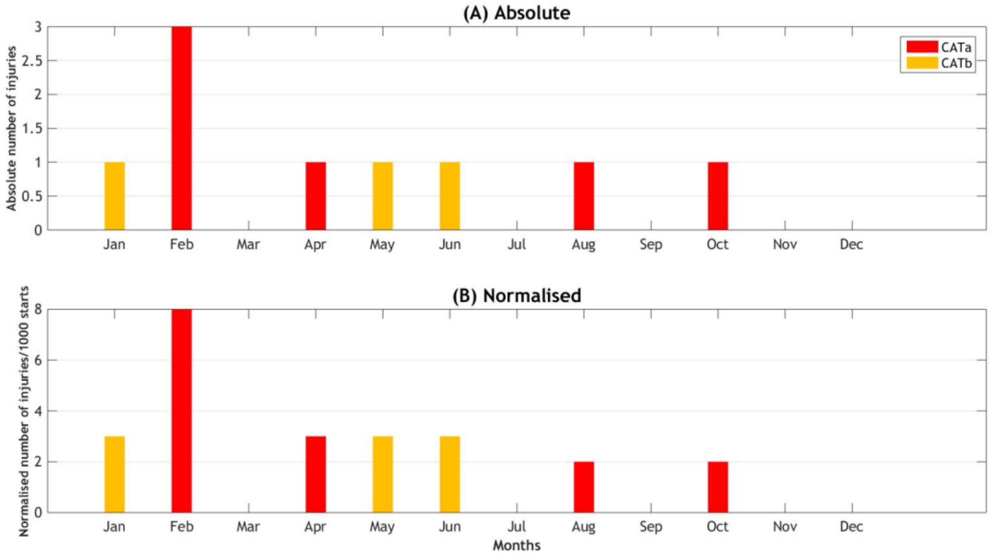

Figure 4.55: Bathurst track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

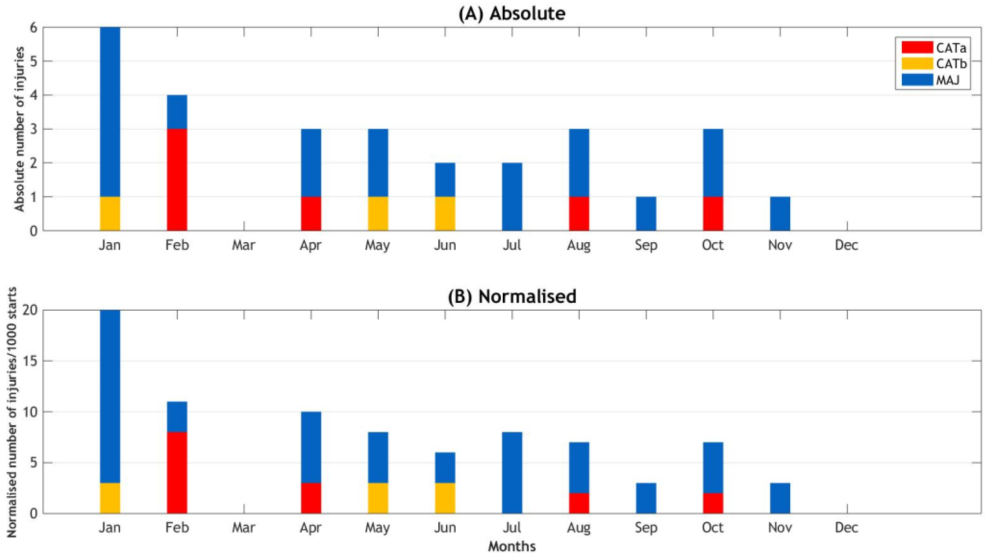

Figure 4.56: Bathurst track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

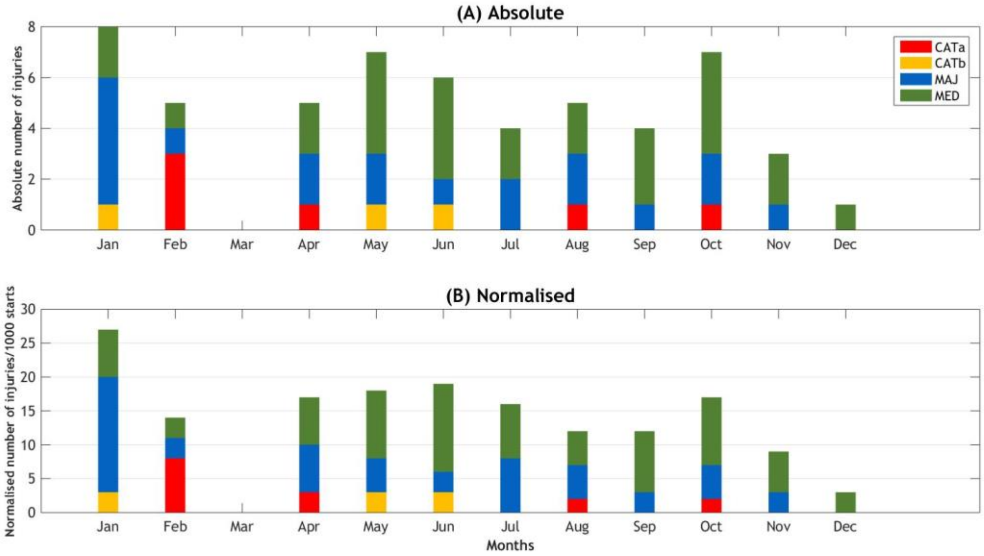

Figure 4.57: Bathurst track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

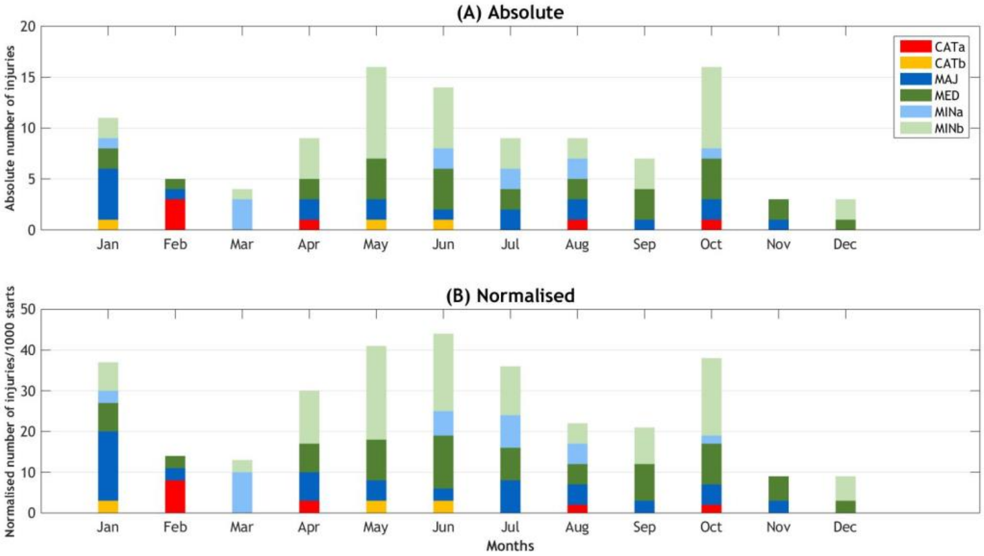

Figure 4.58: Bathurst track Level 4 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

BATHURST - LOCATION OF INJURIES 307 M - 1 JAN TO 31 DEC 2016

4.299 For the Bathurst 307 m distance race the locations of injuries are illustrated in Figure 4.59.

4.300 There were 191 races and 1455 starts from 1 January to 31 December 2016 at the 307 m distance.

4.301 Most of the injuries occurred at the beginning of Western Turn.

4.302 There were 6 Level 2 injuries for races started at the 307 m distance with 4 occurring at the Western Turn.

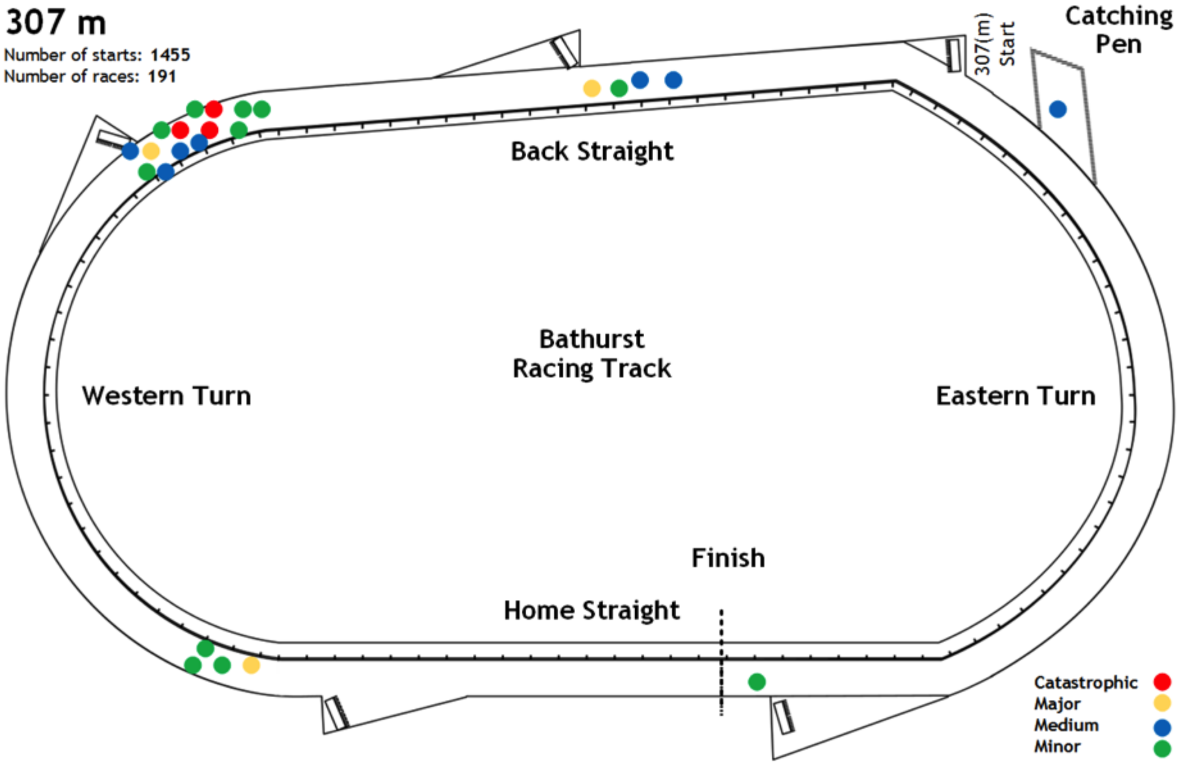

Figure 4.59: Bathurst track location of injuries for the 307 m distance – 1 Jan to 31 Dec 2016.

BATHURST - LOCATION OF INJURIES 450 M - 1 JAN TO 31 DEC 2016

4.303 For the Bathurst 450 m distance race the locations of injuries are illustrated in Figure 4.60.

4.304 There were 182 races and 1387 starts from 1 January to 31 December 2016 at the 450 m distance.

4.305 Most of the injuries occurred shortly after the start at the beginning of Eastern Turn.

4.306 There were 10 Level 2 injuries for races started at the 450 m distance with 6 occurring at the Eastern Turn.

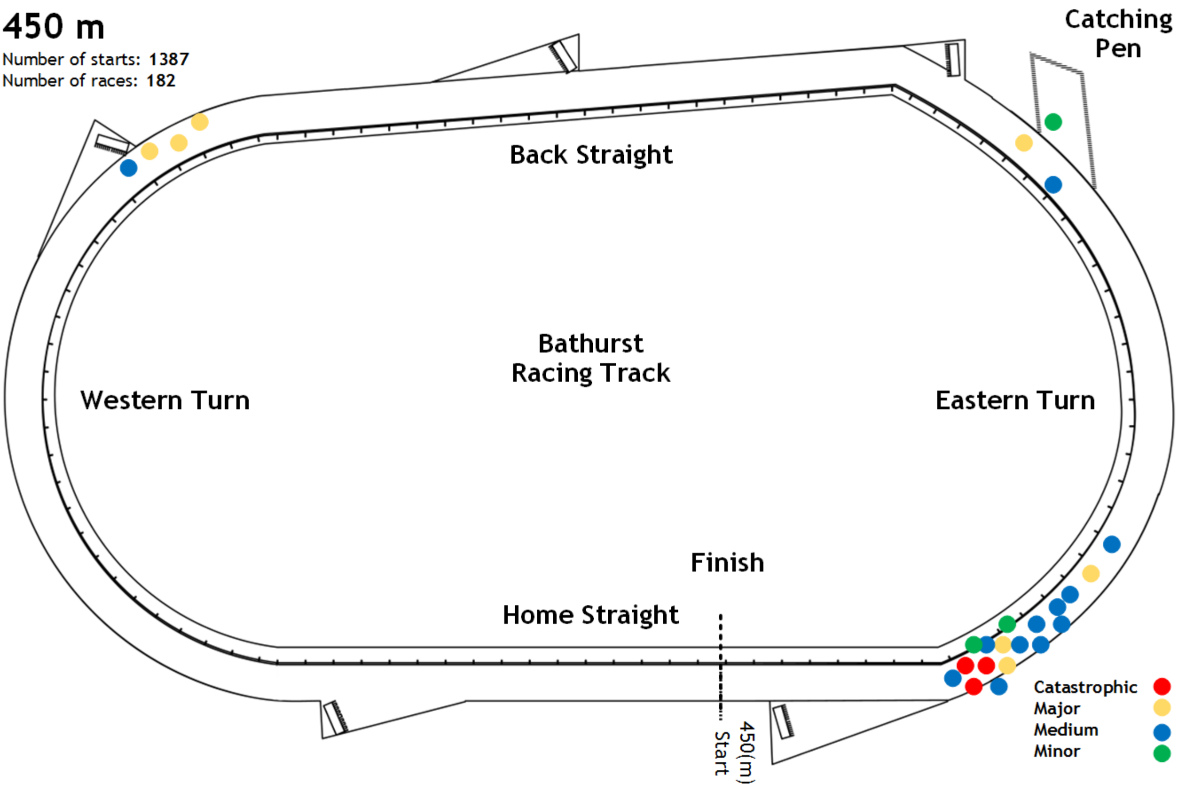

Figure 4.60: Bathurst track location of injuries for the 450 m distance - 1 Jan to 31 Dec 2016.

Bathurst - Location of injuries 520 m - 1 Jan to 31 Dec 2016

4.307 For the Bathurst 520 m distance race the locations of injuries are illustrated in Figure 4.61.

4.308 There were 125 races and 952 starts from 1 January to 31 December 2016 at the 520 m distance.

4.309 The data are not sufficient to determine the hazardous locations for this distance.

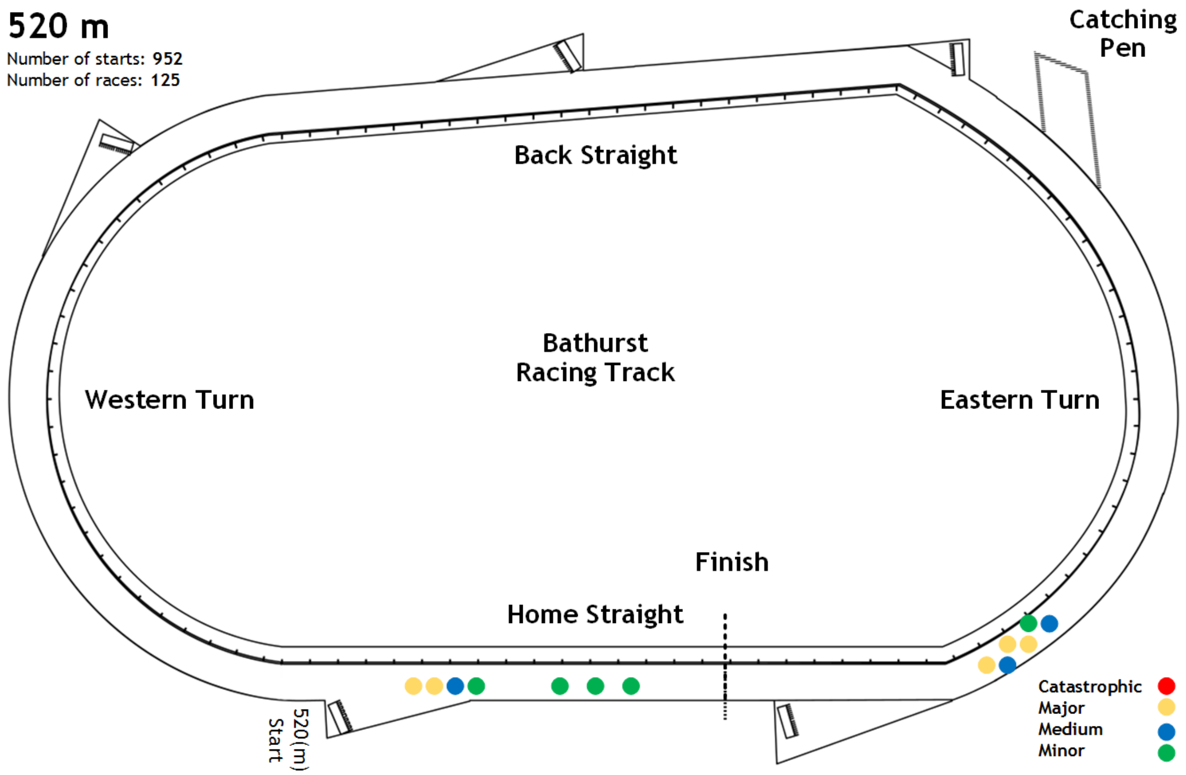

Figure 4.61: Bathurst track location of injuries for the 520 m distance – 1 Jan to 31 Dec 2016.

BATHURST - LOCATION OF INJURIES 618 M - 1 JAN TO 31 DEC 2016

4.310 For the Bathurst 618 m distance race the locations of injuries are illustrated in Figure 4.62.

4.311 There were 40 races and 286 starts from 1 January to 31 December 2016 at the 618 m distance.

4.312 The data are not sufficient to determine the hazardous locations for this distance.

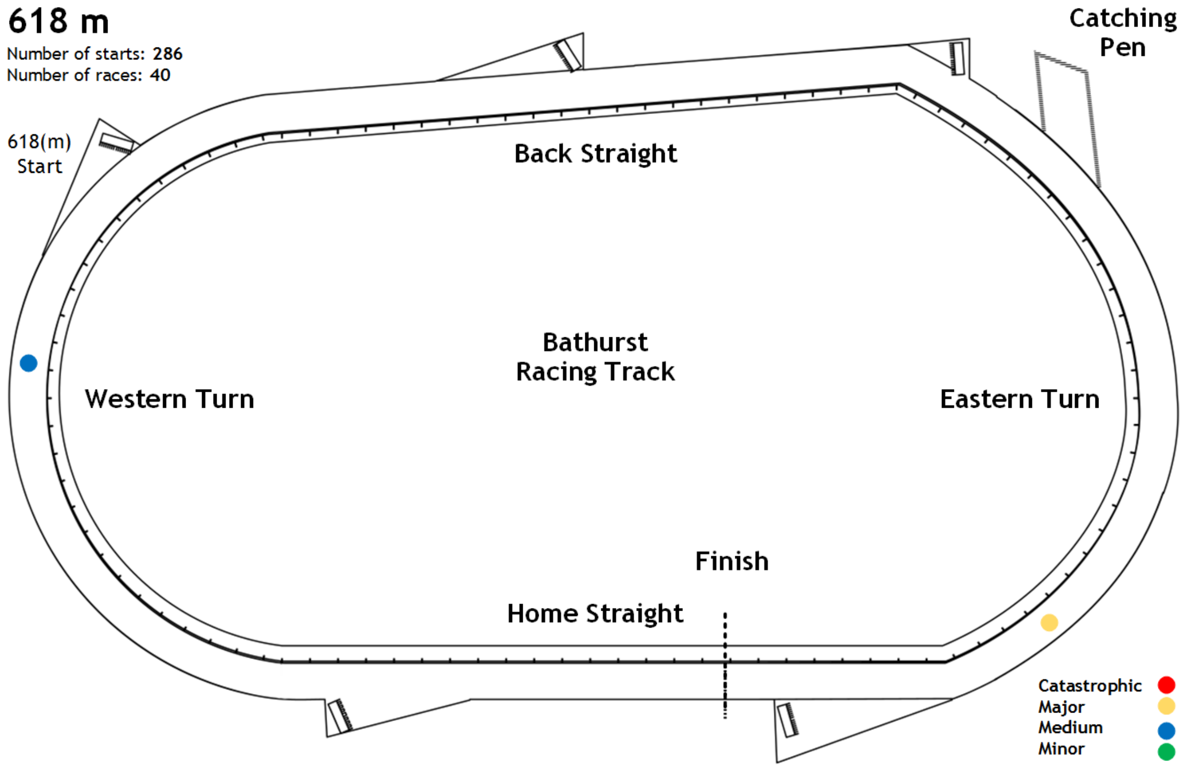

Figure 4.62: Bathurst track location of injuries for the 618 m distance - 1 Jan to 31 Dec 2016.

Dapto

Dapto - Absolute and normalised injury rates - Jan to Dec 2016

4.313 Figures 4.63 to 4.66 contain Dapto Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.314 Absolute Level 1 injury rates for Dapto are shown in Figure 4.63.A.

4.315 May and November were the only months with level 1 injuries with 3 and 1 injuries, respectively.

4.316 Normalized Level 1 injury rates for Dapto are shown in Figure 4.63.B.

4.317 Absolute Level 2 injury rates for Dapto are shown in Figure 4.64.A.

4.318 May has the highest absolute Level 2 injury rate with 5 injuries.

4.319 July has the lowest absolute Level 2 Injury rate with 0 injuries.

4.320 Normalized Level 2 injury rates for Dapto are shown in Figure 4.64.B.

4.321 May has the highest normalized Level 2 Injury rate.

4.322 July has the lowest normalized Level 2 injury.

4.323 Absolute Level 3 injury rates for Dapto are shown in Figure 4.65.A.

4.324 December has the highest absolute Level 3 injury rate with 12 injuries.

4.325 July has the lowest absolute Level 3 injuries rate with 1 injury.

4.326 Normalized Level 3 injury rates for Dapto are shown in Figure 4.65.B.

4.327 May has the highest normalized Level 3 injury rate followed by December.

4.328 July has the lowest normalized Level 3 injury rate followed by February.

4.329 Absolute Level 4 injury rates for Dapto are shown in Figure 4.66.A.

4.330 May has the highest absolute Level 4 injury rate with 18 injuries.

4.331 July has the lowest absolute Level 4 injury rate with 3 injuries.

4.332 Normalized Level 4 injury rates for Dapto are shown in Figure 4.66.B.

4.333 May has the highest normalized Level 4 injury rate.

4.334 July has the lowest normalized Level 4 injury rate followed by February.

4.335 CATb does not include all the data.

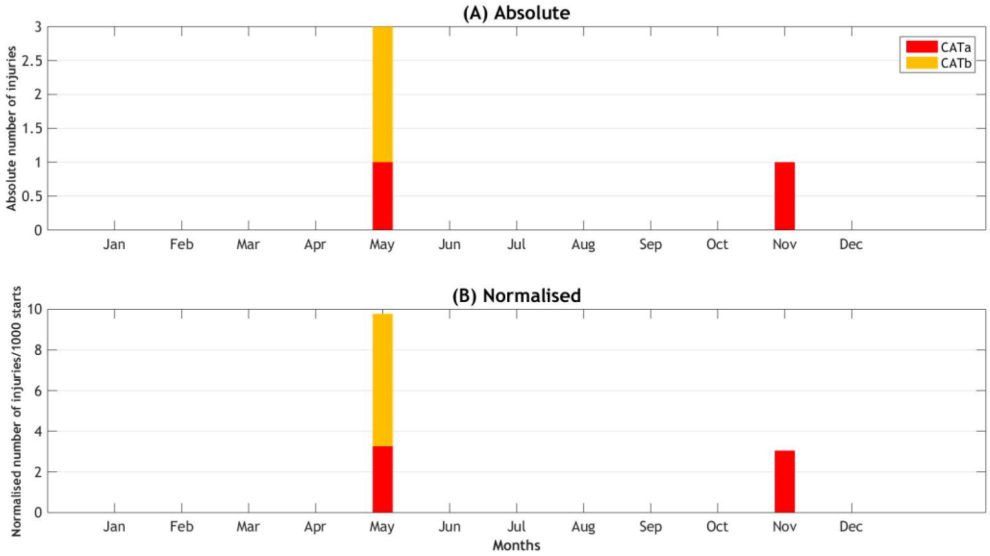

Figure 4.63: Dapto track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

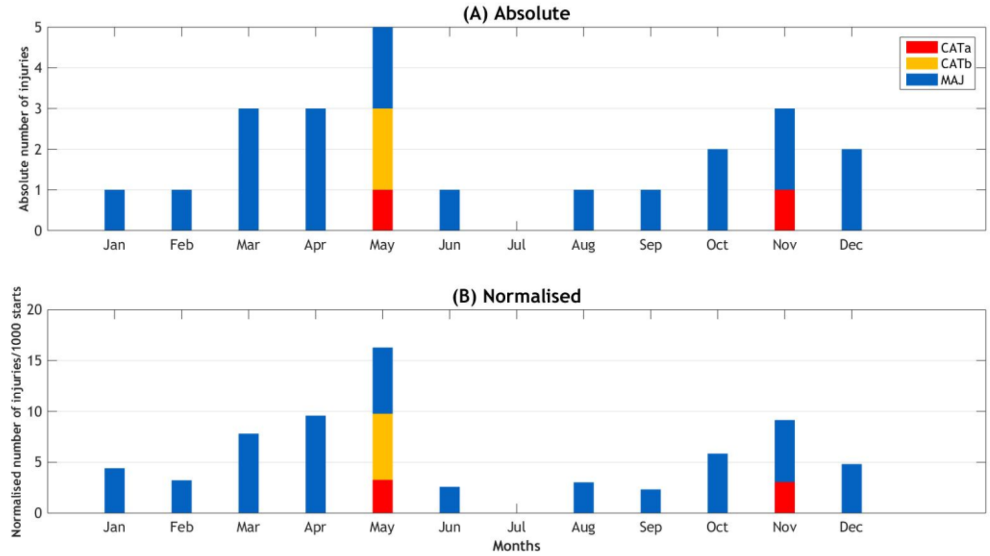

Figure 4.64: Dapto track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

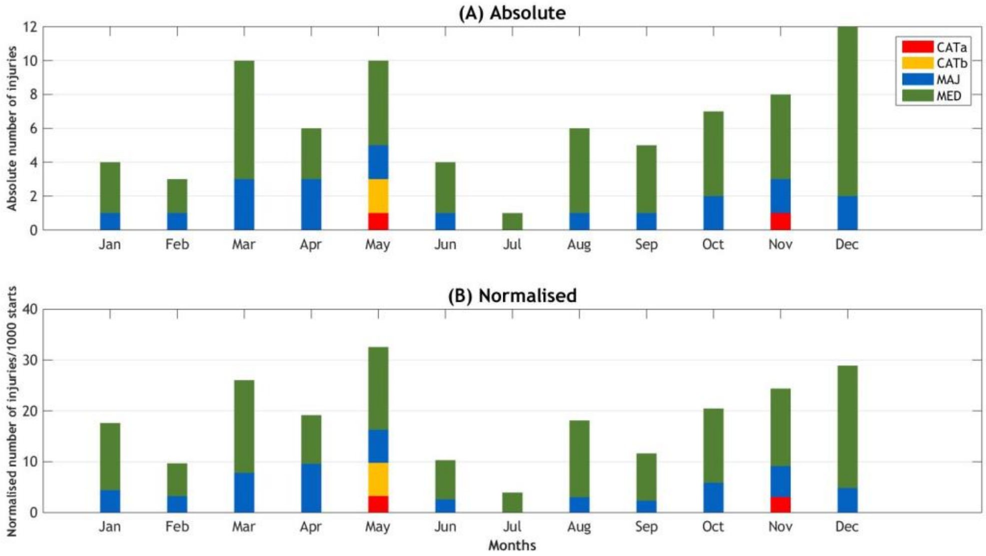

Figure 4.65: Dapto track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

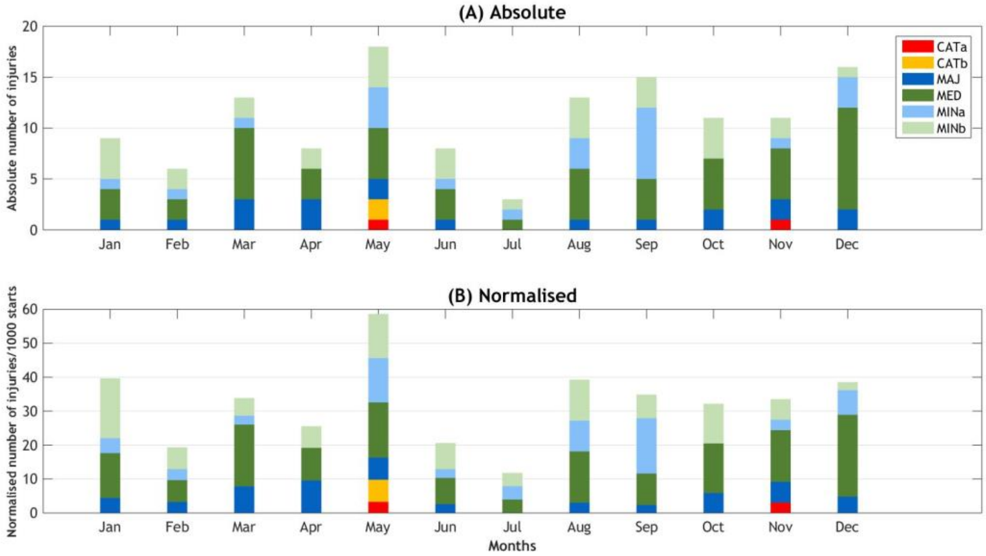

Figure 4.66: Dapto track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

DAPTO - LOCATION OF INJURIES 297 M - 1 JAN TO 31 DEC 2016

4.336 For the Dapto 297 m distance race the locations of injuries are illustrated in Figure 4.67.

4.337 There were 42 races and 324 starts from 1 January to 31 December 2016 at the 297 m distance.

4.338 The data are not sufficient to determine the hazardous location of injuries for this distance.

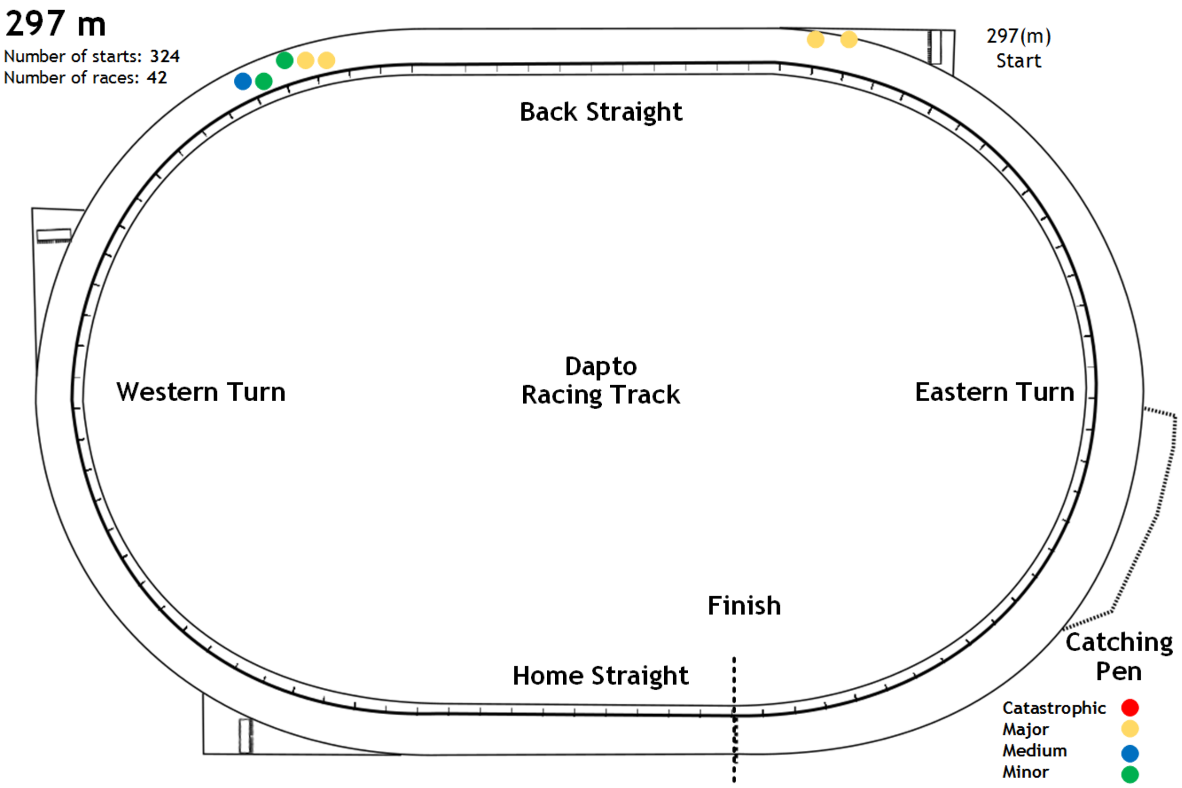

Figure 4.67: Dapto track location of injuries for the 297 m distance - 1 Jan to 31 Dec 2016.

DAPTO - LOCATION OF INJURIES 520 M - 1 JAN TO 31 DEC 2016

4.339 For the Dapto 520 m distance race the locations of injuries are illustrated in Figure 4.68.

4.340 There were 420 races and 3252 starts from 1 January to 31 December 2016 at the 520 m distance.

4.341 Most of the injuries occurred at the beginning of Eastern Turn.

4.342 There were 12 Level 2 injuries for races started at the 520 m distance with 8 occurring at the Eastern Turn.

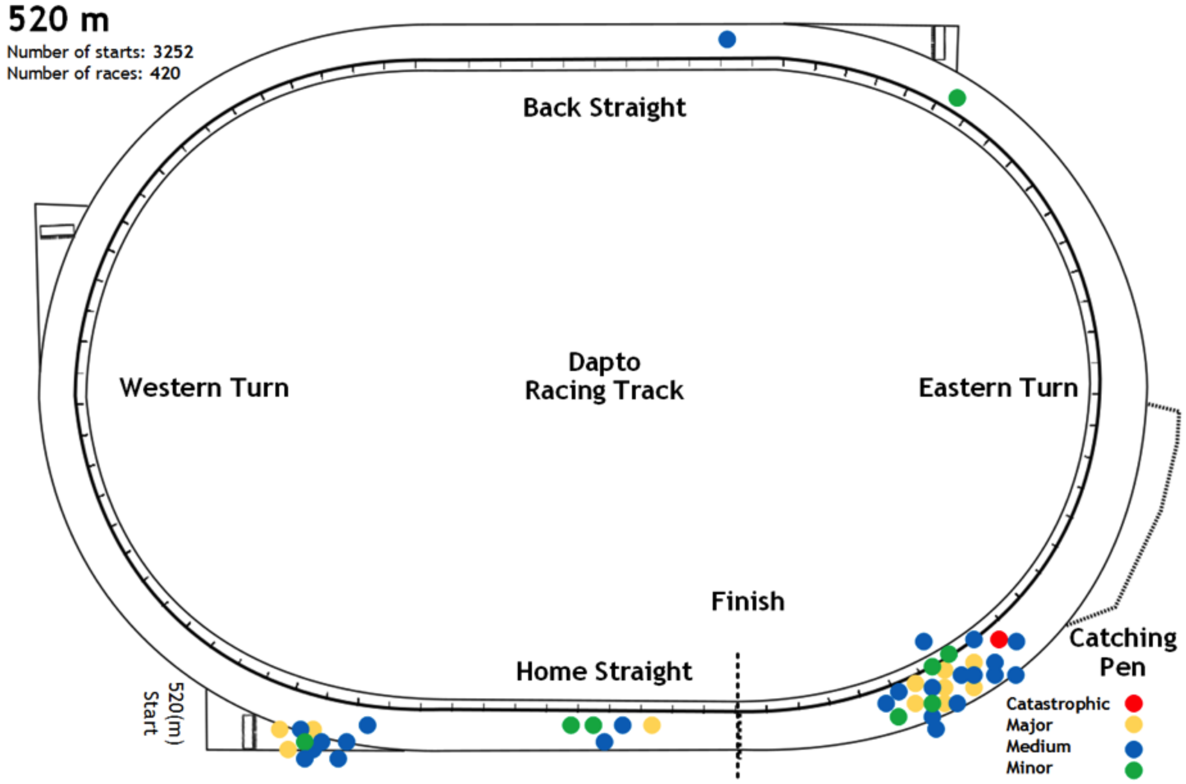

Figure 4.68: Dapto track location of injuries for the 520 m distance - 1 Jan to 31 Dec 2016.

DAPTO - LOCATION OF INJURIES 600 M - 1 JAN TO 31 DEC 2016

4.343 For the Dapto 600 m distance race the locations of injuries are illustrated in Figure 4.69.

4.344 There were 61 races and 453 starts from 1 January to 31 December 2016 at the 600 m distance.

4.345 The data are not sufficient to determine the hazardous locations of injuries for this distance.

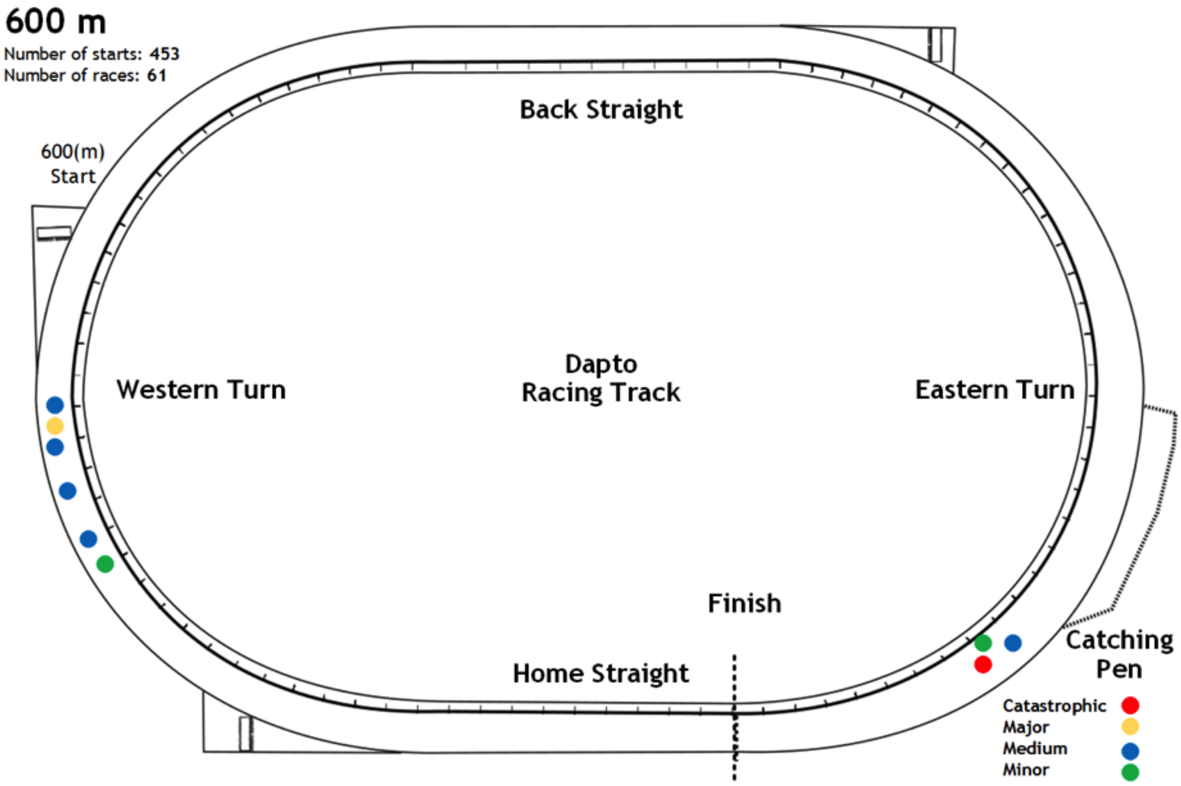

Figure 4.69: Dapto track location of injuries for the 600 m distance - 1 Jan to 31 Dec 2016.

Bulli

Bulli - Absolute and normalised injury rates - Jan to Dec 2016

4.346 Figure 4.70 to 4.73 contain Bulli Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.347 Absolute Level 1 injury rates for Bulli are shown in Figure 4.70.A.

4.348 January, April and September were the only months with Level 1 injuries with 1 and 3 injuries, respectively.

4.349 Normalized Level 1 injury rates for Bulli are shown in Figure 4.70.B.

4.350 Absolute Level 2 injury rates for Bulli are shown in Figure 4.71.A.

4.351 September has the highest absolute Level 2 injury rate with 4 injuries.

4.352 December has the lowest absolute Level 2 Injury rate with 0 injuries.

4.353 Normalized Level 2 injury rates for Bulli are shown in Figure 4.71.B.

4.354 September has the highest normalized Level 2 Injury rate followed by March.

4.355 December has the lowest normalized Level 2 injury followed by May.

4.356 Absolute Level 3 injury rates for Bulli are shown in Figure 4.72.A.

4.357 December has the highest absolute Level 3 injury rate with 9 injuries.

4.358 January has the lowest absolute Level 3 injury rate with 2 injuries.

4.359 Normalized Level 3 injury rates for Bulli are shown in Figure 4.72.B.

4.360 February has the highest normalized Level 3 injury rate followed by December.

4.361 January has the lowest normalized Level 3 injury rates followed by March.

4.362 Absolute Level 4 injury rates for Bulli are shown in Figure 4.73.A.

4.363 August has the highest absolute Level 4 injury rate with 17 injuries.

4.364 November has the lowest absolute Level 4 injury rate with 3 injuries.

4.365 Normalized Level 4 injury rates for Bulli are shown in Figure 4.73.B.

4.366 August has the highest normalized Level 4 injury rate followed by September.

4.367 November has the lowest normalized Level 4 injury rate followed by October.

4.368 CATb does not include all the data.

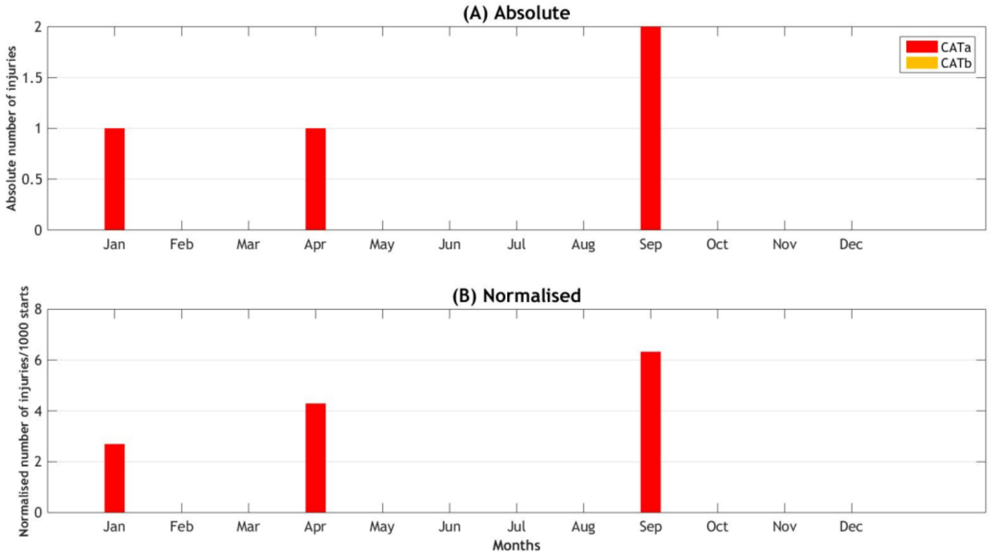

Figure 4.70: Bulli track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

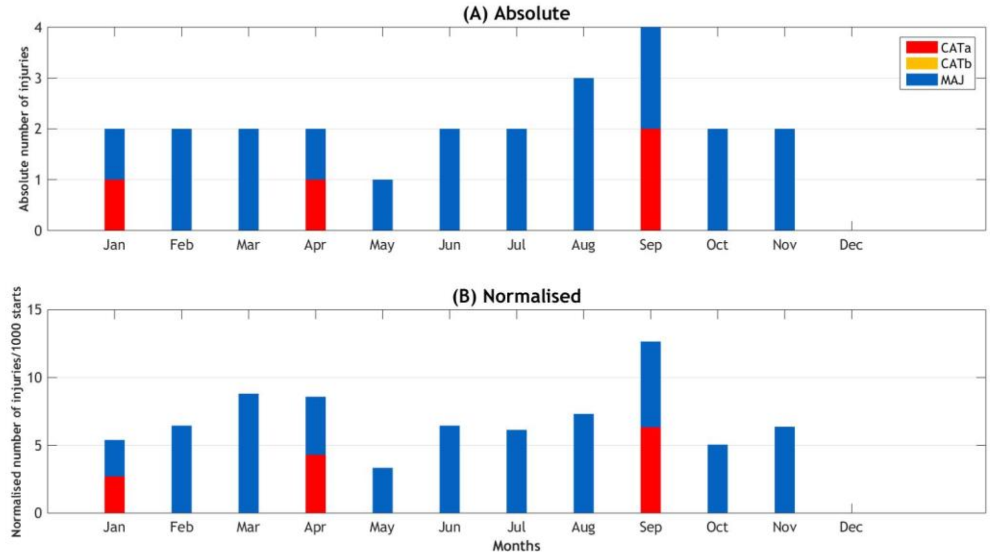

Figure 4.71: Bulli track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

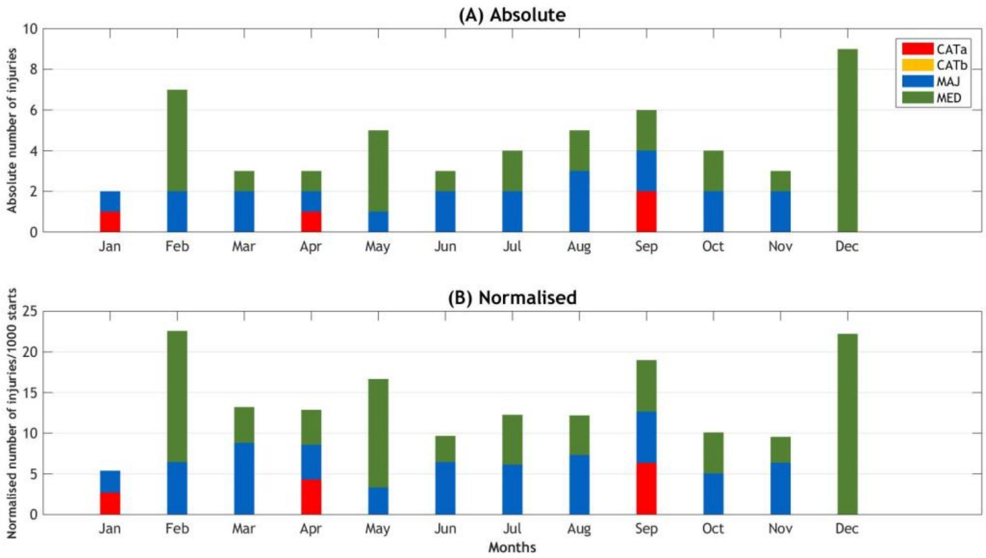

Figure 4.72: Bulli track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

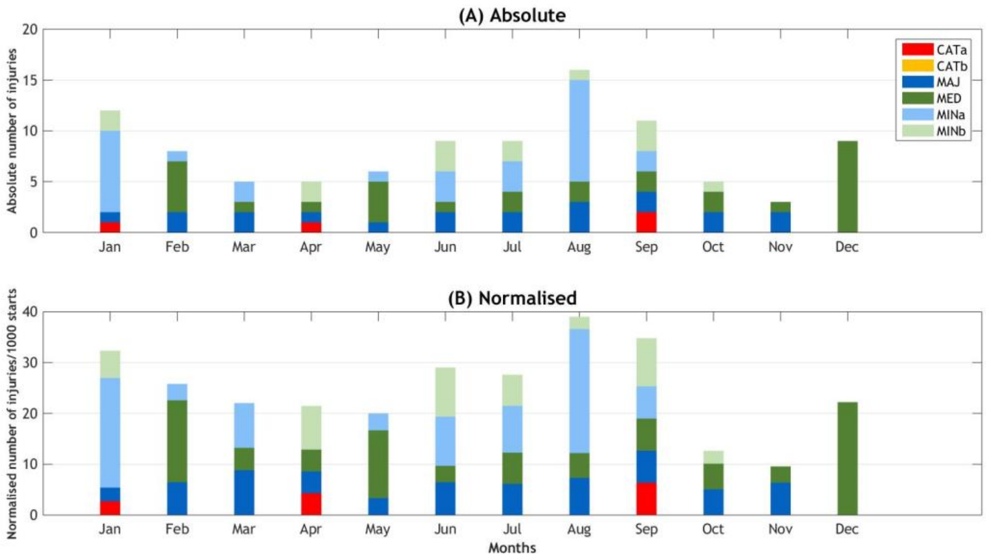

Figure 4.73: Bulli track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

BULLI - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.369 For the Bulli 400 m distance race the locations of injuries are illustrated in Figure 4.74.

4.370 There were 219 races and 1688 starts from 1 January to 31 December 2016 at the 400 m distance.

4.371 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.372 There were 7 Level 2 injuries for races started at the 400 m distance with 5 occurring at the Northern Turn.

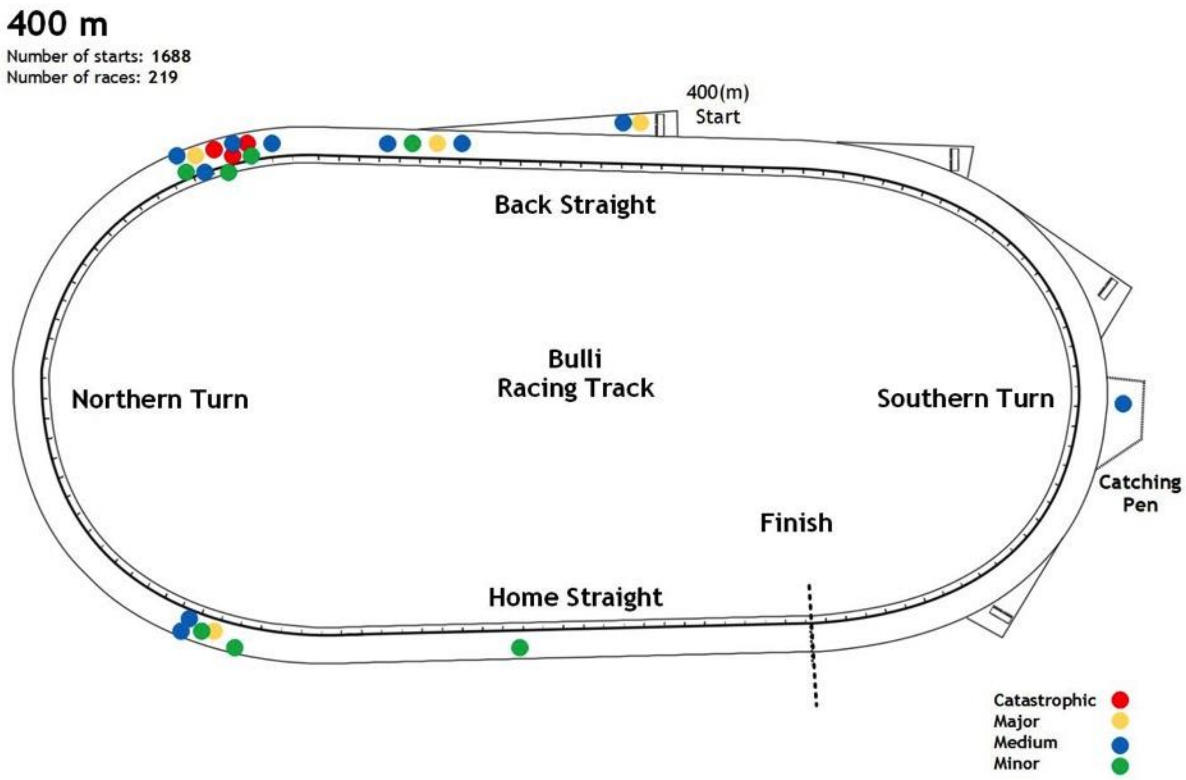

Figure 4.74: Bulli track location of injuries for the 400 m distance – 1 Jan to 31 Dec 2016.

BULLI - LOCATION OF INJURIES 472 M - 1 JAN TO 31 DEC 2016

4.373 For the Bulli 472 m distance race the locations of injuries are illustrated in Figure 4.75.

4.374 There were 277 races and 1705 starts from 1 January to 31 December 2016 at the 472 m distance.

4.375 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.376 There were 11 Level 2 injuries for races started at the 472 m distance with 9 occurring at the Northern Turn.

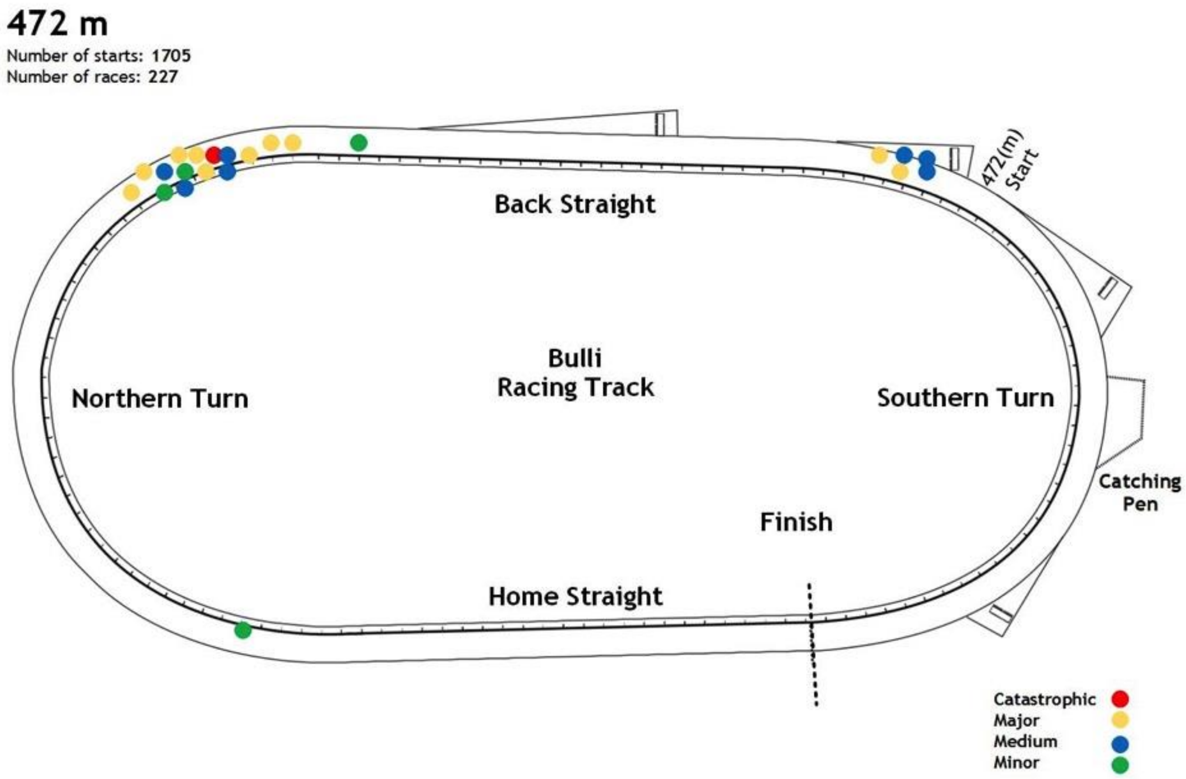

Figure 4.75: Bulli track location of injuries for the 472 m distance – 1 Jan to 31 Dec 2016.

BULLI - LOCATION OF INJURIES 515 M - 1 JAN TO 31 DEC 2016

4.377 For the Bulli 515 m distance race the locations of injuries are illustrated in Figure 4.76.

4.378 There were 38 races and 279 starts from 1 January to 31 December 2016 at the 515 m distance.

4.379 The data are not sufficient to determine the hazardous locations in the track.

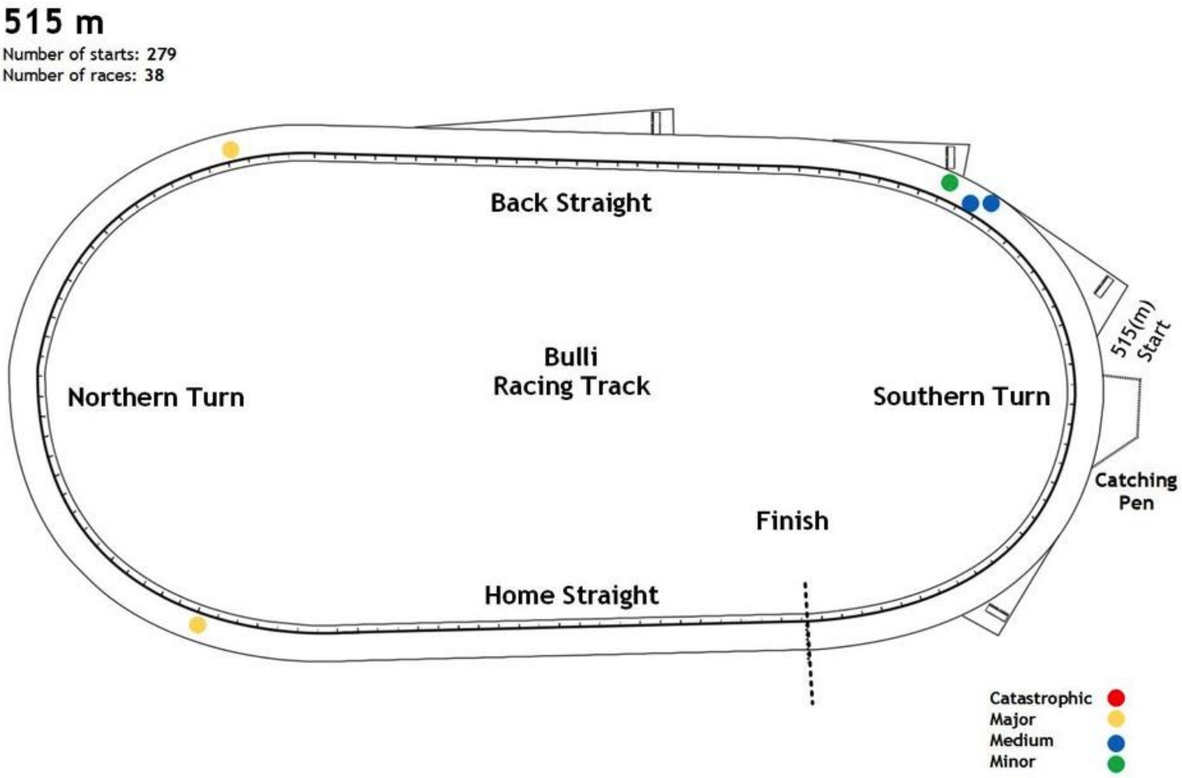

Figure 4.76: Bulli track location of injuries for the 515 m distance – 1 Jan to 31 Dec 2016.

BULLI - LOCATION OF INJURIES 590 M - 1 JAN TO 31 DEC 2016

4.380 For the Bulli 590 m distance race the locations of injuries are illustrated in Figure 4.77.

4.381 There were 33 races and 226 starts from 1 January to 31 December 2016 at the 590 m distance.

4.382 The data are not sufficient to determine the hazardous location of injuries for this distance.

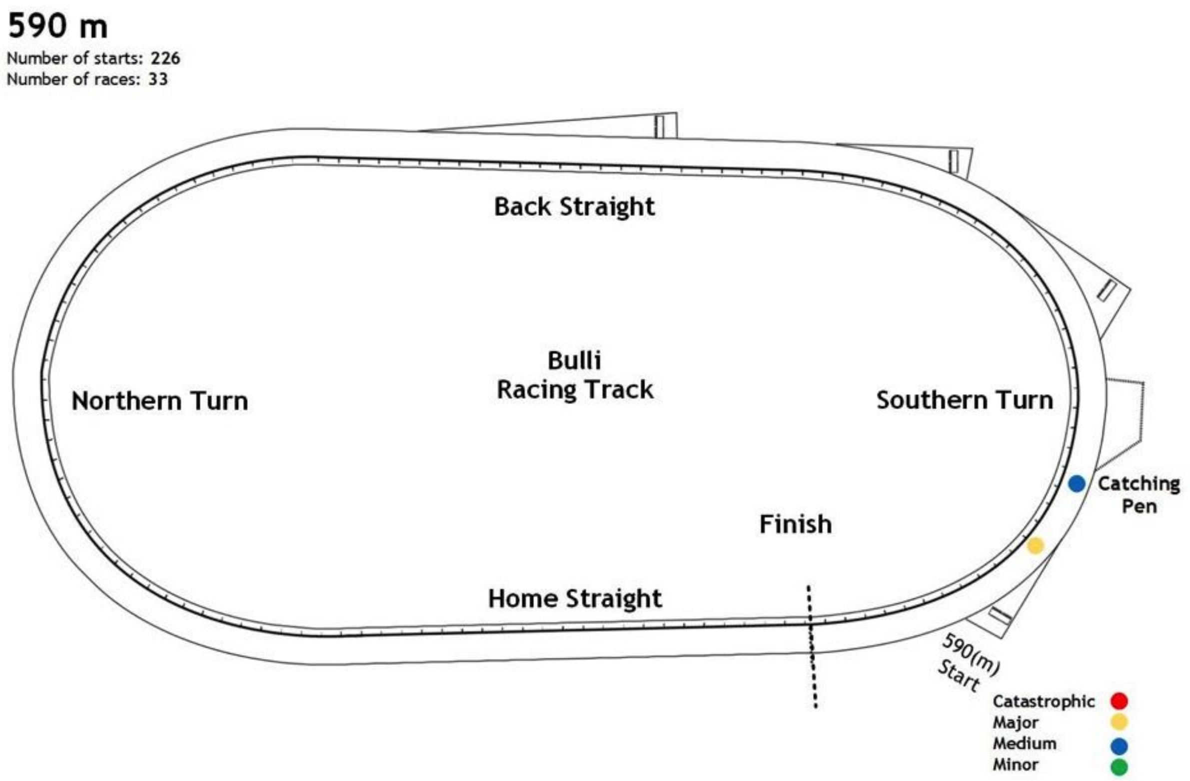

Figure 4.77: Bulli track location of injuries for the 590 m distance – 1 Jan to 31 Dec 2016.

Dubbo

Dubbo - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.383 Figures 4.78 to 4.81 contain Dubbo Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.384 There were no race events in May at the Dubbo track.

4.385 Absolute Level 1 injury rates for Dubbo are shown in Figure 4.78.A.

4.386 April has the highest absolute Level 1 injury with 5 injuries.

4.387 Normalized Level 1 injury rates for Dubbo are shown in Figure 4.78.B.

4.388 October has the highest normalized Level 1 Injury rate.

4.389 Absolute Level 2 injury rates for Dubbo are shown in Figure 4.79.A.

4.390 April has the highest absolute Level 2 injury rate with 6 injuries.

4.391 January and December have the lowest absolute Level 2 Injury rate with 0 injuries.

4.392 Normalized Level 2 injury rates for Dubbo are shown in Figure 4.79.B.

4.393 October has the highest normalized Level 2 Injury rate.

4.394 January and December have the lowest normalized Level 2 injury.

4.395 Absolute Level 3 injury rates for Dubbo are shown in Figure 4.80.A.

4.396 April has the highest absolute Level 3 injury rate with 13 injuries.

4.397 Normalized Level 3 injury rates for Dubbo is shown in Figure 4.80.B.

4.398 March has the highest normalized Level 3 injury rate followed by February.

4.399 December has the lowest normalized Level 3 injury rate.

4.400 Absolute Level 4 injury rates for Dubbo are shown in Figure 4.81.A.

4.401 April has the highest absolute Level 4 injury rate with 22 injuries.

4.402 December has the lowest absolute Level 4 injury rate with 3injuries.

4.403 Normalized Level 4 injury rates for Dubbo are shown in Figure 4.81.B.

4.404 March has the highest normalized Level 4 injury rate.

4.405 December has the lowest normalized Level 4 injury rate followed by November.

4.406 CATb does not include all the data.

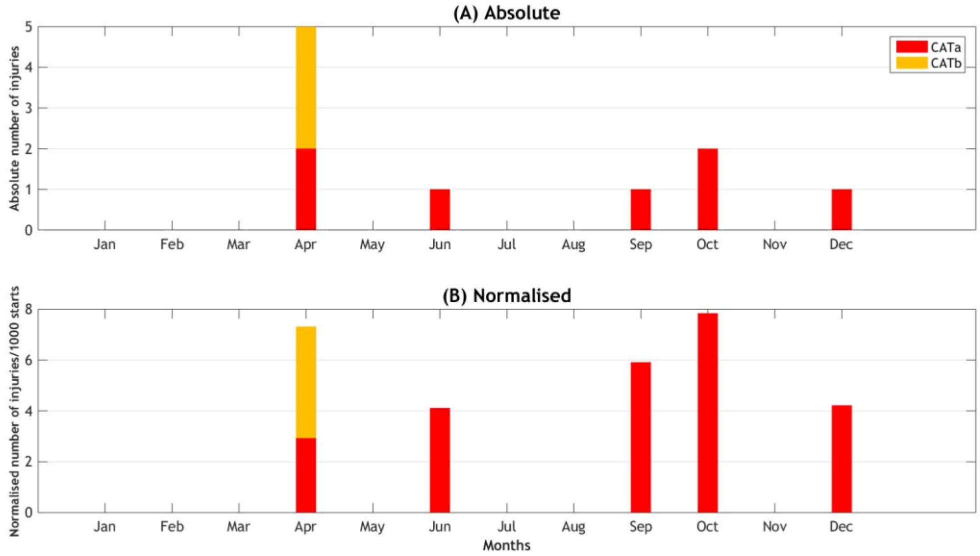

Figure 4.78: Dubbo track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

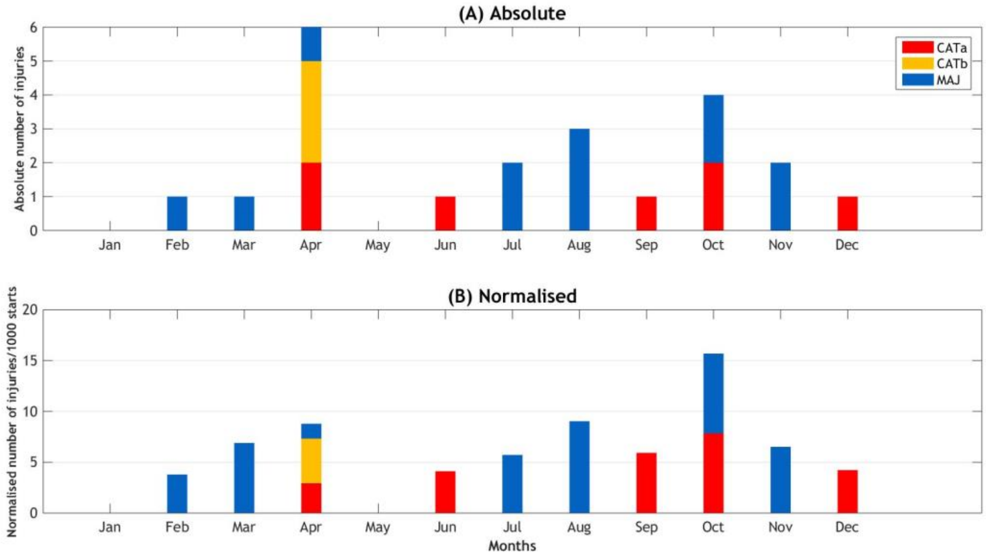

Figure 4.79: Dubbo track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

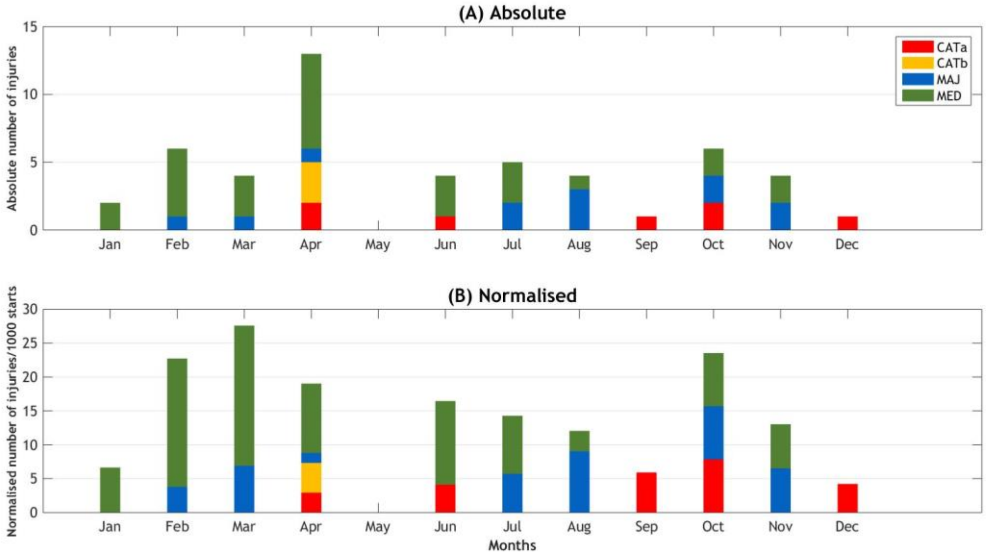

Figure 4.80: Dubbo track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

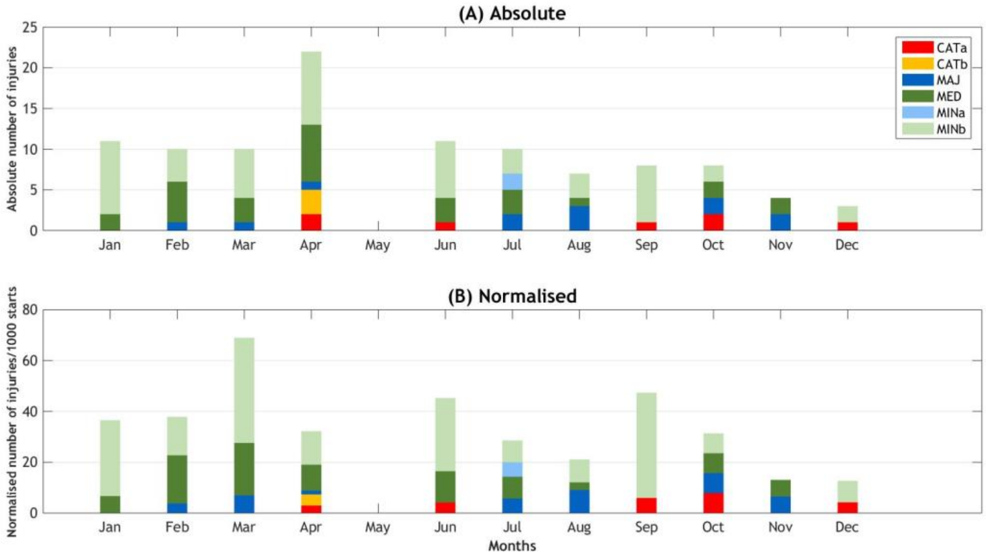

Figure 4.81: Dubbo track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

DUBBO - LOCATION OF INJURIES 318 M - 1 JAN TO 31 DEC 2016

4.407 For the Dubbo 318 m distance race the locations of injuries are illustrated in Figure 4.82.

4.408 There were 195 races and 1456 starts from 1 January to 31 December 2016 at the 318 m distance.

4.409 Most of the injuries occurred shortly after the start at the beginning of Western Turn.

4.410 There were 7 Level 2 injuries for races started at the 318 m distance with 5 occurring at the Western Turn.

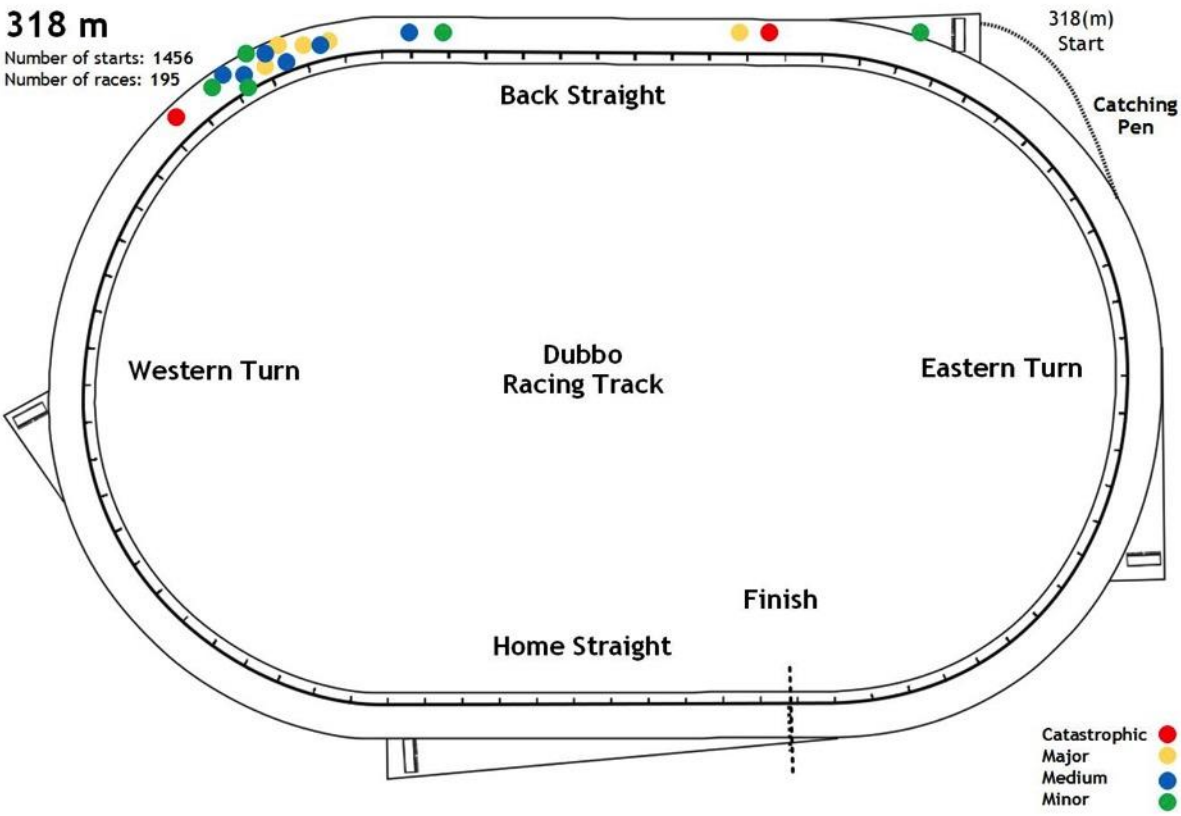

Figure 4.82: Dubbo track location of injuries for the 318 m distance – 1 Jan to 31 Dec 2016.

DUBBO - LOCATION OF INJURIES 400 M - 1 JAN TO 31 DEC 2016

4.411 For the Dubbo 400 m distance race the locations of injuries are illustrated in Figure 4.83.

4.412 There were 154 races and 1233 starts from 1 January to 31 December 2016 at the 400 m distance.

4.413 Most of the injuries occurred shortly after the start at the middle of Eastern Turn.

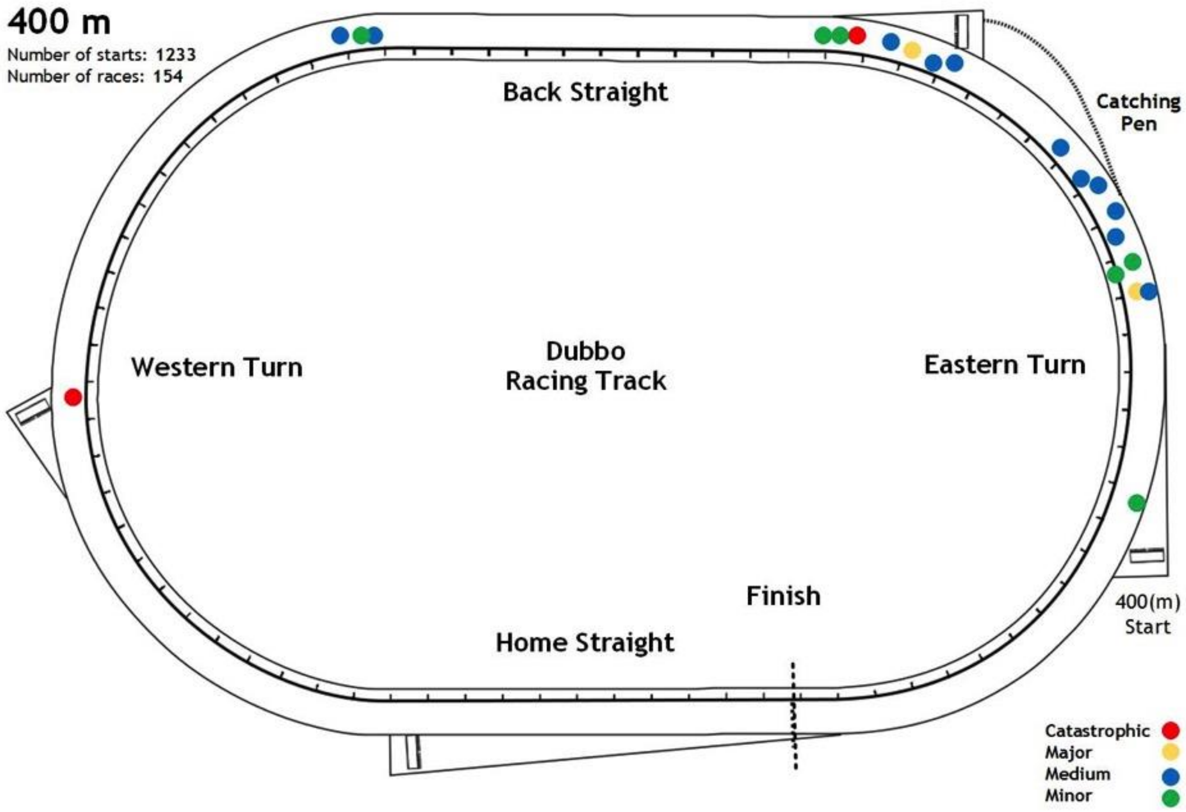

Figure 4.83: Dubbo track location of injuries for the 400 m distance – 1 Jan to 31 Dec 2016.

DUBBO - LOCATION OF INJURIES 516M - 1 JAN TO 31 DEC 2016

4.414 For the Dubbo 516 m distance race the locations of injuries are illustrated in Figure 4.84.

4.415 There were 81 races and 618 starts from 1 January to 31 December 2016 at the 516 m distance.

4.416 The data are not sufficient to determine the hazardous location of injuries for this distance.

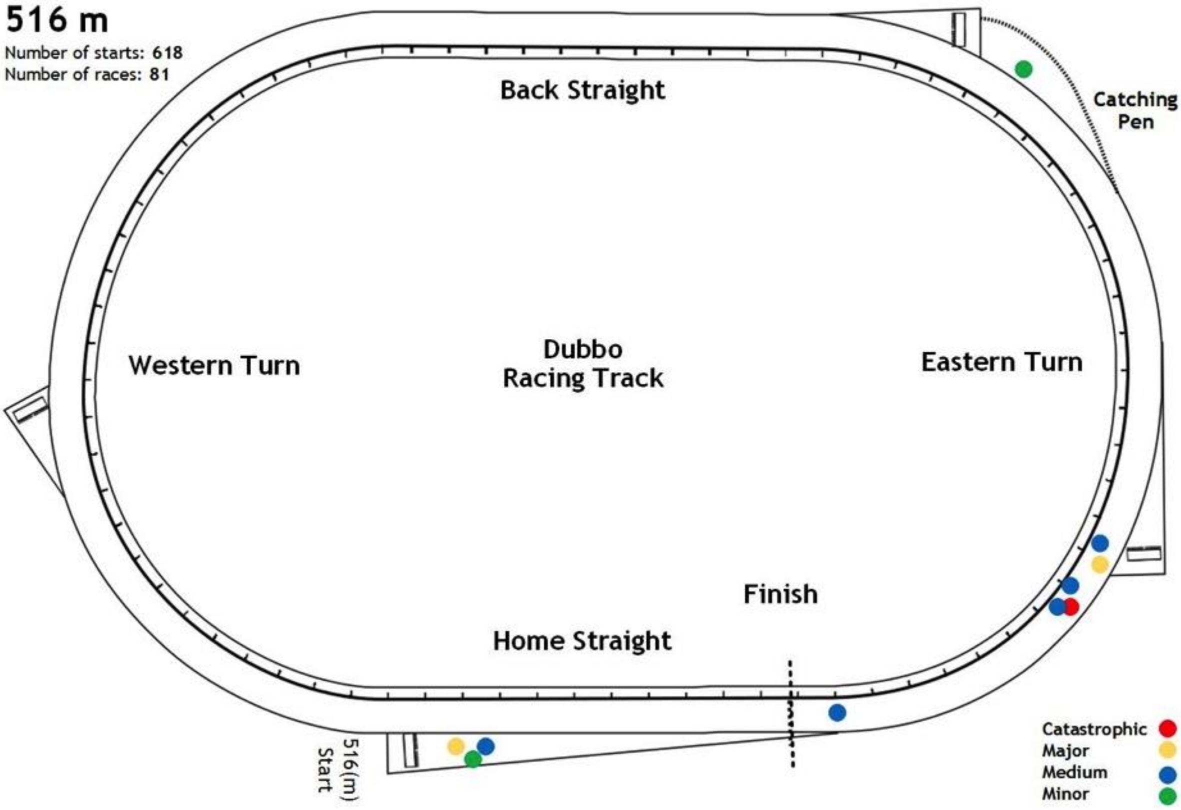

Figure 4.84: Dubbo track location of injuries for the 516 m distance – 1 Jan to 31 Dec 2016.

Goulburn

Goulburn - Absolute and normalised injury rates - Jan to Dec 2016

4.417 Figures 4.85 to 4.88 contain Goulburn Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.418 There were no race events at the Goulburn track in January.

4.419 Absolute Level 1 injury rates for Goulburn are shown in Figure 4.85.A.

4.420 May, June and August were the only months with Level 1 injuries with 1 and 2 injuries, respectively.

4.421 Normalized Level 1 injury rates for Goulburn are shown in Figure 4.85.B.

4.422 August has the highest normalized Level 1 Injury rate.

4.423 Absolute Level 2 injury rates for Goulburn are shown in Figure 4.86.A.

4.424 September has the highest absolute Level 2 injury rate with 5 injuries.

4.425 April, July, October, November and December have the lowest absolute Level 2 Injury rate with 0 injuries.

4.426 Normalized Level 2 injury rates for Goulburn are shown in Figure 4.86.B.

4.427 September has the highest normalized Level 2 Injury rate followed by March.

4.428 April, July, October, November and December have the lowest normalized Level 2 injury.

4.429 Absolute Level 3 injury rates for Goulburn are shown in Figure 4.87.A.

4.430 May and September have the highest absolute Level 3 injury rate with 11 injuries.

4.431 July has the lowest absolute Level 3 injury rate with 0 injuries.

4.432 Normalized Level 3 injury rates for Goulburn are shown in Figure 4.87.B.

4.433 September has the highest normalized Level 3 injury rate followed by May.

4.434 July has the lowest normalized Level 3 injury rate.

4.435 Absolute Level 4 injury rates for Goulburn are shown in Figure 4.88.A.

4.436 March has the highest absolute Level 4 injury rate with 17 injuries.

4.437 December has the lowest absolute Level 4 injury rate with 2 injuries.

4.438 Normalized Level 4 injury rates for Goulburn are shown in Figure 4.88.B.

4.439 March has the highest normalized Level 4 injury rate.

4.440 December has the lowest normalized Level 4 injury rate followed by February.

4.441 CATb does not include all the data.

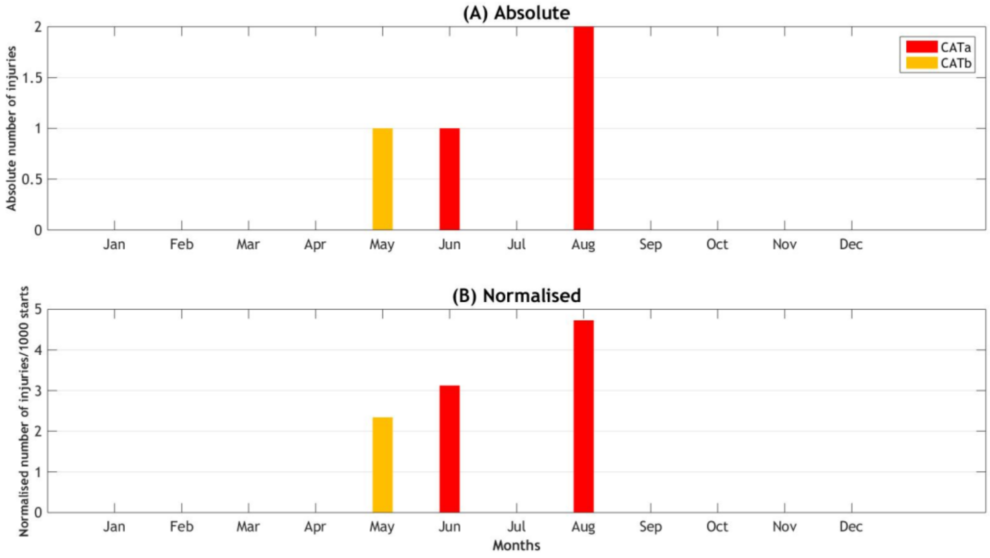

Figure 4.85: Goulburn track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

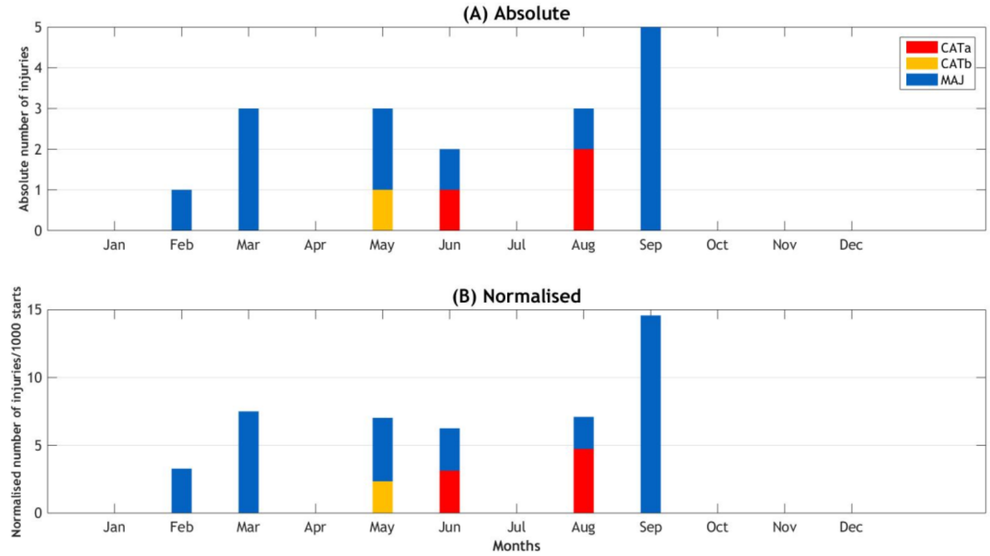

Figure 4.86: Goulburn track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

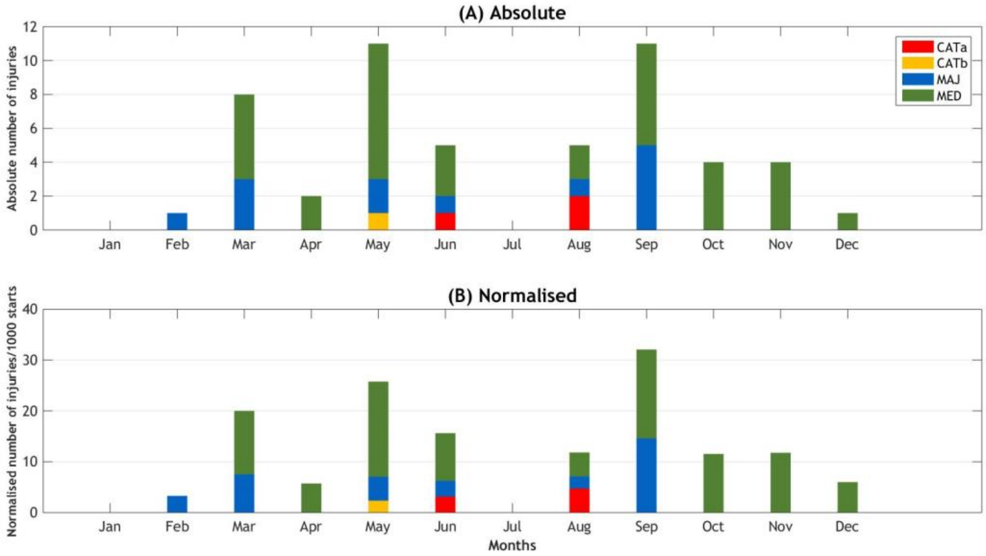

Figure 4.87: Goulburn track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

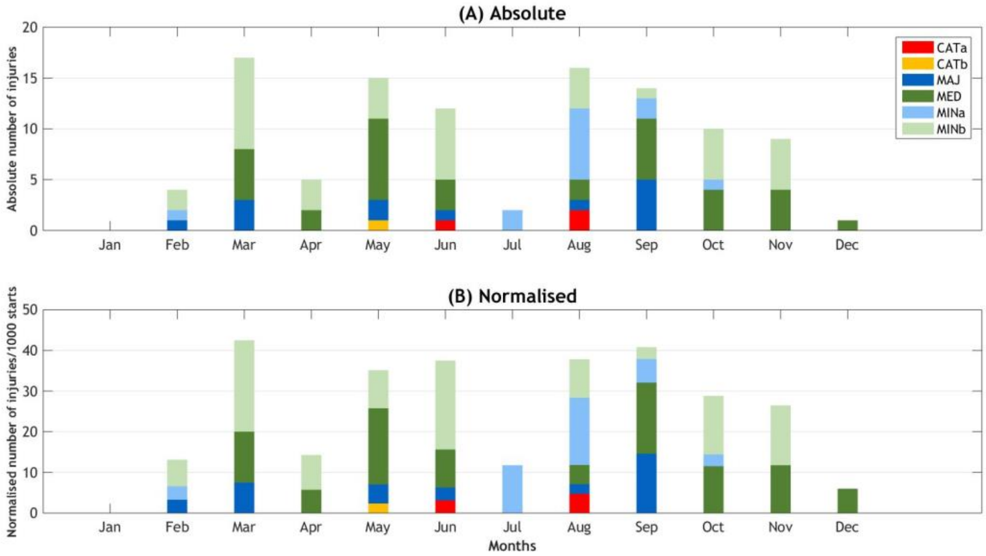

Figure 4.88: Goulburn track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

GOULBURN - LOCATION OF INJURIES 350 M - 1 JAN TO 31 DEC 2016

4.442 For the Goulburn 350 m distance race the locations of injuries are illustrated in Figure 4.89.

4.443 There were 217 races and 1565 starts from 1 January to 31 December 2016 at the 350 m distance.

4.444 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.445 There were 10 Level 2 injuries for races started at the 350 m distance with 9 occurring at the Northern Turn.

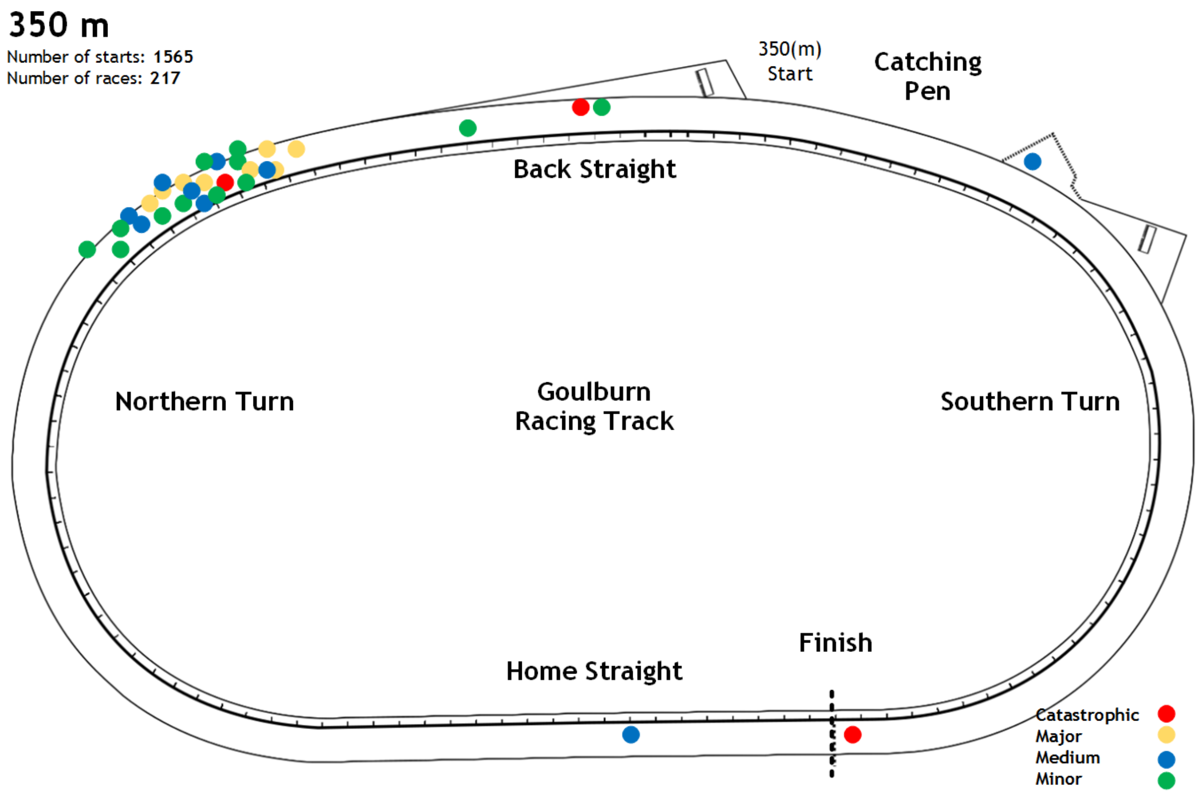

Figure 4.89: Goulburn track location of injuries for the 350 m distance – 1 Jan to 31 Dec 2016.

GOULBURN - LOCATION OF INJURIES 440 M - 1 JAN TO 31 DEC 2016

4.446 For the Goulburn 440 m distance race the locations of injuries are illustrated in Figure 4.90.

4.447 There were 191 races and 1455 starts from 1 January to 31 December 2016 at the 440 m distance.

4.448 Most of the injuries occurred shortly after the start and at the beginning of Northern Turn.

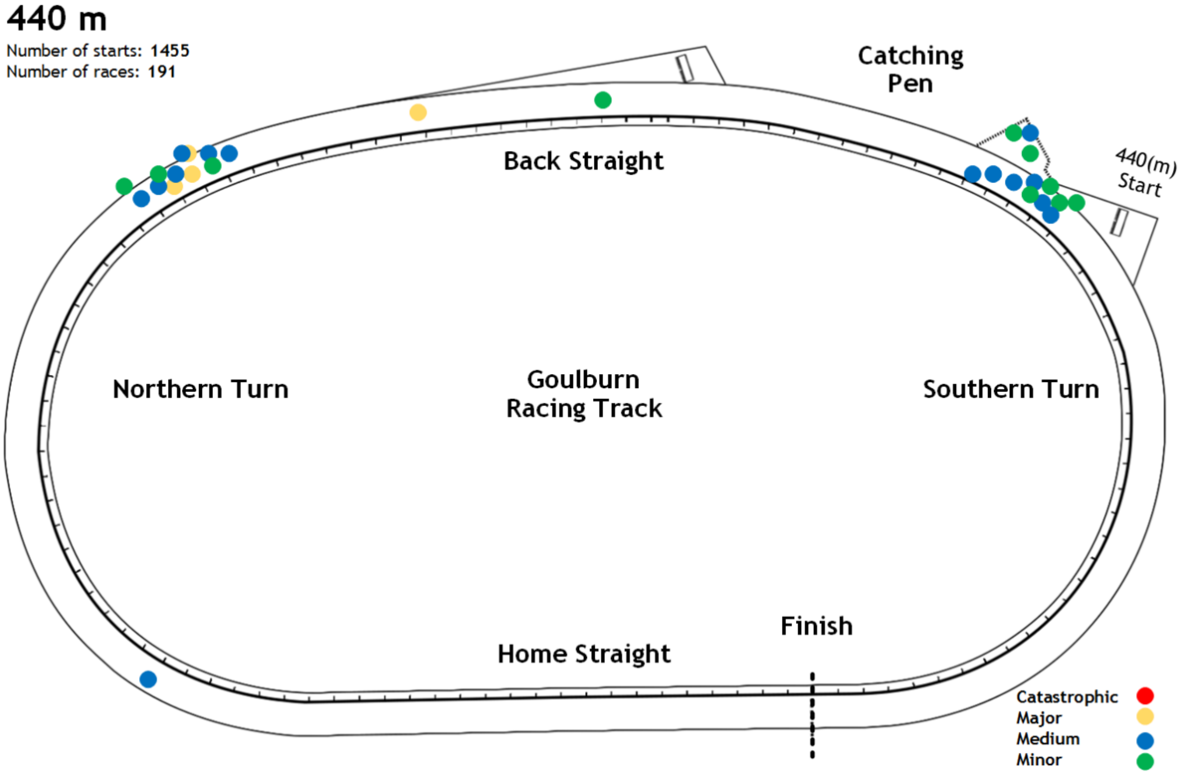

Figure 4.90: Goulburn track location of injuries for the 440 m distance - 1 Jan to 31 Dec 2016.

Lismore

Lismore - Absolute and normalised injury rates - Jan to Dec 2016

4.449 Figures 4.91 to 4.94 contain Lismore Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.450 There were no race events at the Lismore track in June, July, August and September.

4.451 Absolute Level 1 injury rates for Lismore are shown in Figure 4.91.A.

4.452 April, May and November have the highest absolute Level 1 injuries with 2 injuries each.

4.453 February, October and December have the lowest absolute Level 1 injury rate with 0 injuries.

4.454 Normalized Level 1 injury rates for Lismore are shown in Figure 4.91.B.

4.455 May has the highest normalized Level 1 Injury rate followed by April.

4.456 Absolute Level 2 injury rates for Lismore are shown in Figure 4.92.A.

4.457 November has the highest absolute Level 2 injury rate with 5 injuries.

4.458 February and December have the lowest absolute Level 2 Injury rate with 0 injuries.

4.459 Normalized Level 2 injury rates for Lismore are shown in Figure 4.92.B.

4.460 April and November have the highest normalized Level 2 Injury rate.

4.461 February and December have the lowest normalized Level 2 injury rate.

4.462 Absolute Level 3 injury rates for Lismore are shown in Figure 4.93.A.

4.463 November has the highest absolute Level 3 injury rate with 8 injuries.

4.464 October has the lowest absolute Level 3 injury rate with 2 injuries.

4.465 Normalized Level 3 injury rates for Lismore are shown in Figure 4.93.B.

4.466 November has the highest normalized Level 3 injury rate.

4.467 March has the lowest normalized Level 3 injury rate.

4.468 Absolute Level 4 injury rates for Lismore are shown in Figure 4.94.A.

4.469 January and November have the highest absolute Level 4 injury rate with 11 injuries each.

4.470 October has the lowest absolute Level 4 injury rate with 3 injuries.

4.471 Normalized Level 4 injury rates for Lismore are shown in Figure 4.94.B.

4.472 January has the highest normalized Level 4 injury rate.

4.473 October has the lowest normalized Level 4 injury rate followed by March.

4.474 CATb does not include all the data.

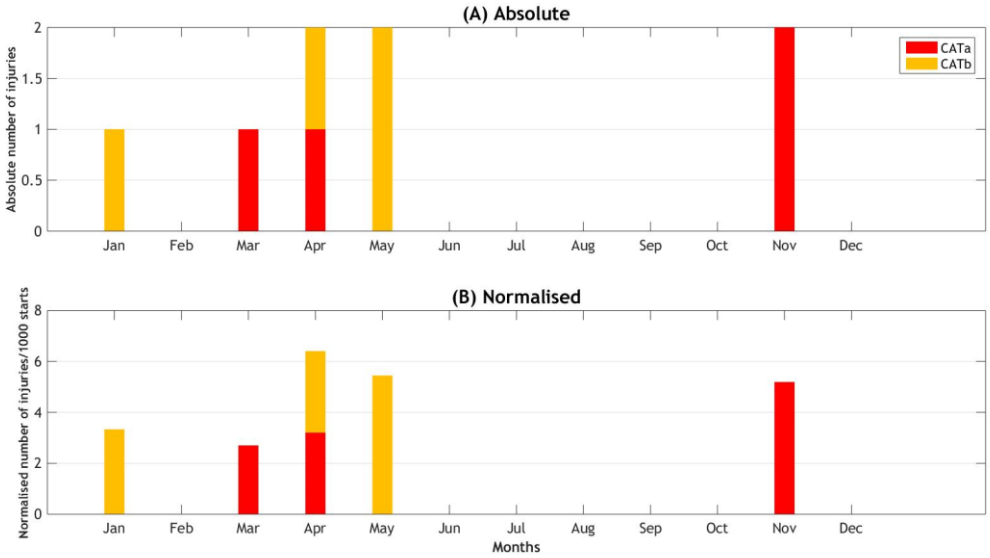

Figure 4.91: Lismore track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

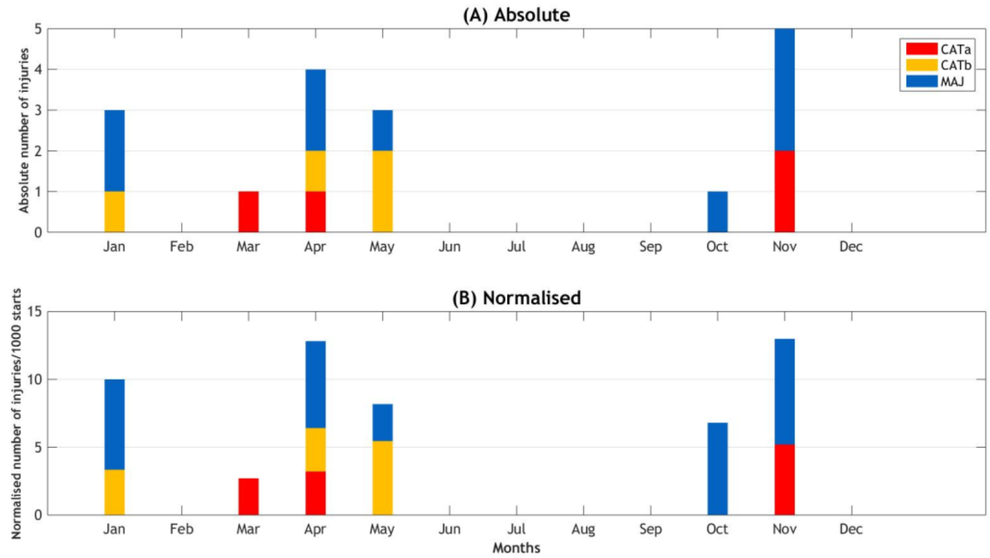

Figure 4.92: Lismore track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

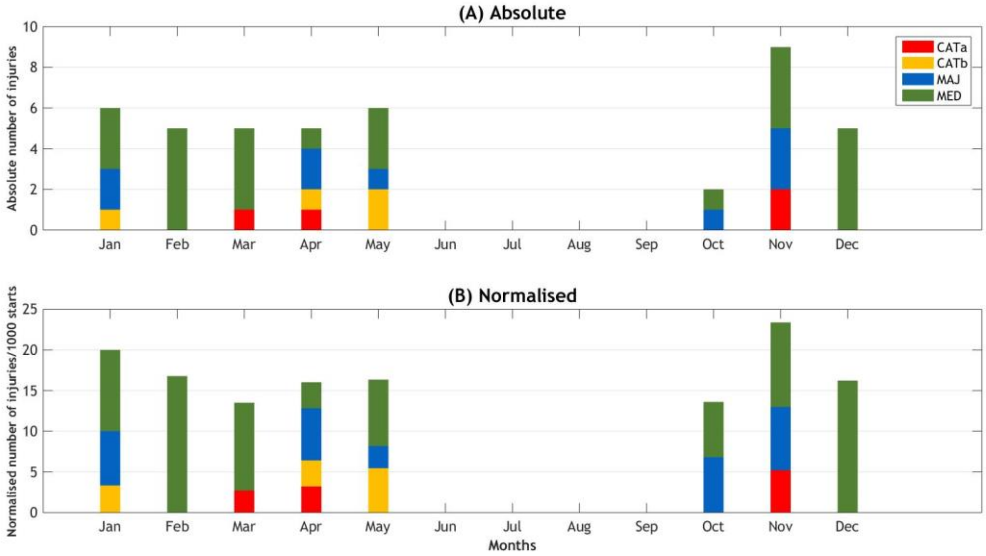

Figure 4.93: Lismore track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

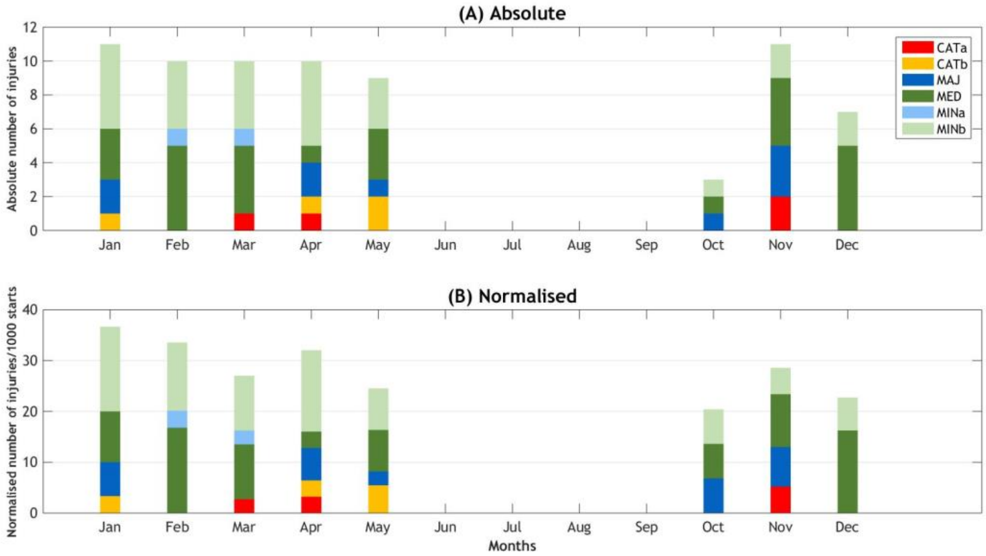

Figure 4.94: Lismore track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

LISMORE - LOCATION OF INJURIES 420 M - 1 JAN TO 31 DEC 2016

4.475 For the Lismore 420 m distance race the locations of injuries are illustrated in Figure 4.95.

4.476 There were 211 races and 1653 starts from 1 January to 31 December 2016 at the 420 m distance.

4.477 Most of the injuries occurred shortly after the start at the middle of Northern Turn.

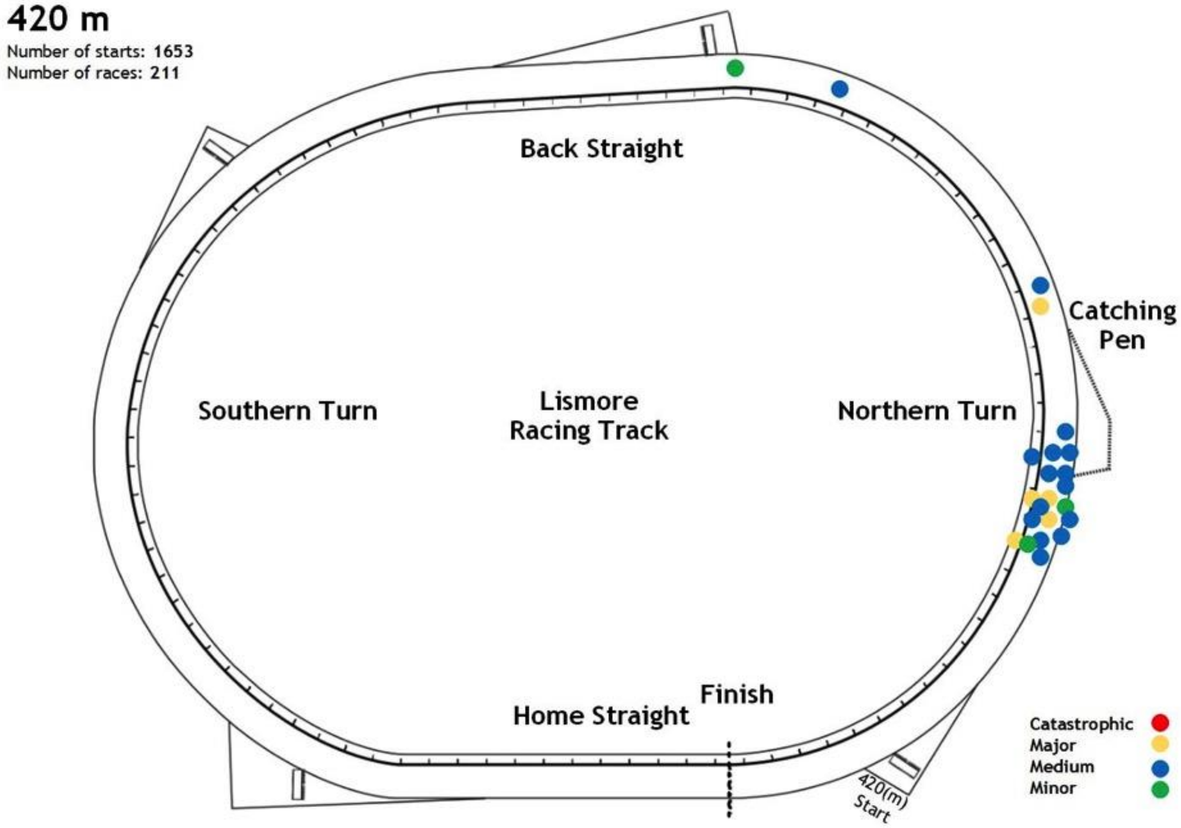

Figure 4.95: Lismore track location of injuries for the 420 m distance – 1 Jan to 31 Dec 2016.

LISMORE - LOCATION OF INJURIES 520 M - 1 JAN TO 31 DEC 2016

4.478 For the Lismore 520 m distance race the locations of injuries are illustrated in Figure 4.96.

4.479 There were 111 races and 829 starts from 1 January to 31 December 2016 at the 520 m distance.

4.480 Most of the injuries occurred shortly after the start at the beginning of Northern Turn.

4.481 There were 6 level 2 injuries with 5 occurring at the beginning of Northern Turn.

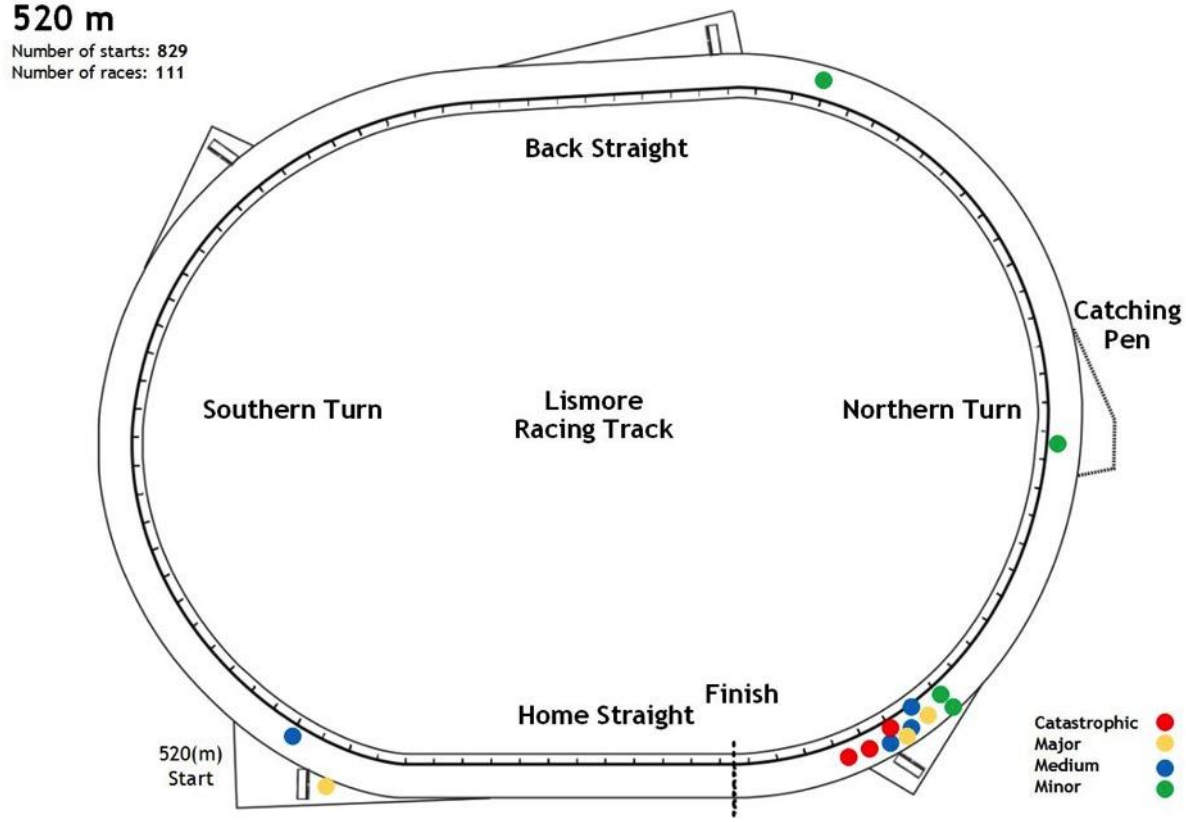

Figure 4.96: Lismore track location of injuries for the 520 m distance – 1 Jan to 31 Dec 2016.

Coonamble

Coonamble - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.482 Figures 4.97 to 4.100 contain Coonamble Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.483 There were no race events at the Coonamble track in January, April, July and August.

4.484 Absolute Level 1 injury rates for Coonamble are shown in Figure 4.97.A.

4.485 June and September have the highest number of absolute Level 1 injuries with 2 injuries.

4.486 February, March and December have the lowest absolute level 1 injuries with 0 injuries.

4.487 Normalized Level 1 injury rates for Coonamble are shown in Figure 4.97.B.

4.488 November has the highest normalized Level 1 Injury rate.

4.489 Absolute Level 2 injury rates for Coonamble are shown in Figure 4.98.A.

4.490 September and October have the highest absolute Level 2 injury rate with 5 injuries each.

4.491 February, March and December have the lowest absolute Level 2 Injury rate with 0 injuries.

4.492 Normalized Level 2 injury rates for Coonamble are shown in Figure 4.98.B.

4.493 September has the highest normalized Level 2 Injury rate.

4.494 February, March and December have the lowest normalized Level 2 injury.

4.495 Absolute Level 3 injury rates for Coonamble are shown in Figure 4.99.A.

4.496 September and October have the highest absolute Level 3 injury rate with 7 injuries each.

4.497 February, March and December have the lowest absolute Level 3 injuries rate with 0 injuries.

4.498 Normalized Level 3 injury rates for Coonamble is shown in Figure 4.99.B.

4.499 September has the highest normalized Level 3 injury rate.

4.500 February, March and December have the lowest normalized Level 3 injury.

4.501 Absolute Level 4 injury rates for Coonamble are shown in Figure 4.100.A.

4.502 October has the highest absolute Level 4 injury rate with 11 injuries.

4.503 February, March and December have the lowest absolute Level 4 injury rate with 3 injuries each.

4.504 Normalized Level 4 injury rates for Coonamble are shown in Figure 4.100.B.

4.505 September has the highest normalized Level 4 injury rate.

4.506 February, March and December have the lowest normalized Level 4 injury.

4.507 CATb does not include all the data.

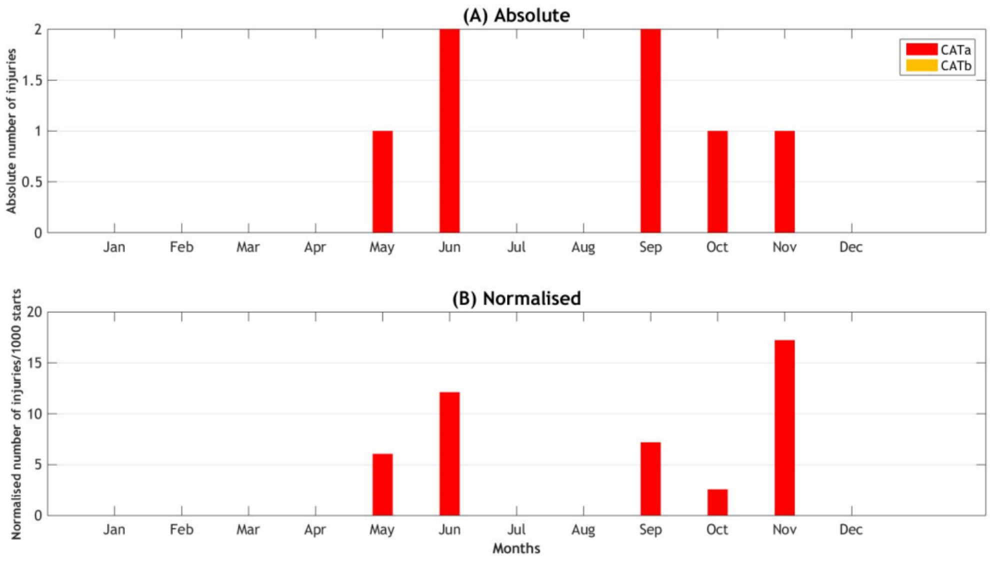

Figure 4.97: Coonamble track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

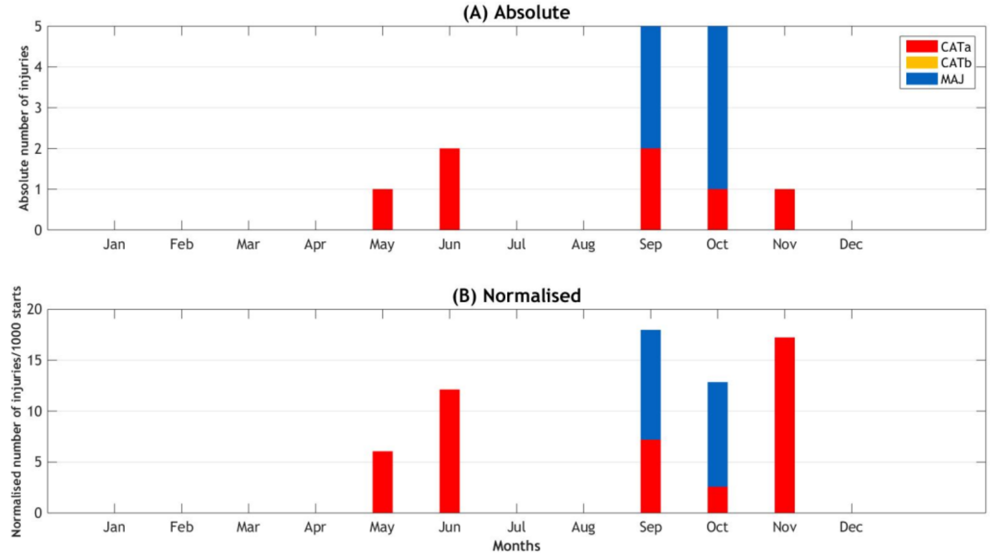

Figure 4.98: Coonamble track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

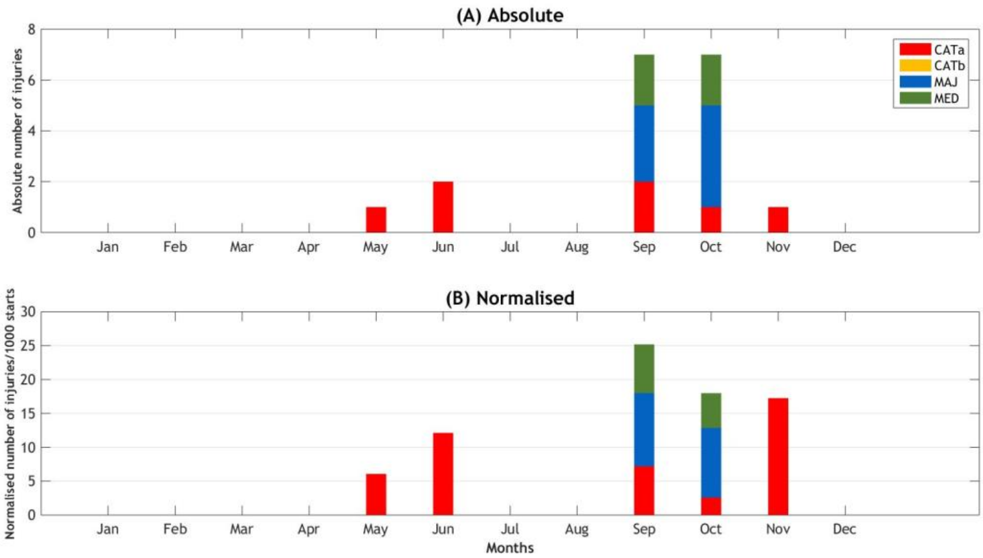

Figure 4.99: Coonamble track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

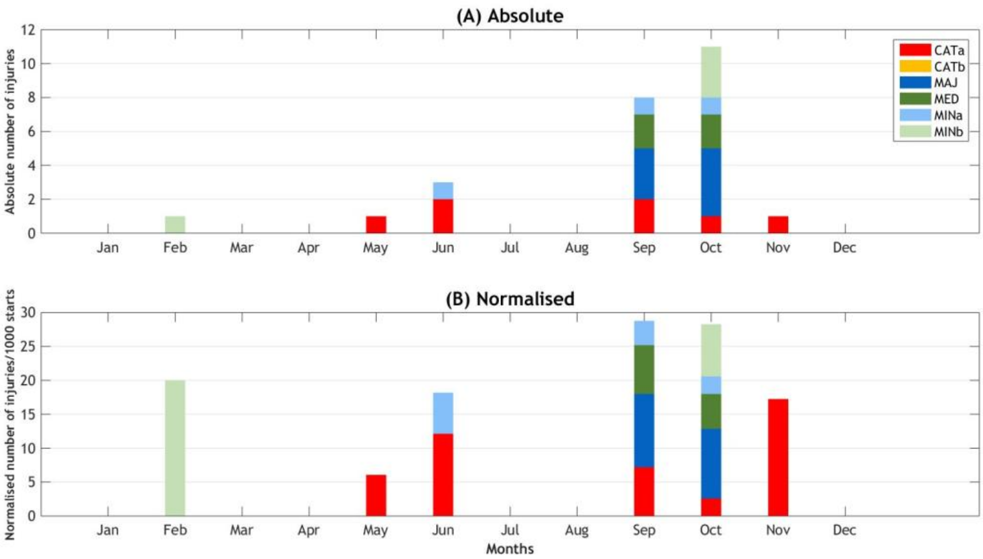

Figure 4.100: Coonamble track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Tweed Heads

Tweed Heads - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.508 Figures 4.101 to 4.104 contain Tweed Heads Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.509 There were no race events at the Tweed Heads track in July.

4.510 Absolute Level 1 injury rates for Tweed Heads are shown in Figure 4.101.A.

4.511 October has the highest number of absolute Level 1 injuries with 2 injuries.

4.512 February, June, August and November have the lowest absolute Level 1 injuries with 0 injuries.

4.513 Normalized Level 1 injury rates for Tweed Heads are shown in Figure 4.101.B.

4.514 October has the highest normalized Level 1 Injury rate followed by December.

4.515 Absolute Level 2 injury rates for Tweed Heads are shown in Figure 4.102.A.

4.516 September has the highest absolute Level 2 injury rate with 3 injuries.

4.517 February, June and August have the lowest absolute Level 2 Injury rate with 0 injuries.

4.518 Normalized Level 2 injury rates for Tweed Heads are shown in Figure 4.102.B.

4.519 September has the highest normalized Level 2 Injury rate followed by October.

4.520 February, June and August have the lowest normalized Level 2 injury.

4.521 Absolute Level 3 injury rates for Tweed Heads are shown in Figure 4.103.A.

4.522 September and November have the highest absolute Level 3 injury rate with 6 injuries each.

4.523 June has the lowest absolute Level 3 injury rate with 0 injuries.

4.524 Normalized Level 3 injury rates for Tweed Heads are shown in Figure 4.103.B.

4.525 February has the highest normalized Level 3 injury rate followed by September.

4.526 June has the lowest normalized Level 3 injury rate.

4.527 Absolute Level 4 injury rates for Tweed Heads are shown in Figure 4.104.A.

4.528 November has the highest absolute Level 4 injury rate with 9 injuries.

4.529 June the lowest absolute Level 4 injury rate with 0 injuries.

4.530 Normalized Level 4 injury rates for Tweed Heads are shown in Figure 4.104.B.

4.531 February has the highest normalized Level 4 injury rate followed by September.

4.532 June has the lowest normalized Level 4 injury rate followed by August.

4.533 CATb does not include all the data.

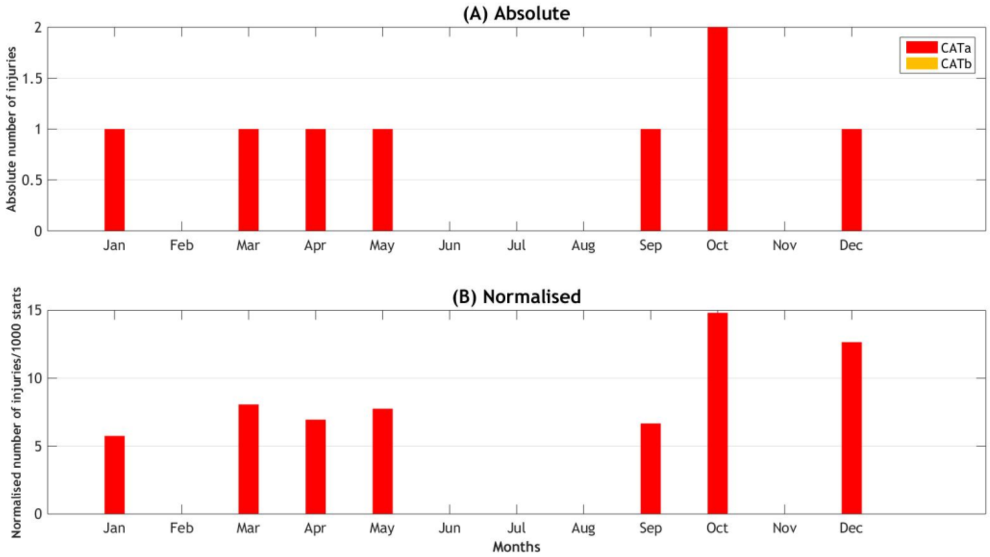

Figure 4.101: Tweed Heads track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

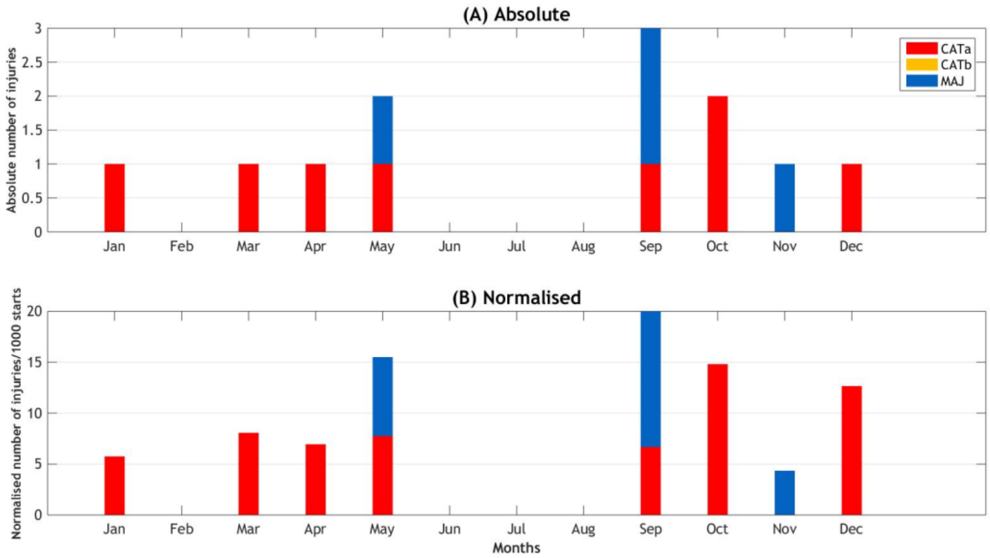

Figure 4.102: Tweed Heads track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

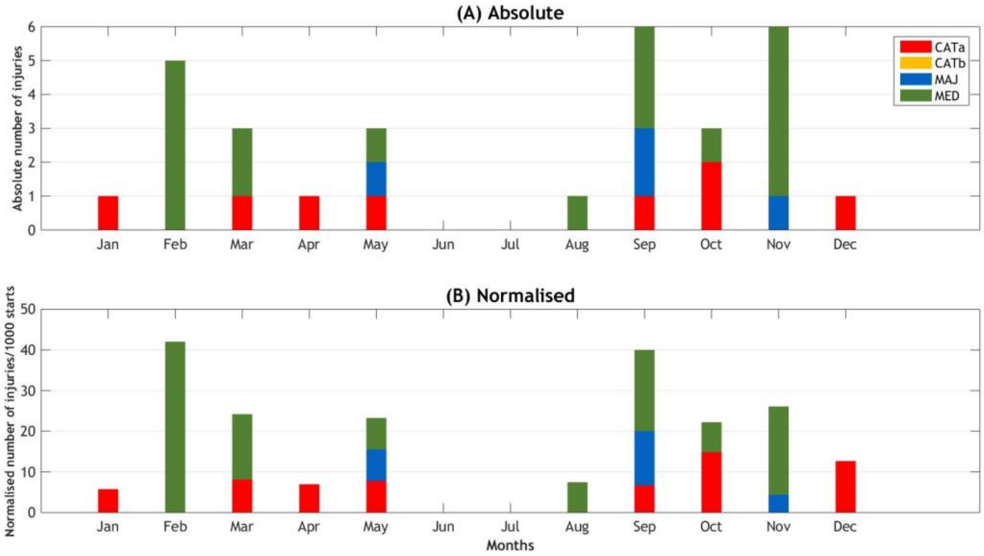

Figure 4.103: Tweed Heads track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

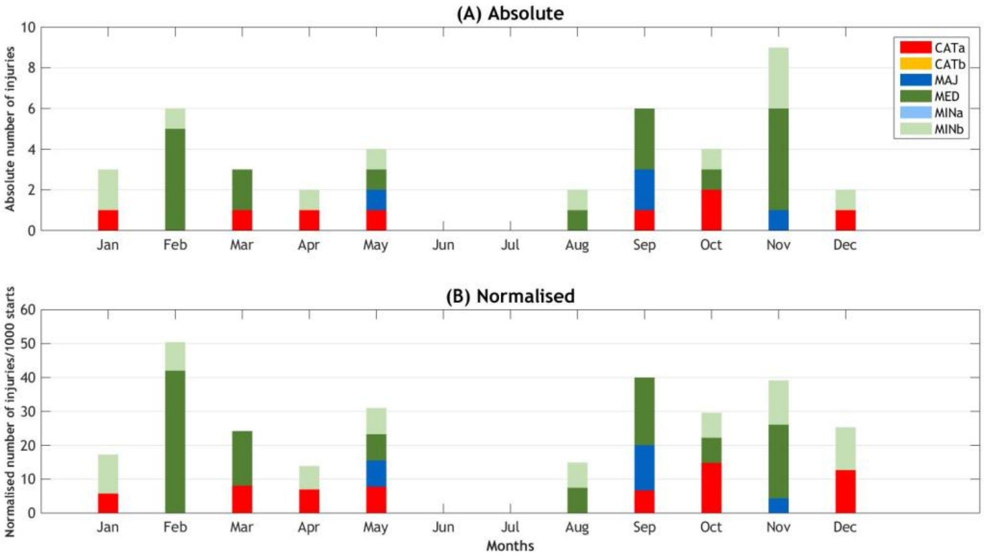

Figure 4.104: Tweed Heads track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Potts Park

Potts Park - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.534 Figures 4.105 to 4.108 contain Potts Park Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.535 There were no race events at the Potts Park track in January, July and December.

4.536 Absolute Level 1 injury rates for Potts Park are shown in Figure 4.105.A.

4.537 November has the highest number of absolute Level 1 injuries with 2 injuries.

4.538 February, May, June, August, September and October have the lowest absolute level 1 injuries with 0 injuries.

4.539 Normalized Level 1 injury rates for Potts Park are shown in Figure 4.105.B.

4.540 November has the highest normalized Level 1 Injury rate.

4.541 Absolute Level 2 injury rates for Potts Park are shown in Figure 4.106.A.

4.542 October has the highest absolute Level 2 injury rate with 3 injuries.

4.543 February, May, June and August have the lowest absolute Level 2 Injury rate with 0 injuries.

4.544 Normalized Level 2 injury rates for Potts Park are shown in Figure 4.106.B.

4.545 October has the highest normalized Level 2 injury rate followed by November.

4.546 February, May, June and August have the lowest normalized Level 2 injury.

4.547 Absolute Level 3 injury rates for Potts Park are shown in Figure 4.107.A.

4.548 November has the highest absolute Level 3 injury rate with 6 injuries.

4.549 February, May and June have the lowest absolute Level 3 injury rate with 0 injuries.

4.550 Normalized Level 3 injury rates for Potts Park are shown in Figure 4.107.B.

4.551 November has the highest normalized Level 3 injury rate followed by October.

4.552 February, May and June have the lowest normalized Level 3 injury rate.

4.553 Absolute Level 4 injury rates for Potts Park are shown in Figure 4.108.A.

4.554 November has the highest absolute Level 4 injury rate with 10 injuries.

4.555 June has the lowest absolute Level 4 injury rate with 1 injury.

4.556 Normalized Level 4 injury rates for Potts Park are shown in Figure 4.108.B.

4.557 November has the highest normalized Level 4 injury rate followed by October.

4.558 June has the lowest normalized Level 4 injury rate followed by February.

4.559 CATb does not include all the data.

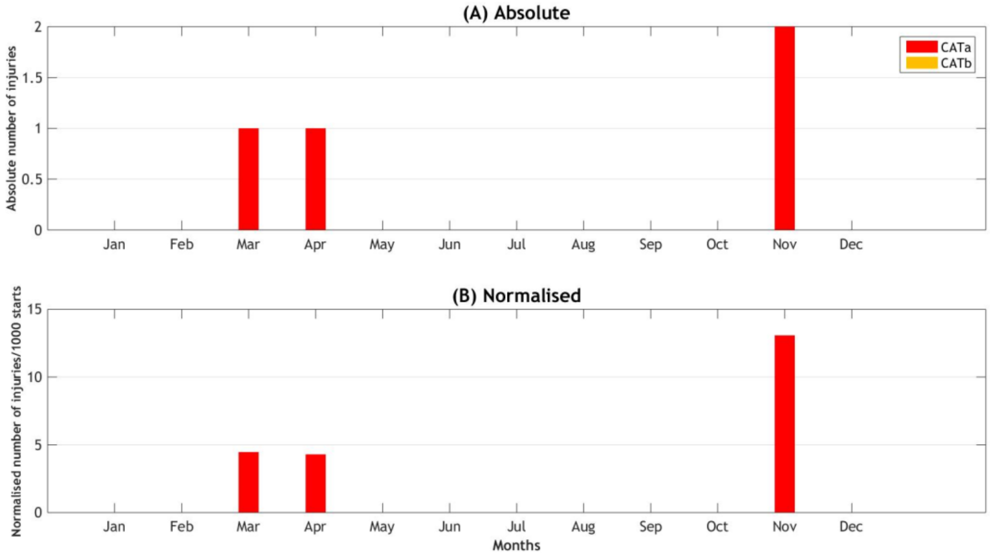

Figure 4.105: Potts Park track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

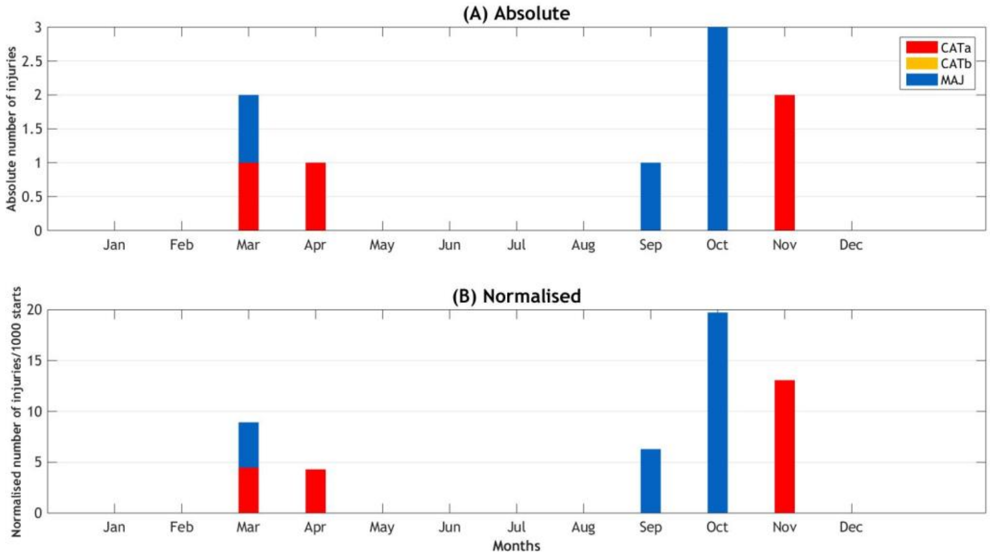

Figure 4.106: Potts Park track Level 2 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

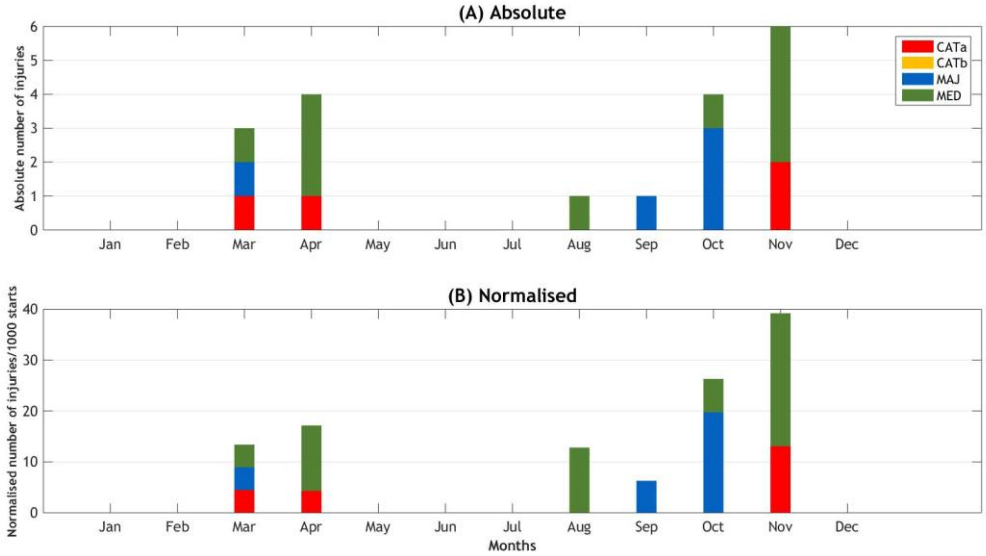

Figure 4.107: Potts Park track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

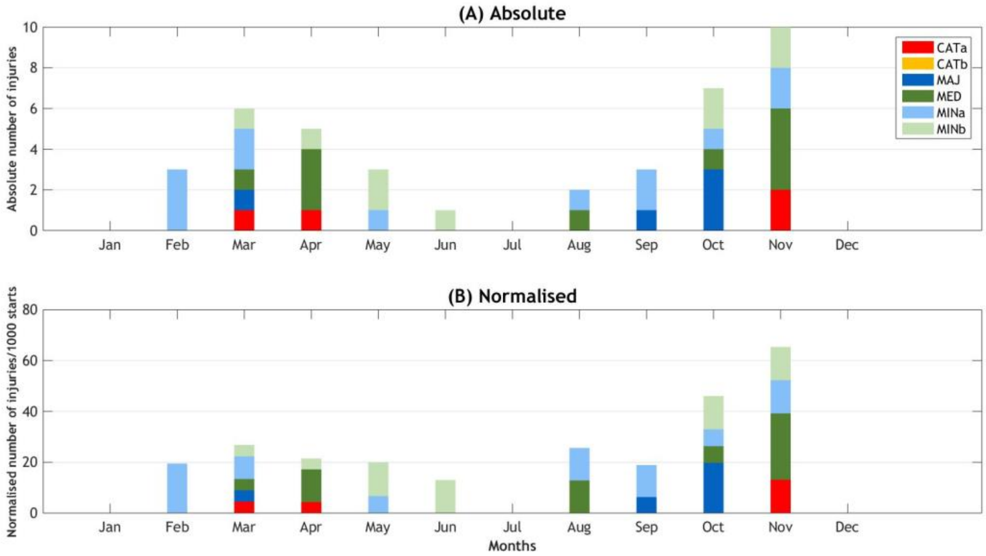

Figure 4.108: Potts Park track Level 4 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

Tamworth

Tamworth - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.560 Figures 4.109 to 4.111 contain Tamworth Level 1, Level 3 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.561 There were no race events at Tamworth in July and August.

4.562 Absolute Level 1 injury rates for Tamworth are shown in Figure 4.109.A.

4.563 March and December have the highest number of absolute Level 1 injuries with 2 injuries.

4.564 February, May, September and October have the lowest absolute Level 1 injuries with 0 injuries.

4.565 Normalized Level 1 injury rates for Tamworth are shown in Figure 4.109.B.

4.566 March has the highest normalized Level 1 injury rate.

4.567 Absolute Level 3 injury rates for Tamworth are shown in Figure 4.110.A.

4.568 March, September and December have the highest absolute Level 3 injury rate with 2 injuries.

4.569 February, May and October have the lowest absolute Level 3 Injury rate with 0 injuries.

4.570 Normalized Level 3 injury rates for Tamworth are shown in Figure 4.110.B.

4.571 March has the highest normalized Level 3 injury rate followed by September.

4.572 February, May and October have the lowest normalized Level 3 injury rate.

4.573 Absolute Level 4 injury rates for Tamworth are shown in Figure 4.111.A.

4.574 December has the highest absolute Level 4 injury rate with 4 injuries.

4.575 May has the lowest absolute Level 4 injury rate with 0 injuries.

4.576 Normalized Level 4 injury rates for Tamworth are shown in Figure 4.111.B.

4.577 December has the highest normalized Level 4 injury rate followed by March.

4.578 May has the lowest normalized Level 4 injury rate followed by October.

4.579 CATb does not include all the data.

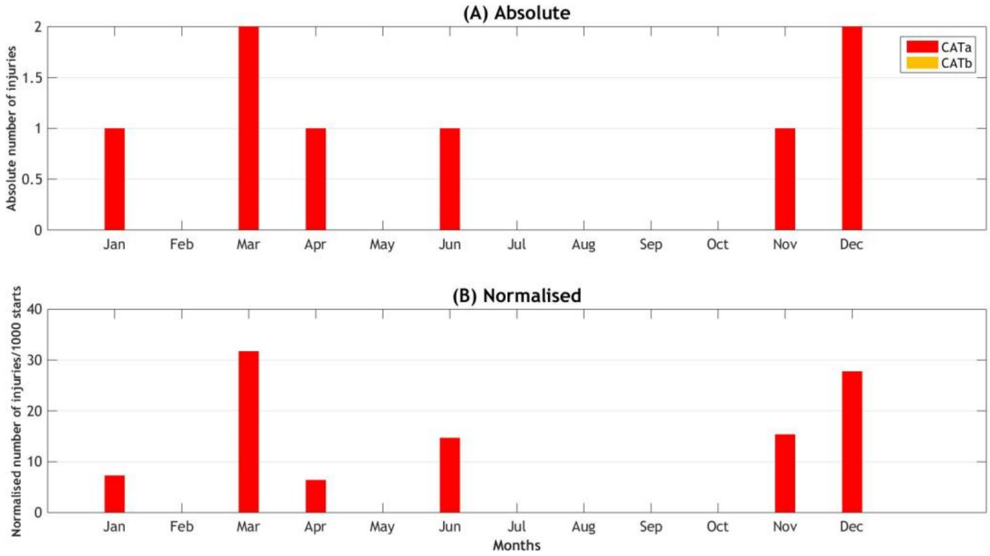

Figure 4.109: Tamworth track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

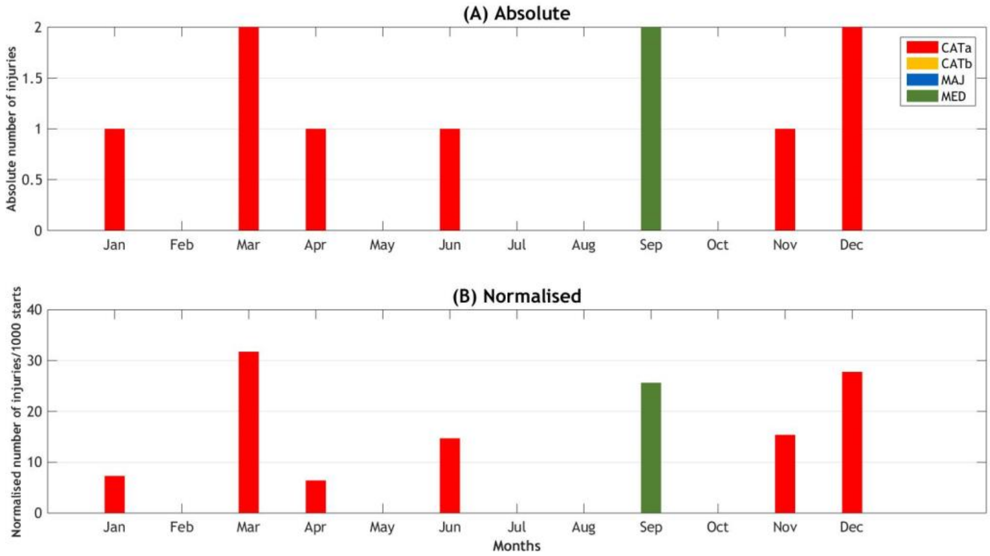

Figure 4.110: Tamworth track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

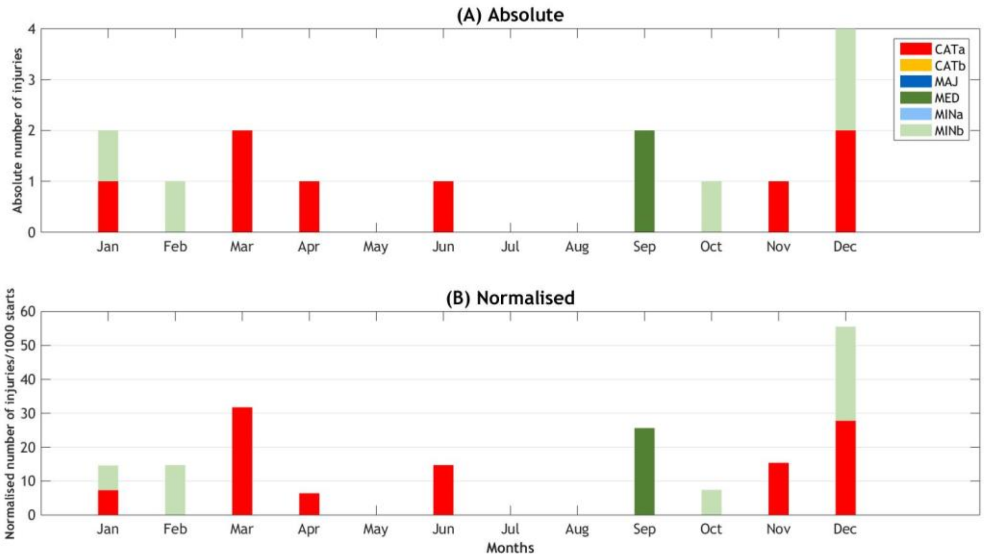

Figure 4.111: Tamworth track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

TAREE

TAREE - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.580 Figures 4.112 to 4.115 contain Taree Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.581 There were no race events at the Taree track in August and December.

4.582 Absolute Level 1 injury rates for Taree are shown in Figure 4.112.A.

4.583 January is the only month with absolute Level 1 injuries with 4 injuries.

4.584 Normalized Level 1 injury rates for Taree are shown in Figure 4.112.B.

4.585 Absolute Level 2 injury rates for Taree are shown in Figure 4.113.A.

4.586 January has the highest absolute Level 2 injury rate with 4 injuries.

4.587 Normalized Level 2 injury rates for Taree are shown in Figure 4.113.B.

4.588 January has the highest normalized Level 2 Injury rate.

4.589 Absolute Level 3 injury rates for Taree are shown in Figure 4.114.A.

4.590 January has the highest absolute Level 3 injury rate with 5 injuries.

4.591 Normalized Level 3 injury rates for Taree are shown in Figure 4.114.B.

4.592 January has the highest normalized Level 3 injury rate followed by November.

4.593 Absolute Level 4 injury rates for Taree are shown in Figure 4.115.A.

4.594 January has the highest absolute Level 4 injury rate with 5 injuries.

4.595 Normalized Level 4 injury rates for Taree are shown in Figure 4.115.B.

4.596 January has the highest normalized Level 4 injury rate followed by January.

4.597 CATb does not include all the data.

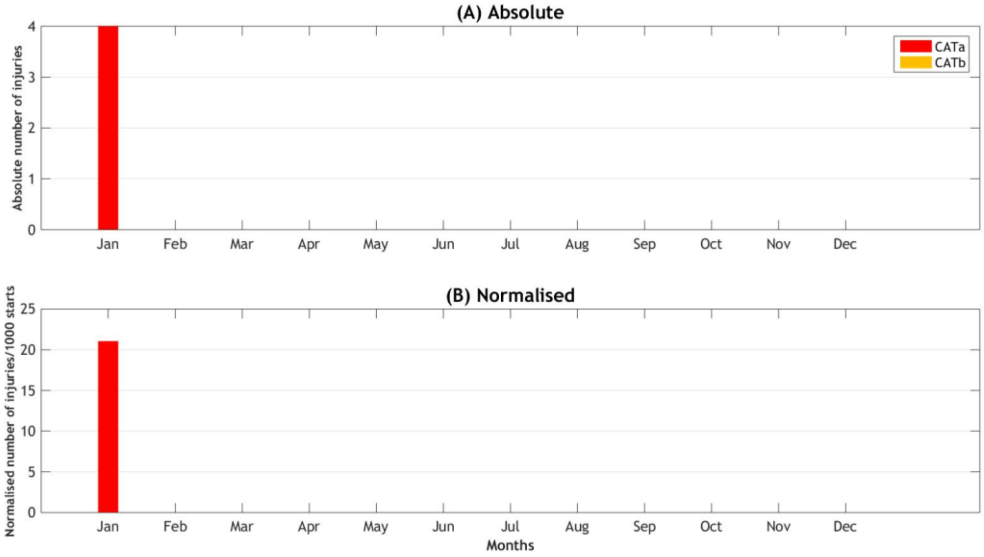

Figure 4.112: Taree track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

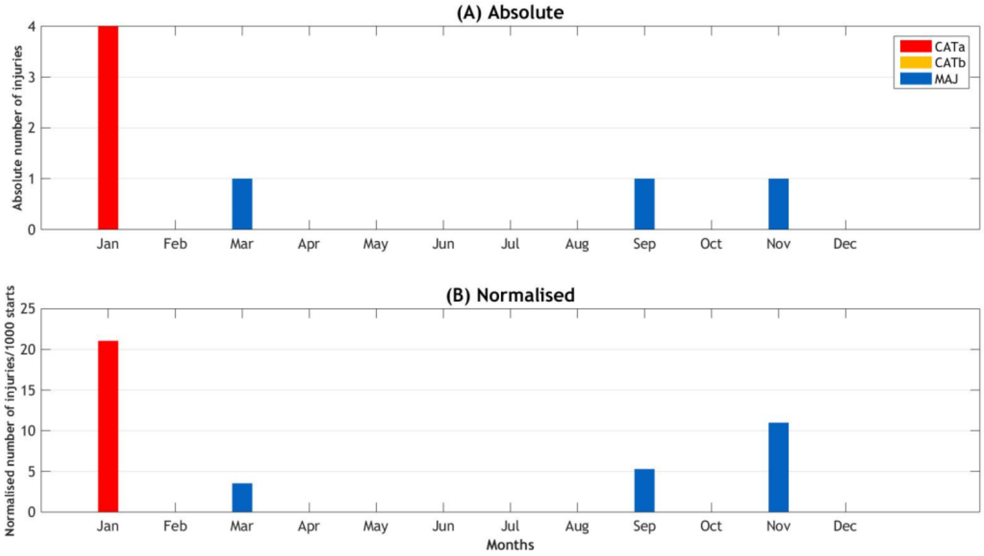

Figure 4.113: Taree track Level 2 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

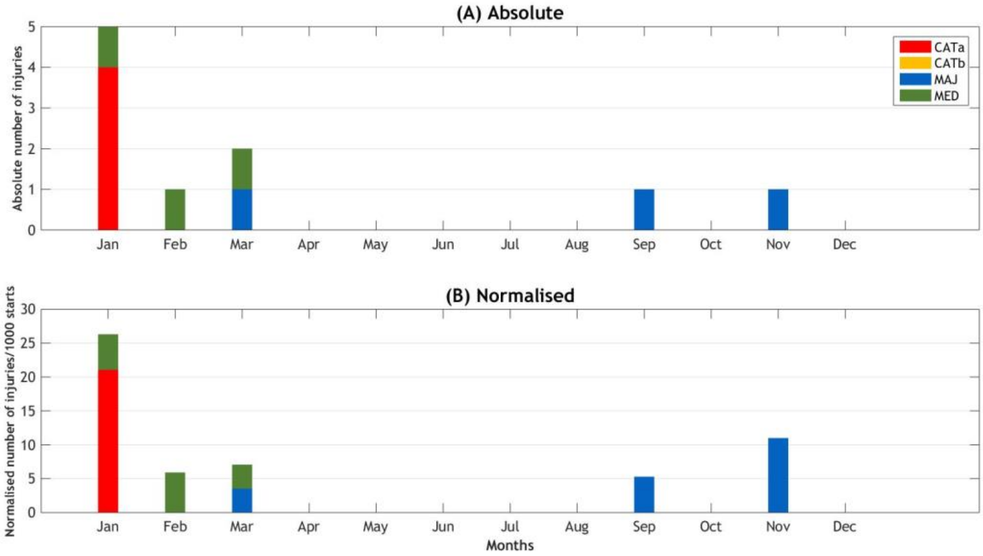

Figure 4.114: Taree track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

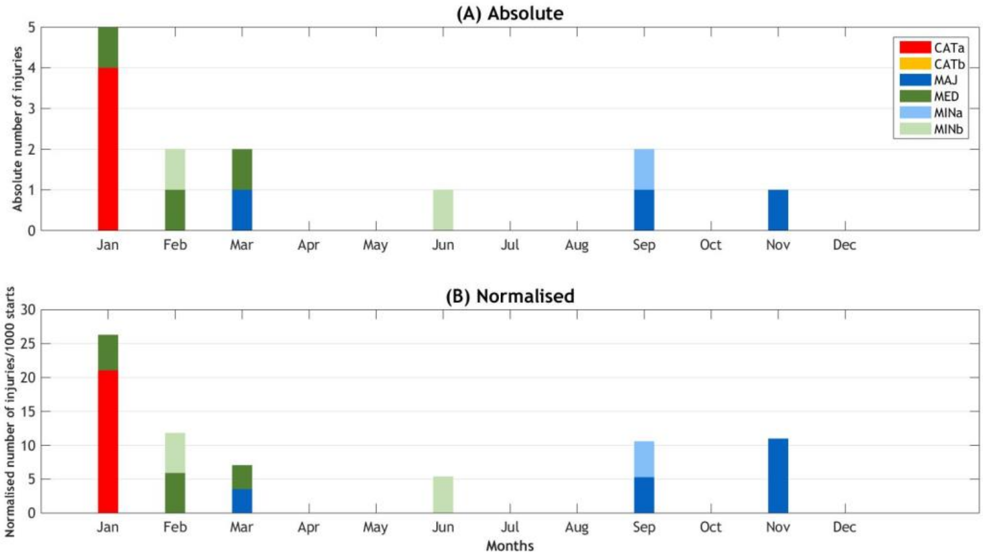

Figure 4.115: Taree track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Wagga Wagga

Wagga Wagga - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.598 Figures 4.116 to 4.119 contain Wagga Wagga Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.599 There were no race events at the Wagga Wagga track in July.

4.600 Absolute Level 1 injury rates for Wagga Wagga are shown in Figure 4.116.A.

4.601 June has the highest number of absolute Level 1 injury with 2 injuries followed by March, May and August with 1 injury each. All other months have 0 absolute Level 1 injuries.

4.602 Normalized Level 1 injury rates for Wagga Wagga are shown in Figure 4.116.B.

4.603 June has the highest normalized Level 1 injury rate.

4.604 Absolute Level 2 injury rates for Wagga Wagga are shown in Figure 4.117.A.

4.605 June has the highest absolute Level 2 injury rate with 2 injuries.

4.606 March, April, May and August have 1 absolute Level 2 injury. All other months have 0 absolute Level 2 injuries.

4.607 Normalized Level 2 injury rates for Wagga Wagga are shown in Figure 4.117.B.

4.608 June has the highest normalized Level 3 injury rate followed by May.

4.609 Absolute Level 3 injury rates for Wagga Wagga are shown in Figure 4.118.A.

4.610 February has the highest absolute Level 3 injury rate with 3 injuries.

4.611 January, October, November and December have the lowest absolute Level 3 injury rate with 0 injuries.

4.612 Normalized Level 3 injury rates for Wagga Wagga are shown in Figure 4.118.B.

4.613 February has the highest normalized Level 3 injury rate followed by April.

4.614 Absolute Level 4 injury rates for Wagga Wagga are shown in Figure 4.119.A.

4.615 June has the highest absolute Level 4 injury rate with 11 injuries.

4.616 Normalized Level 4 injury rates for Wagga Wagga are shown in Figure 4.119.B.

4.617 February has the highest normalized Level 4 injury rate followed by June.

4.618 CATb does not include all the data.

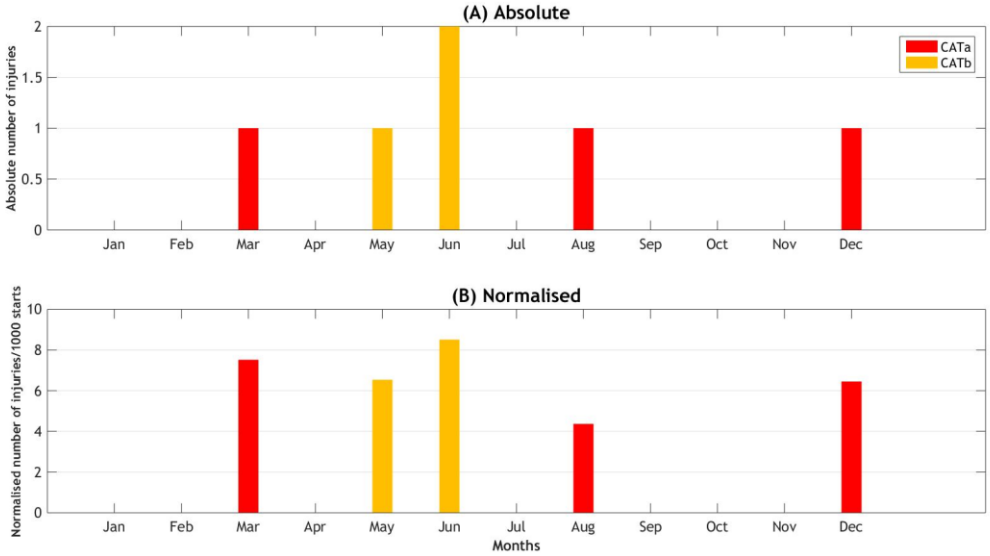

Figure 4.116: Wagga Wagga track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

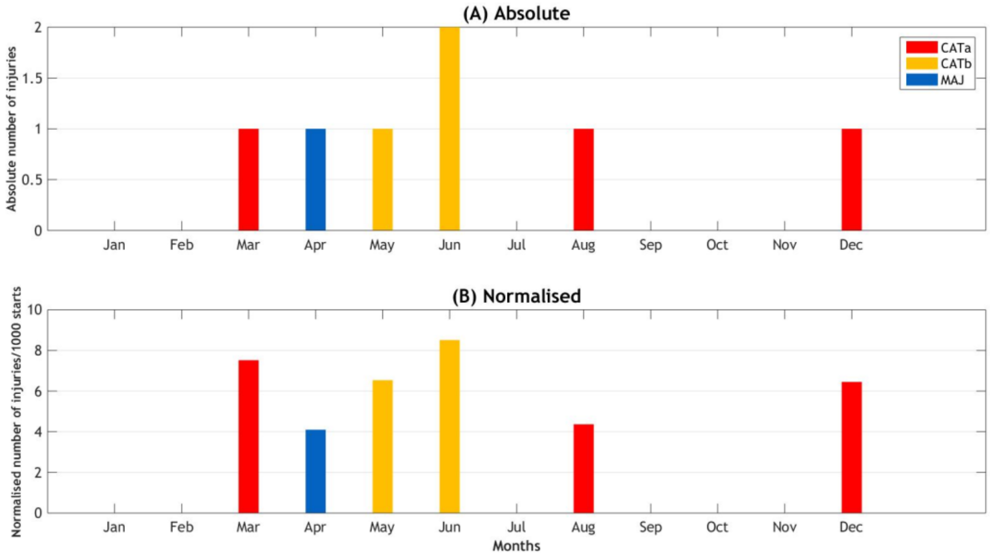

Figure 4.117: Wagga Wagga track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

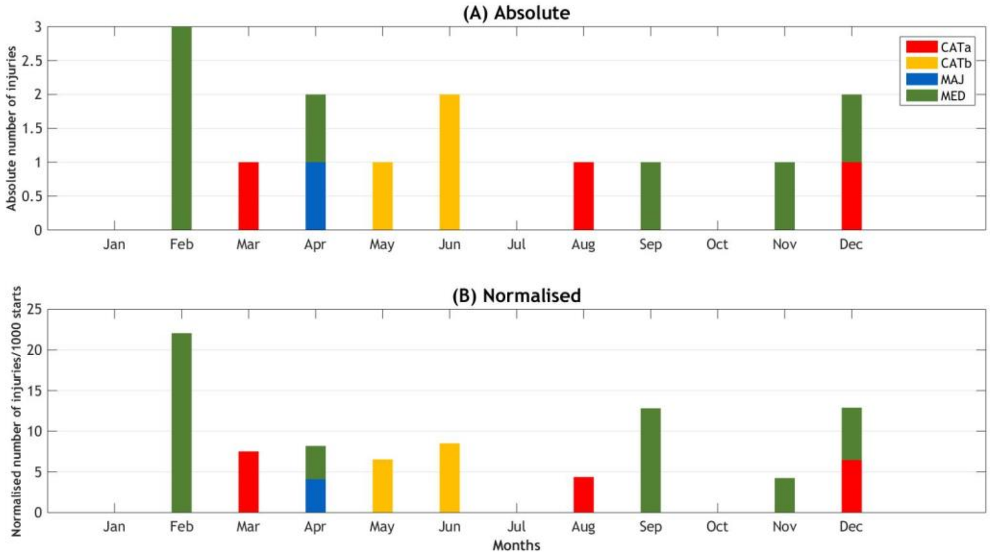

Figure 4.118: Wagga Wagga track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

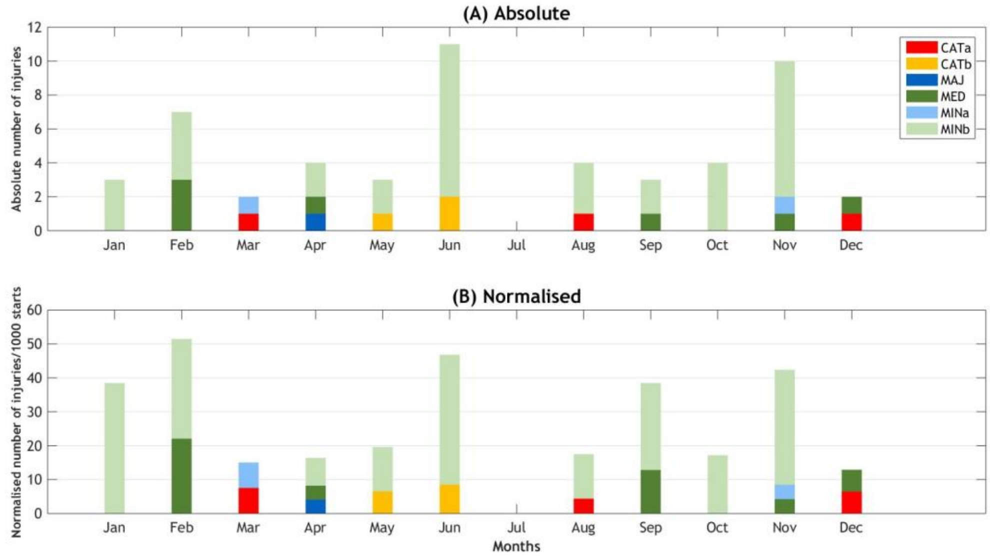

Figure 4.119: Wagga Wagga track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

GUNNEDAH

GUNNEDAH - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.619 Figures 4.120 to 4.122 contain Gunnedah Level 1, Level 2 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.620 There were no race events at the Gunnedah track in May and November.

4.621 Absolute Level 1 injury rates for Gunnedah are shown in Figure 4.120.A.

4.622 January, March, June and July have the highest number of absolute Level 1 injuries with 1 injury each. All other months have 0 absolute Level 1 injuries.

4.623 Normalized Level 1 injury rates for Gunnedah are shown in Figure 4.120.B.

4.624 March has the highest normalized Level 1 injury rate.

4.625 Absolute Level 2 injury rates for Gunnedah are shown in Figure 4.121.A.

4.626 January, March, June, July, August and December have the highest absolute Level 2 injury rate with 1 injury each. All other months have 0 absolute Level 2 injuries.

4.627 Normalized Level 2 injury rates for Gunnedah are shown in Figure 4.121.B.

4.628 March has the highest normalized Level 2 injury rate followed by December.

4.629 Absolute Level 4 injury rates for Gunnedah are shown in Figure 4.122.A.

4.630 January and October have the highest absolute Level 4 injury rate with 3 injuries each.

4.631 Normalized Level 4 injury rates for Gunnedah are shown in Figure 4.122.B.

4.632 February has the highest normalized Level 4 injury rate followed by February.

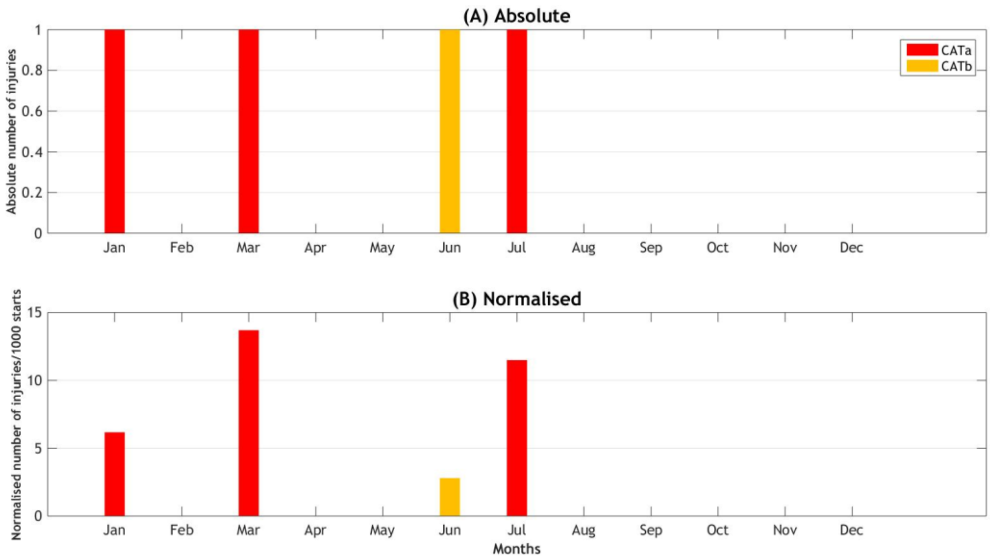

Figure 4.120: Gunnedah track Level 1 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

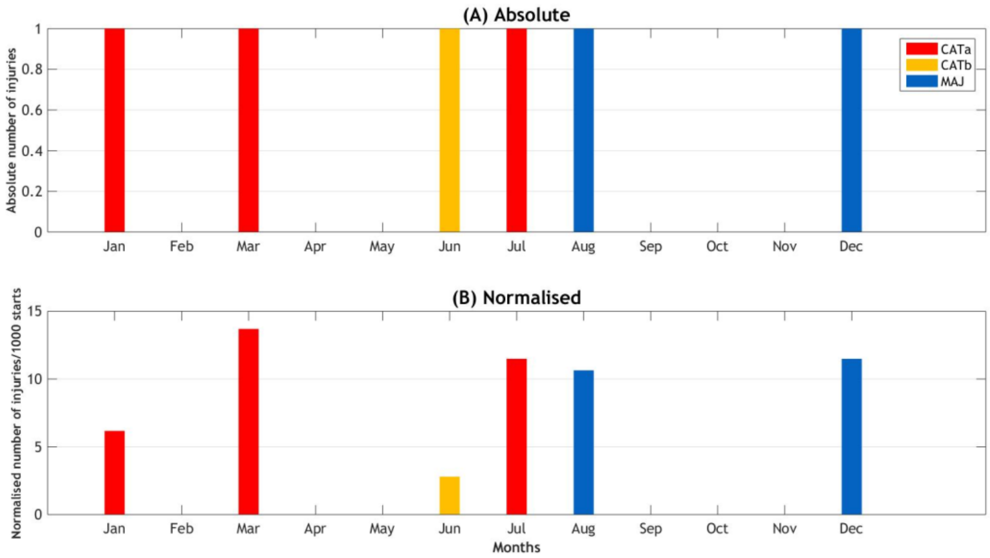

Figure 4.121: Gunnedah track Level 2 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

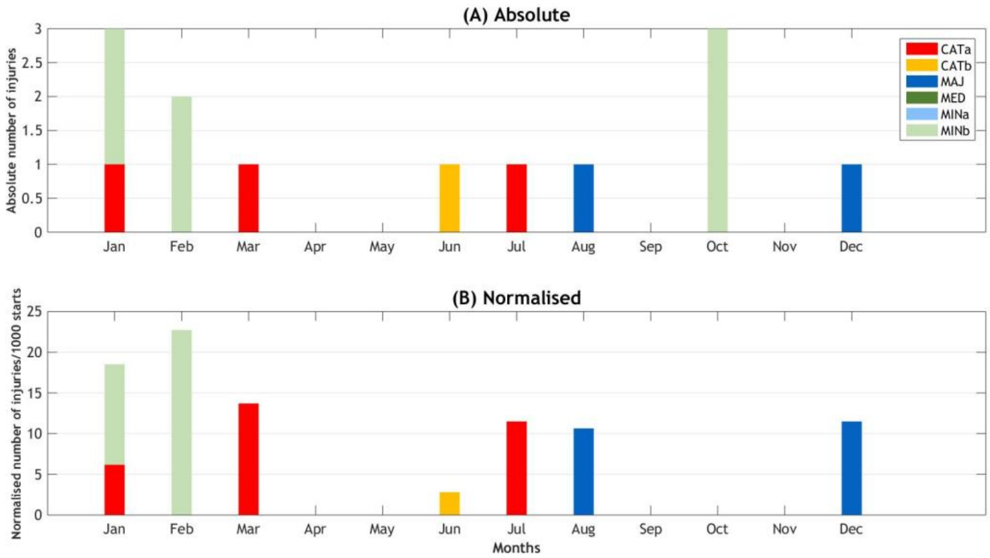

Figure 4.122: Gunnedah track Level 4 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

Lithgow

Lithgow - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.633 Figures 4.123 to 4.126 contain Lithgow Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.634 There were no race events at the Lithgow track in January, June, July and August.

4.635 Absolute Level 1 injury rates for Lithgow are shown in Figure 4.123.A.

4.636 May has the highest number of absolute Level 1 injuries with 2 injuries followed by April with 1 injury. All other months have 0 absolute Level 1 injuries.

4.637 Normalized Level 1 injury rates for Lithgow are shown in Figure 4.123.B.

4.638 Absolute Level 2 injury rates for Lithgow are shown in Figure 4.124.A.

4.639 February and May have the highest absolute Level 2 injury rate with 2 injuries individually.

4.640 Normalized Level 2 injury rates for Lithgow are shown in Figure 4.124.B.

4.641 February has the highest normalized Level 3 injury rate followed by May.

4.642 Absolute Level 3 injury rates for Lithgow are shown in Figure 4.125.A.

4.643 May has the highest absolute Level 3 injury rate with 7 injuries.

4.644 Normalized Level 3 injury rates for Lithgow are shown in Figure 4.125.B.

4.645 February has the highest normalized Level 3 injury rate followed by November.

4.646 Absolute Level 4 injury rates for Lithgow are shown in Figure 4.126.A.

4.647 May has the highest absolute Level 4 injury rate with 8 injuries.

4.648 Normalized Level 4 injury rates for Lithgow are shown in Figure 4.126.B.

4.649 November has the highest normalized Level 4 injury rate followed by April.

4.650 CATb does not include all the data.

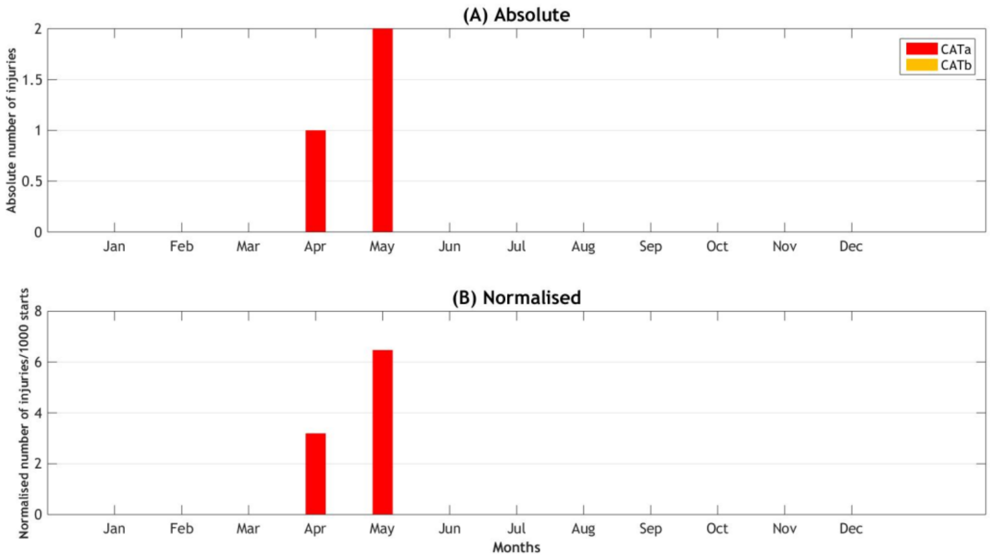

Figure 4.123: Lithgow track Level 1 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

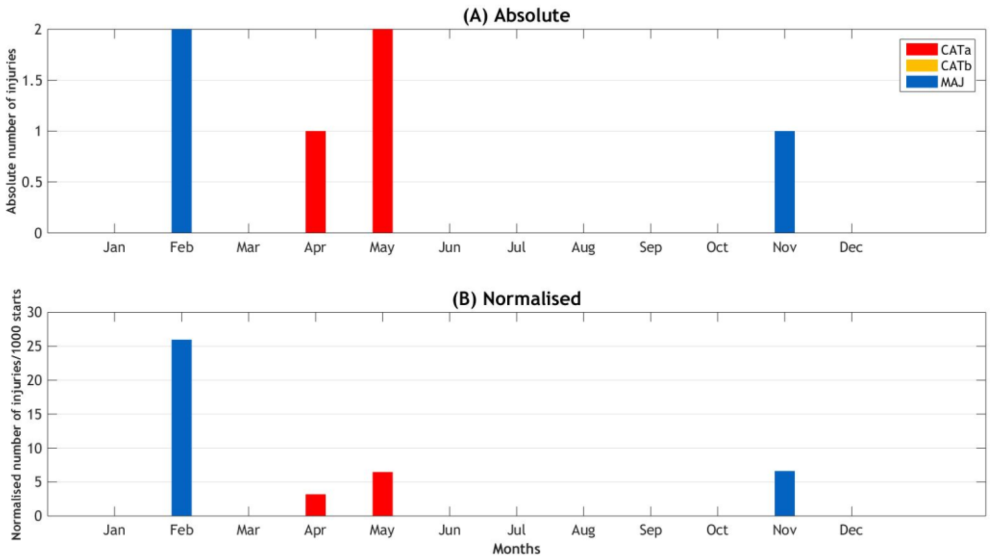

Figure 4.124: Lithgow track Level 2 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

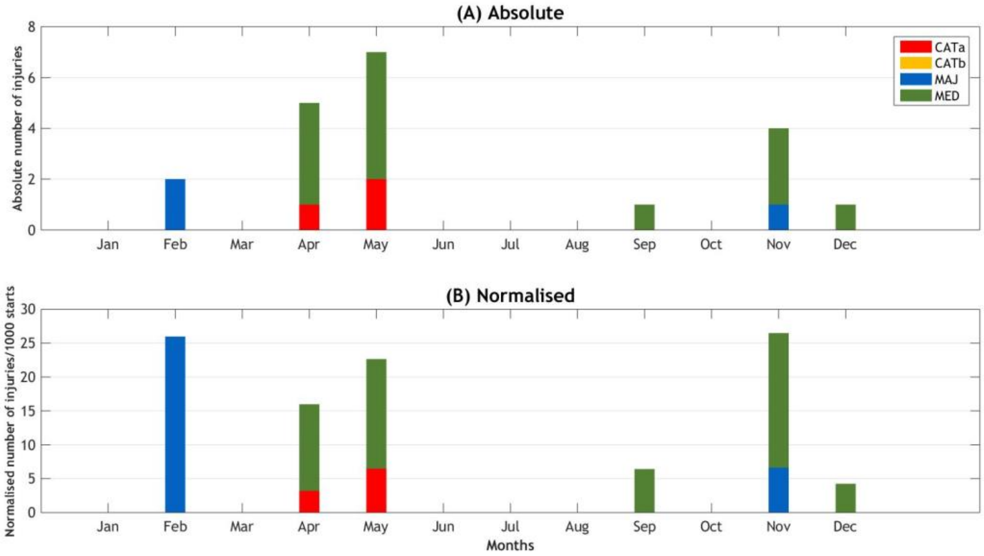

Figure 4.125: Lithgow track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

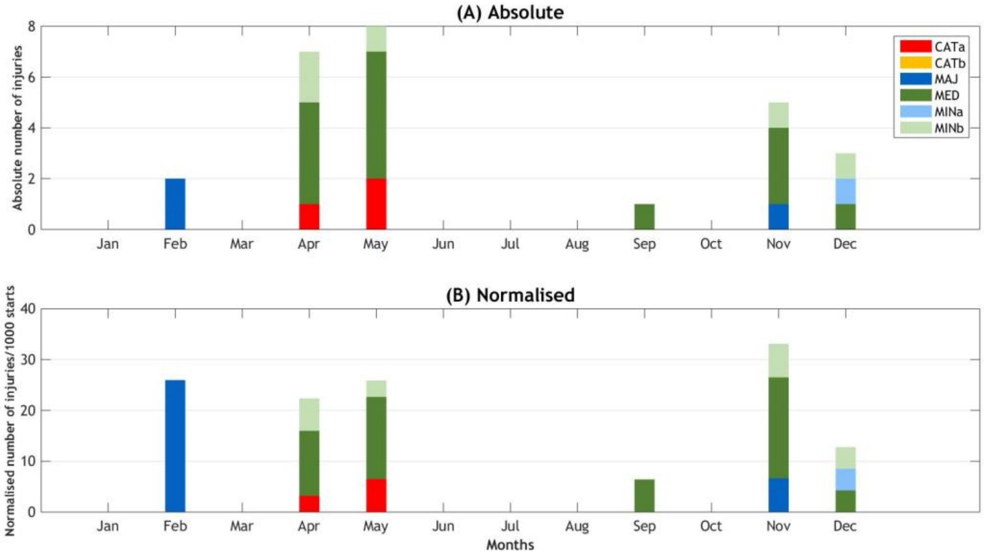

Figure 4.126: Lithgow track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Coonabarabran

Coonabarabran - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.651 Figures 4.127 to 4.130 contain Coonabarabran Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.652 There were no race events at the Coonabarabran track in January, July, August and December.

4.653 Absolute Level 1 injury rates for Coonabarabran are shown in Figure 4.1127.A.

4.654 March has the highest number of absolute Level 1 injuries with 2 injuries followed by April with 1 injury. All other months have 0 absolute Level 1 injuries.

4.655 Normalized Level 1 injury rates for Coonabarabran are shown in Figure 4.127.B.

4.656 Absolute Level 2 injury rates for Coonabarabran are shown in Figure 4.128.A.

4.657 March has the highest absolute Level 2 injury rate with 3 injuries.

4.658 Normalized Level 2 injury rates for Coonabarabran are shown in Figure 4.128.B.

4.659 June has the highest normalized Level 3 injury rate followed by June.

4.660 Absolute Level 4 injury rates for Coonabarabran are shown in Figure 4.130.A.

4.661 Normalized Level 4 injury rates for Coonabarabran are shown in Figure 4.129.B.

4.662 CATb does not include all the data.

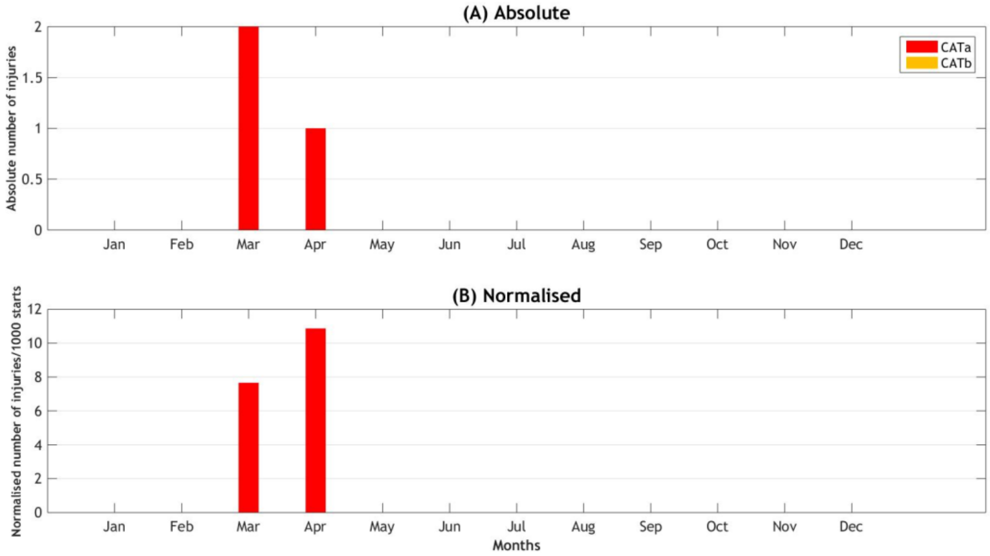

Figure 4.127: Coonabarabran track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

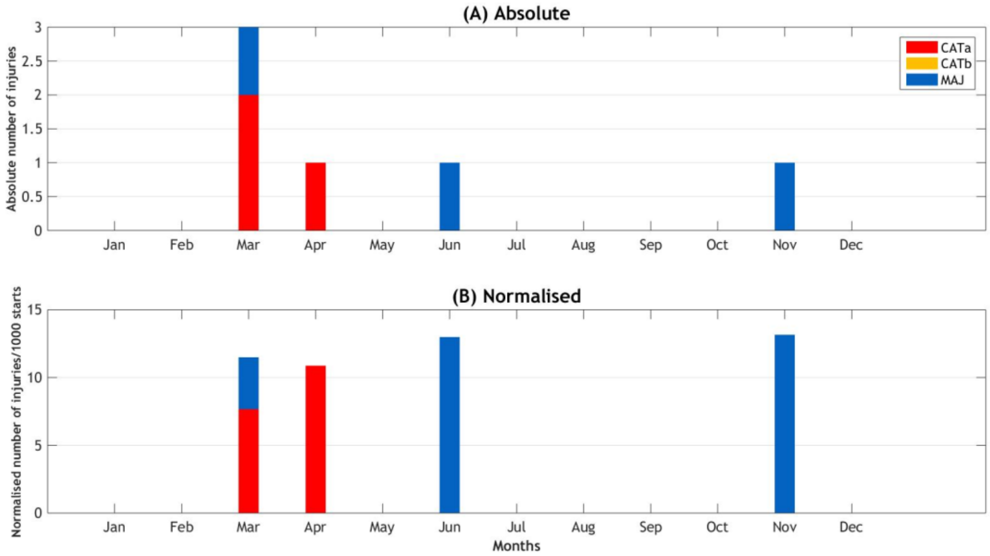

Figure 4.128: Coonabarabran track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

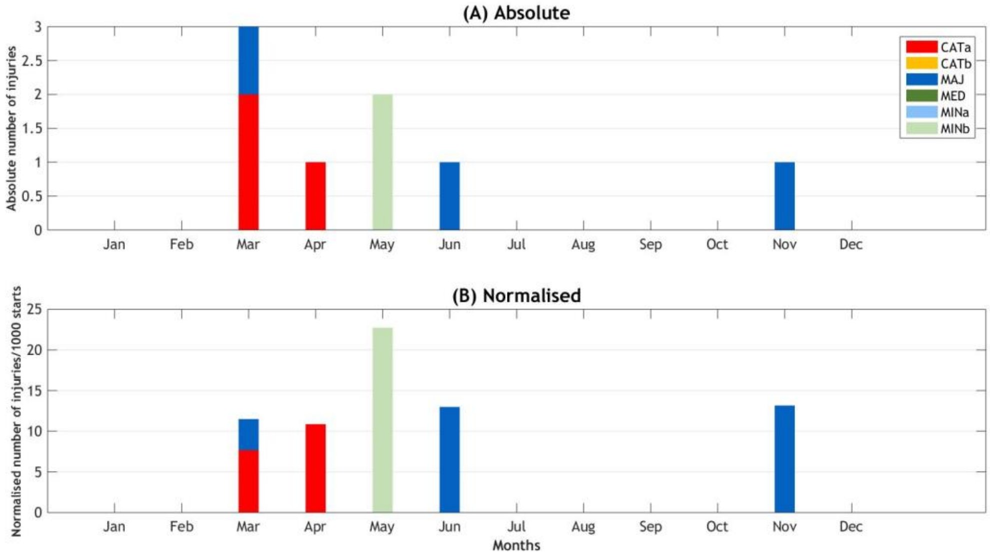

Figure 4.129: Coonabarabran track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

MUDGEE

MUDGEE - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.663 Figures 4.131 to 4.134 contain Mudgee Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.664 There were no race event at the Mudgee track in January, March, July, August, September and December.

4.665 Absolute Level 1 injury rates for Mudgee are shown in Figure 4.131.A.

4.666 June has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.667 Normalized Level 1 injury rates for Mudgee are shown in Figure 4.131.B.

4.668 Absolute Level 2 injury rates for Mudgee are shown in Figure 4.132.A.

4.669 June has the highest absolute Level 2 injury rate with 3 injuries.

4.670 Normalized Level 2 injury rates for Mudgee are shown in Figure 4.132.B.

4.671 June has the highest normalized Level 2 injury rate.

4.672 Absolute Level 3 injury rates for Mudgee are shown in Figure 4.133.A.

4.673 November has the highest absolute Level 3 injury with 4 injuries.

4.674 Normalized Level 3 injury rates for Mudgee are shown in Figure 4.133.B.

4.675 June has the highest normalized Level 3 injury rate.

4.676 Absolute Level 4 injury rates for Mudgee are shown in Figure 4.134.A.

4.677 November has the highest absolute Level 4 injury with 9 injuries.

4.678 Normalized Level 4 injury rates for Mudgee are shown in Figure 4.134.B.

4.679 June has the highest normalized Level 4 injury rate.

4.680 CATb does not include all the data.

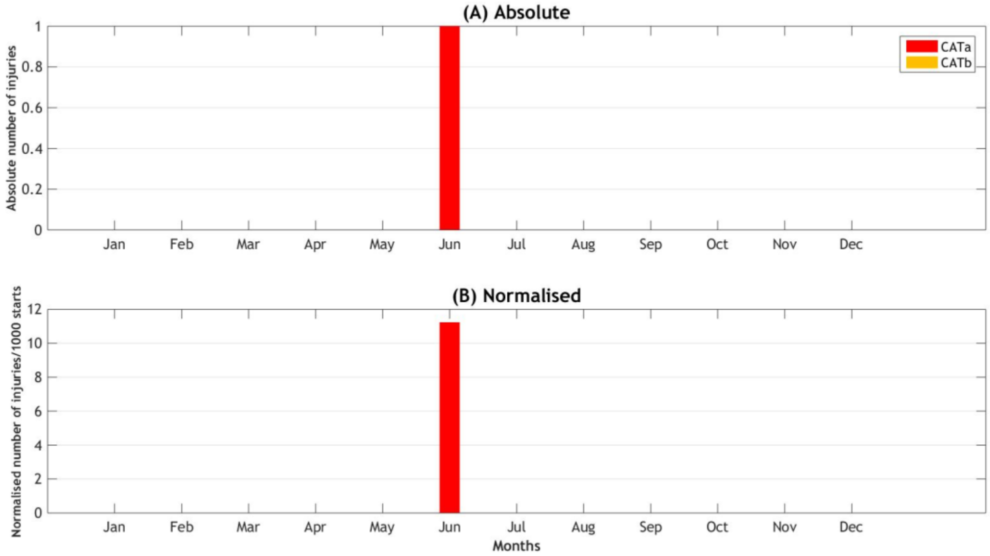

Figure 4.131: Mudgee track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

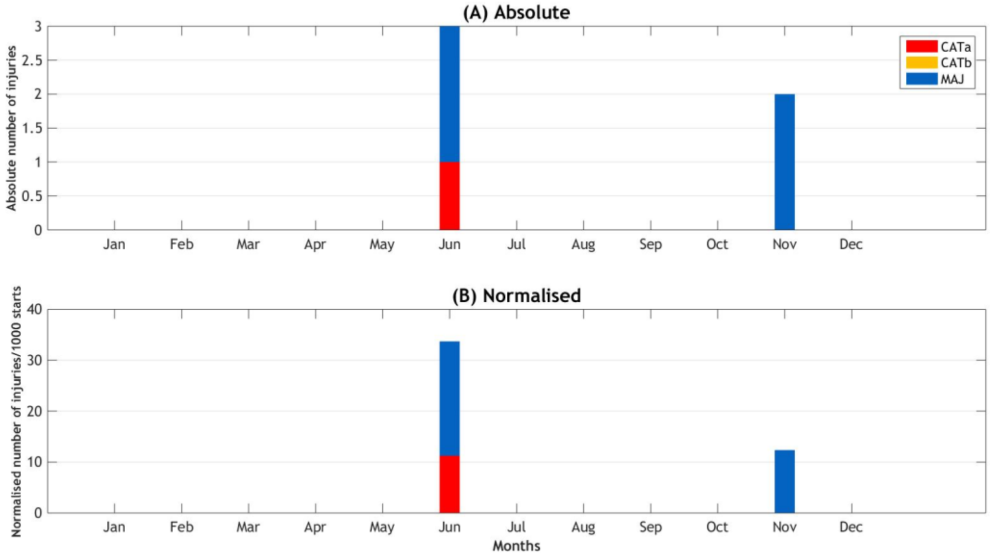

Figure 4.132: Mudgee track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

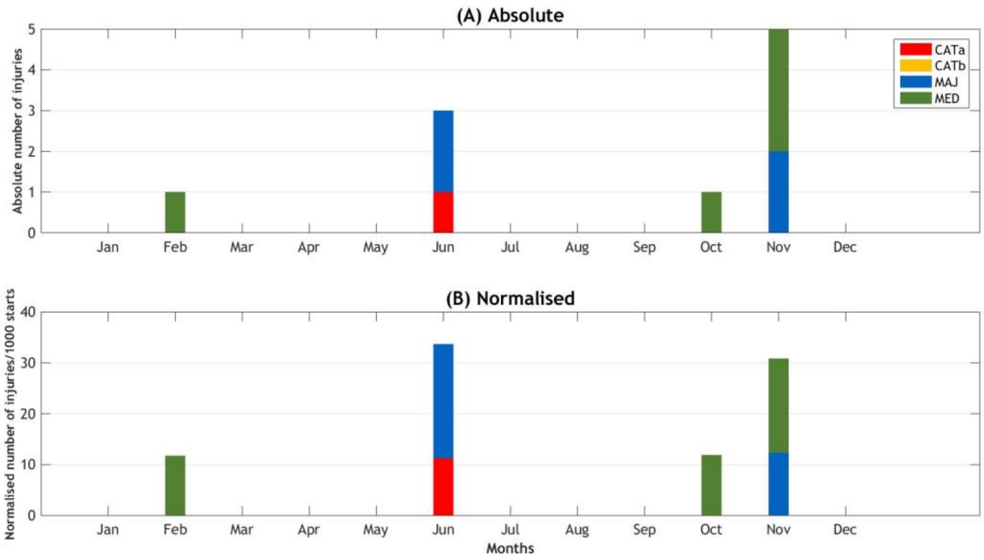

Figure 4.133: Mudgee track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

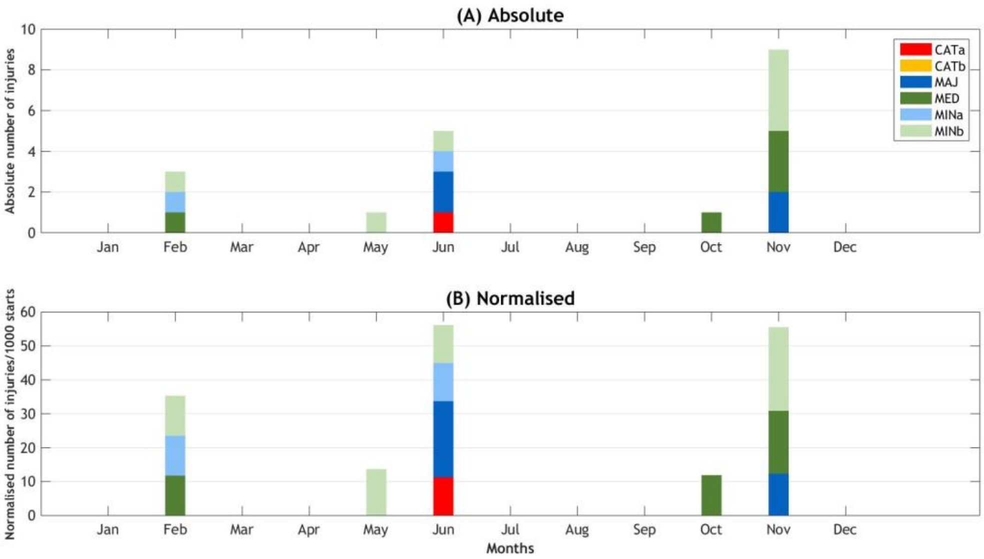

Figure 4.134: Mudgee track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Kempsey

Kempsey- Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.681 Figures 4.135 to 4.138 contain Kempsey Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.682 There were no race events at Kempsey in July, August and September.

4.683 Absolute Level 1 injury rates for Kempsey are shown in Figure 4.135.A.

4.684 May and December has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.685 Normalized Level 1 injury rates for Kempsey are shown in Figure 4.135.B.

4.686 Absolute Level 2 injury rates for Kempsey are shown in Figure 4.136.A.

4.687 May has the highest absolute Level 2 injury rate with 3 injuries.

4.688 Normalized Level 2 injury rates for Kempsey are shown in Figure 4.136.B.

4.689 December has the highest normalized Level 2 injury rate.

4.690 Absolute Level 3 injury rates for Kempsey are shown in Figure 4.137.A.

4.691 May has the highest absolute Level 3 injury with 3 injuries.

4.692 Normalized Level 3 injury rates for Kempsey are shown in Figure 4.137.B.

4.693 December has the highest normalized Level 3 injury rate.

4.694 Absolute Level 4 injury rates for Kempsey are shown in Figure 4.138.A.

4.695 January and May has the highest absolute Level 4 injury rate with 3 injuries.

4.696 Normalized Level 4 injury rates for Kempsey are shown in Figure 4.138.B.

4.697 December has the highest normalized Level 4 injury rate followed by March.

4.698 CATb does not include all the data.

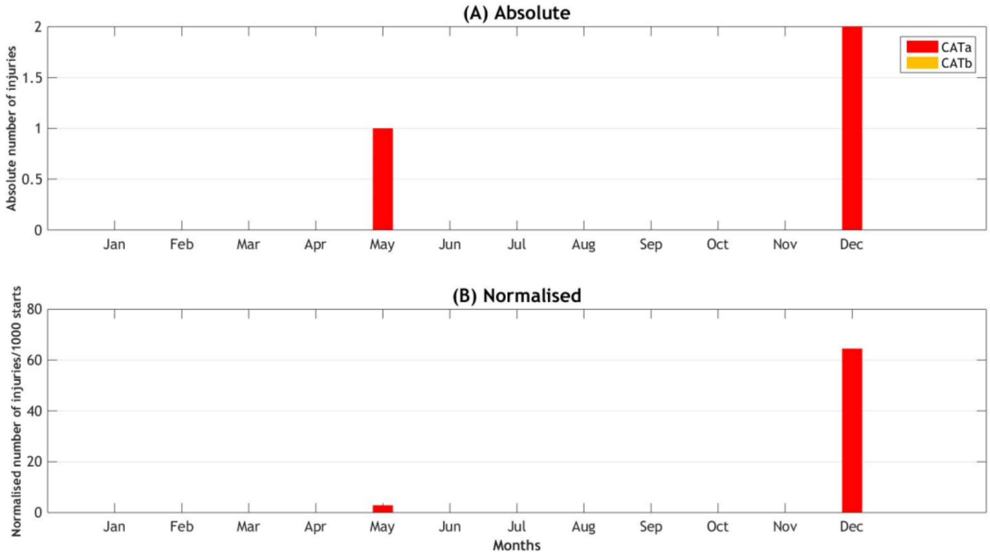

Figure 4.135: Kempsey track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

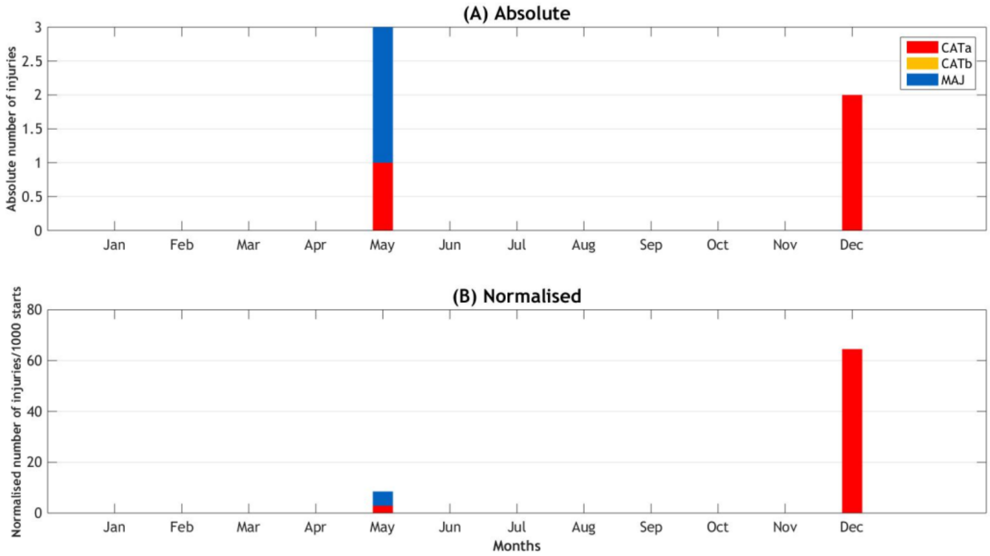

Figure 4.136: Kempsey track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

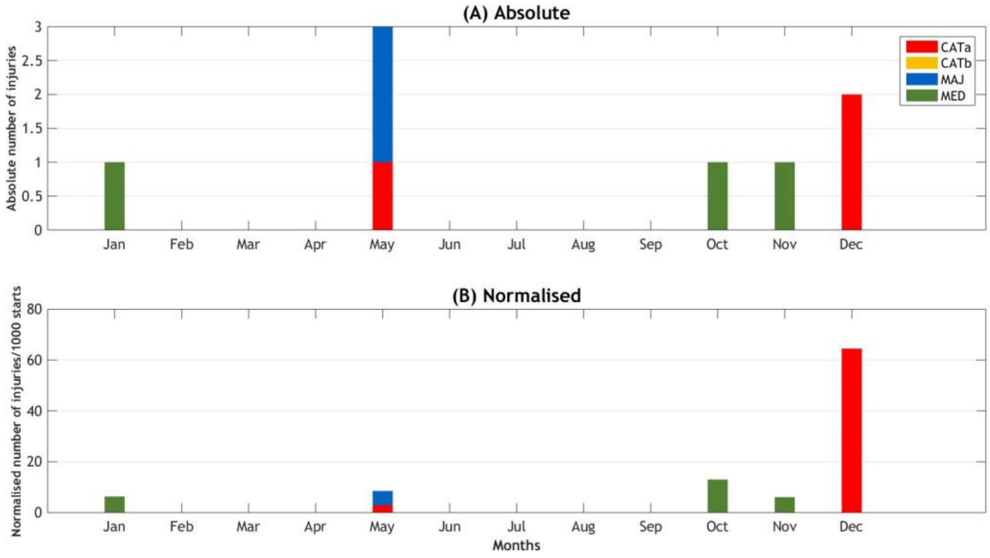

Figure 4.137: Kempsey track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

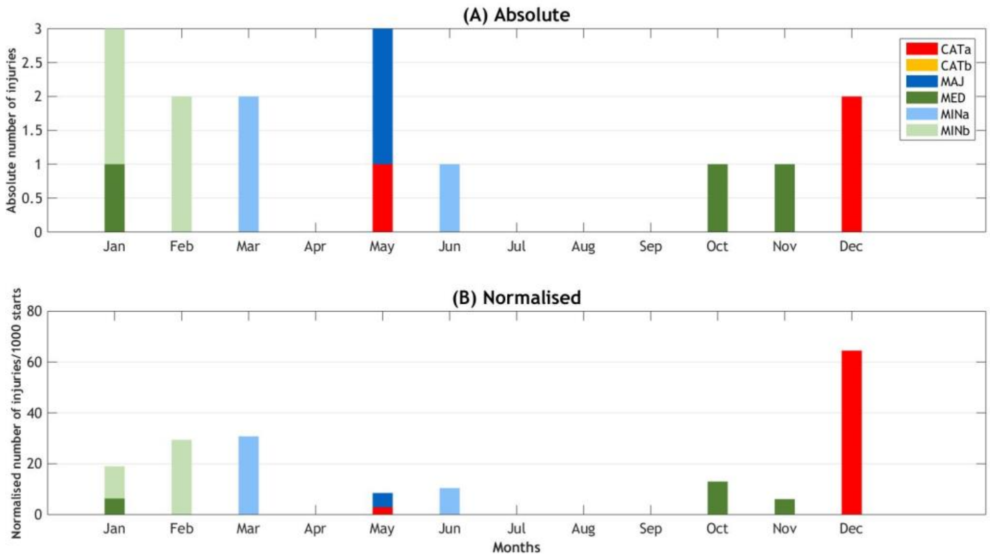

Figure 4.138: Kempsey track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Temora

Temora - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.699 Figures 4.139 to 4.142 contain Temora Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.700 There were no race events at the Temora track in July.

4.701 Absolute Level 1 injury rates for Temora are shown in Figure 4.139.A.

4.702 February has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.703 Normalized Level 1 injury rates for Temora are shown in Figure 4.139.B.

4.704 Absolute Level 2 injury rates for Temora are shown in Figure 4.140.A.

4.705 February, May and August have the highest absolute Level 2 injury rate with 1 injury. All other months have 0 absolute Level 1 injuries.

4.706 February has the highest normalized Level 2 injury rate.

4.707 Normalized Level 2 injury rates for Temora are shown in Figure 4.140.B.

4.708 Absolute Level 3 injury rates for Temora are shown in Figure 4.141.A.

4.709 August and September has the highest absolute Level 3 injury with 2 injuries.

4.710 Normalized Level 3 injury rates for Temora are shown in Figure 4.141.B.

4.711 May has the highest normalized Level 3 injury rate.

4.712 Absolute Level 4 injury rates for Temora are shown in Figure 4.142.A.

4.713 September has the highest absolute Level 4 injury with 8 injuries.

4.714 Normalized Level 4 injury rates for Temora are shown in Figure 4.142.B.

4.715 November has the highest normalized Level 4 injury.

4.716 CATb does not include all the data.

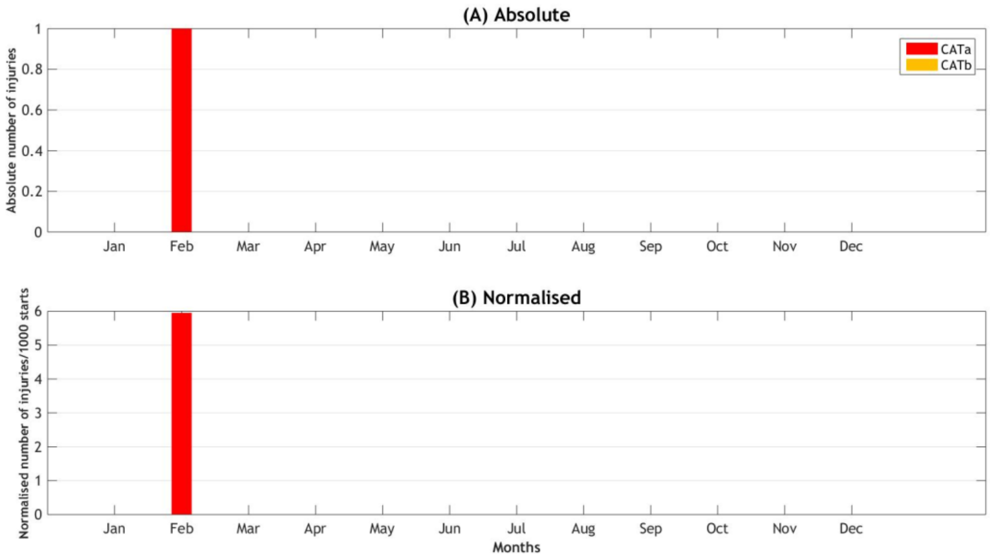

Figure 4.139: Temora track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

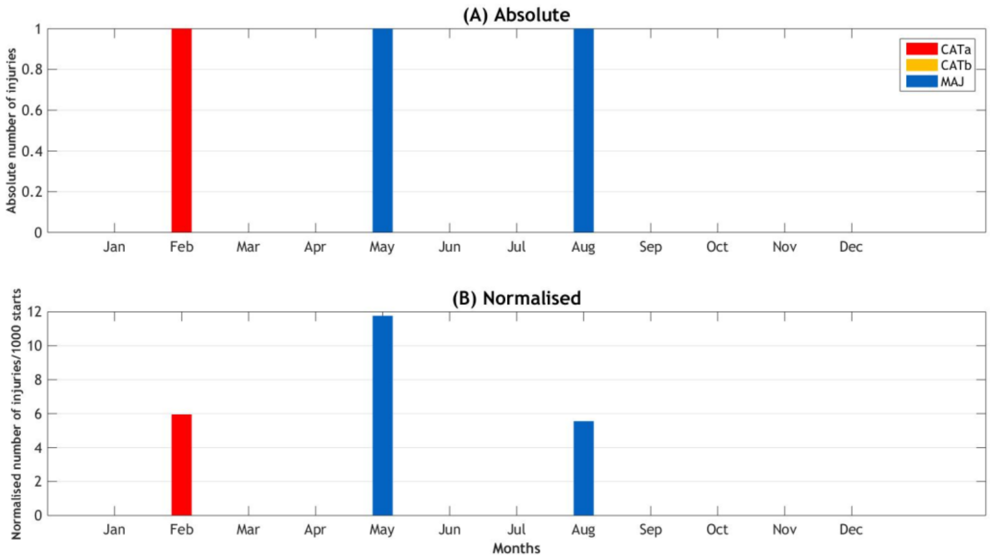

Figure 4.140: Temora track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

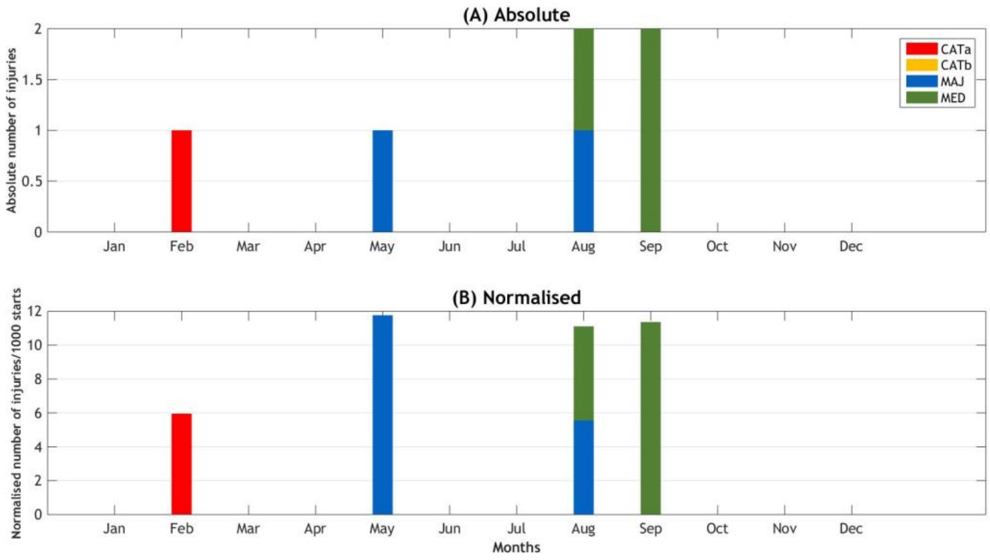

Figure 4.141: Temora track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

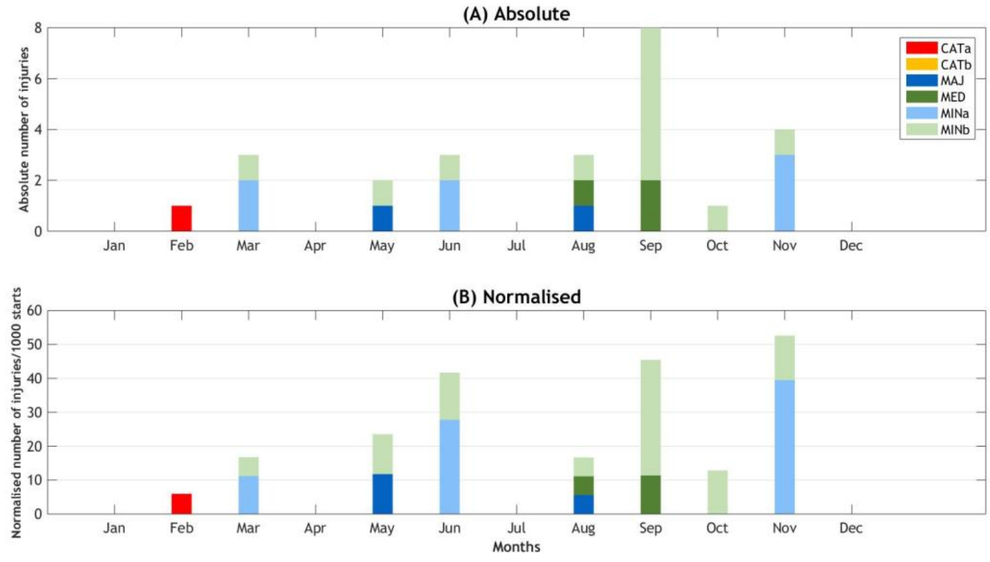

Figure 4.142: Temora track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Moree

Moree - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.717 Figures 4.143 to 4.145 contain Moree Level 1 to Level, Level 2 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.718 There were no race events at Moree in January, July, August and December.

4.719 Absolute Level 1 injury rates for Moree are shown in Figure 4.143.A.

4.720 April and May have the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.721 Normalized Level 1 injury rates for Moree are shown in Figure 4.143.B.

4.722 May has the highest absolute Level 1 injury rate.

4.723 Absolute Level 3 injury rates for Moree are shown in Figure 4.144.A.

4.724 April, May and October have the highest number of absolute Level 1 injuries with 1, 1 and 2 injuries, respectively. All other months have 0 absolute Level 1 injuries.

4.725 Normalized Level 3 injury rates for Moree are shown in Figure 4.144B.

4.726 October has the highest normalized Level 3 injury.

4.727 Absolute Level 4 injury rates for Moree are shown in Figure 4.145.A.

4.728 March and October has the highest absolute Level 4 injury with 2 injuries.

4.729 Normalized Level 4 injury rates for Moree are shown in Figure 4.145.B.

4.730 March has the highest normalized Level 4 injury.

4.731 CATb does not include all the data.

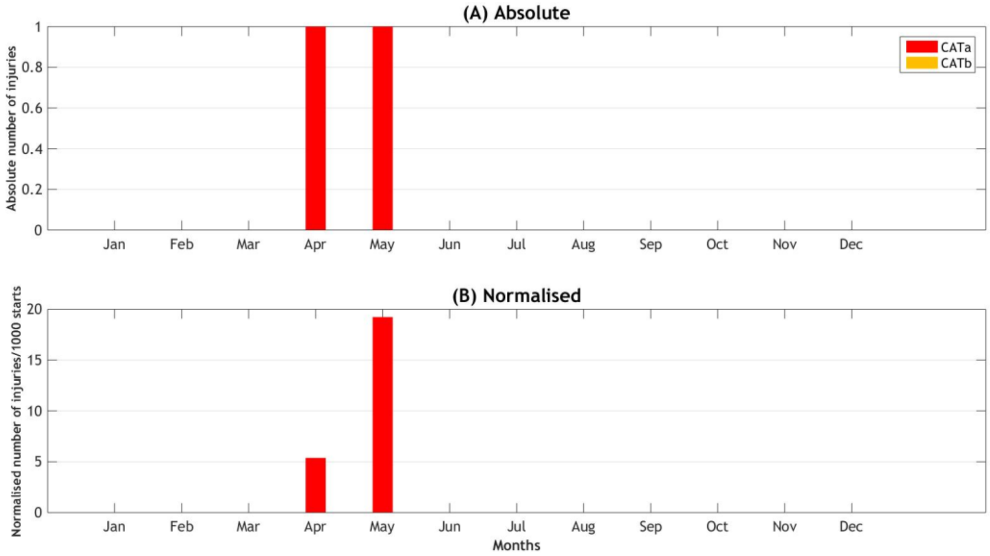

Figure 4.143: Moree track Level 1 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

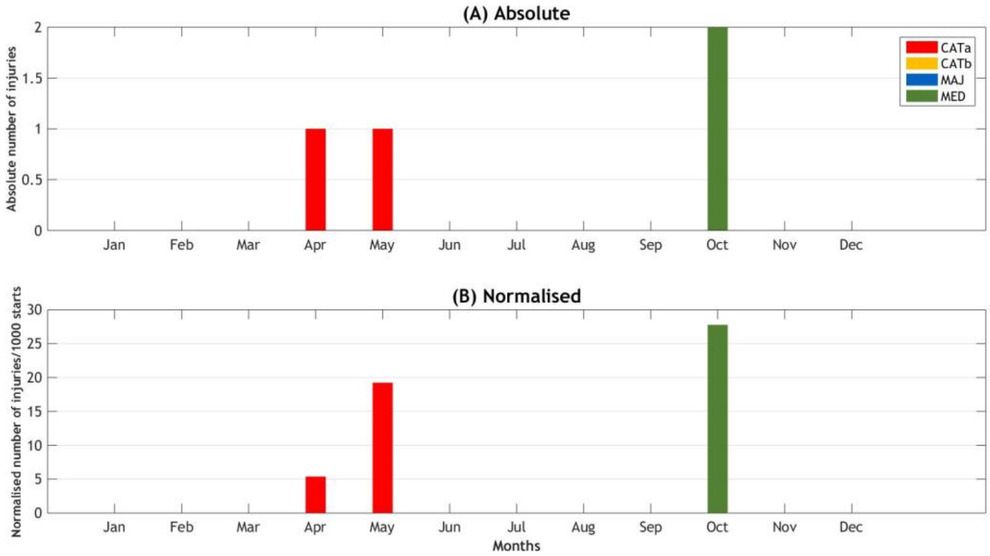

Figure 4.144: Moree track Level 3 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

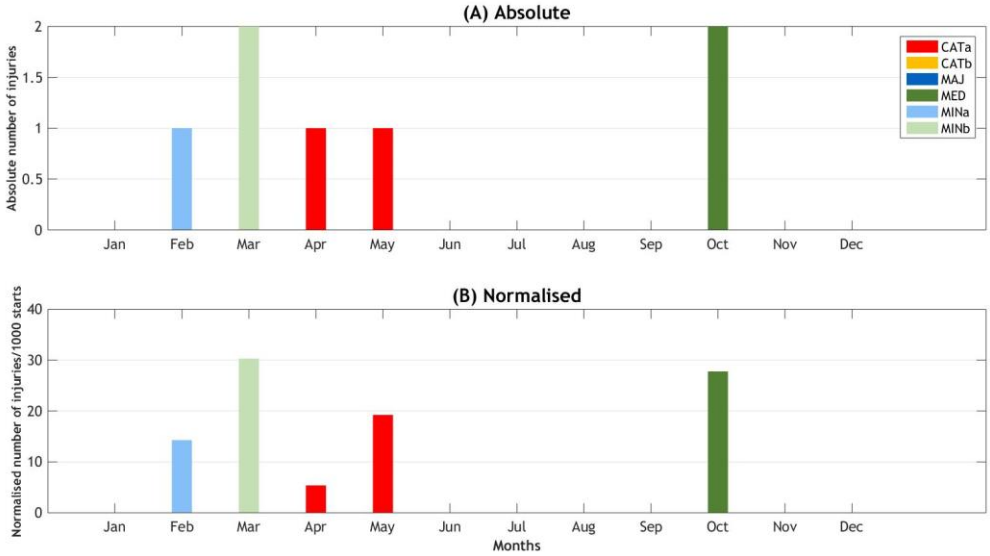

Figure 4.145: Moree track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

MUSWELLBROOK

MUSWELLBROOK - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.732 Figures 4.146 and 4.147 contains Muswellbrook Level 1 and Level 2 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.733 There were no race events at Muswellbrook in January, February, July, August and December.

4.734 Absolute Level 1 injury rates for Muswellbrook are shown in Figure 4.146.A.

4.735 March, May and November have the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.736 Normalized Level 1 injury rates for Muswellbrook are shown in Figure 4.146.B.

4.737 November has the highest absolute Level 1 injury.

4.738 Absolute Level 4 injury rates for Muswellbrook are shown in Figure 4.147.A.

4.739 May has the highest absolute Level 4 injury rate with 3 injuries.

4.740 Normalized Level 4 injury rates for Muswellbrook are shown in Figure 4.147.B.

4.741 October has the highest normalized Level 4 injury.

4.742 CATb does not include all the data.

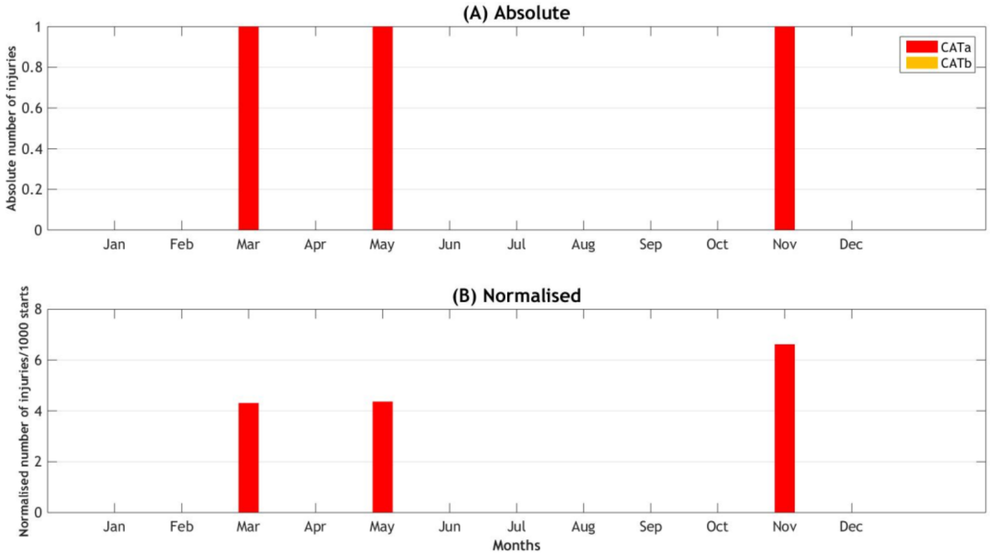

Figure 4.146: Muswellbrook track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

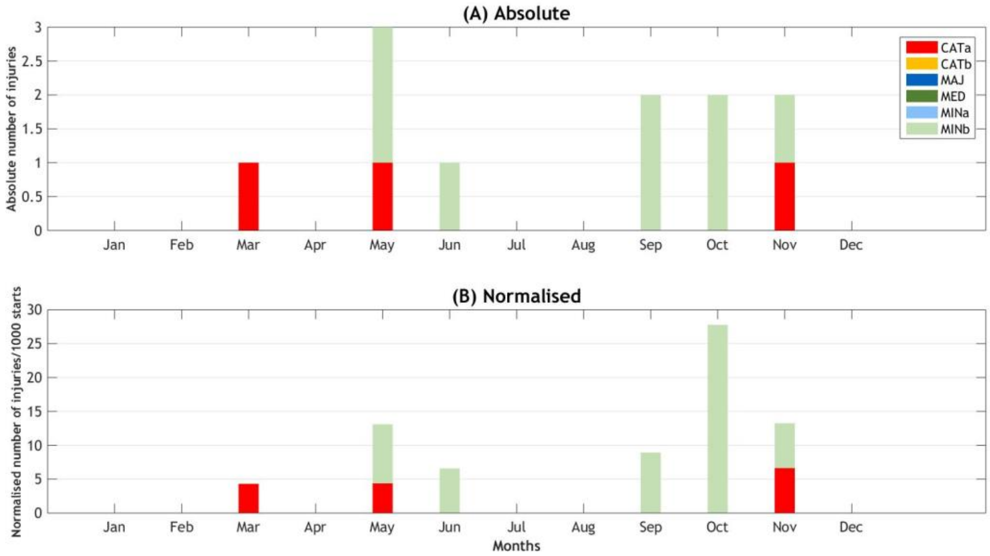

Figure 4.147: Muswellbrook track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

YOUNG

YOUNG - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.743 Figures 4.148 to 4.151 contain Young Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.744 There were no race events at Young in June and July.

4.745 Absolute Level 1 injury rates for Young are shown in Figure 4.148.A.

4.746 August has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.747 Normalized Level 1 injury rates for Young are shown in Figure 4.148.B.

4.748 Absolute Level 2 injury rates for Young are shown in Figure 4.149.A.

4.749 August has the highest absolute Level 2 injury rate with 2 injuries. All other months have 0 absolute Level 1 injuries.

4.750 Normalized Level 2 injury rates for Young are shown in Figure 4.149.B.

4.751 Absolute Level 3 injury rates for Young are shown in Figure 4.150.A.

4.752 November has the highest absolute Level 3 injury with 3 injuries.

4.753 Normalized Level 3 injury rates for Young are shown in Figure 4.150.B.

4.754 November has the highest normalized Level 3 injury.

4.755 Absolute Level 4 injury rates for Young are shown in Figure 4.151.A.

4.756 August has the highest absolute Level 4 injury rate with 4 injuries.

4.757 Normalized Level 4 injury rates for Young are shown in Figure 4.151.B.

4.758 August has the highest normalized Level 4 injury.

4.759 CATb does not include all the data.

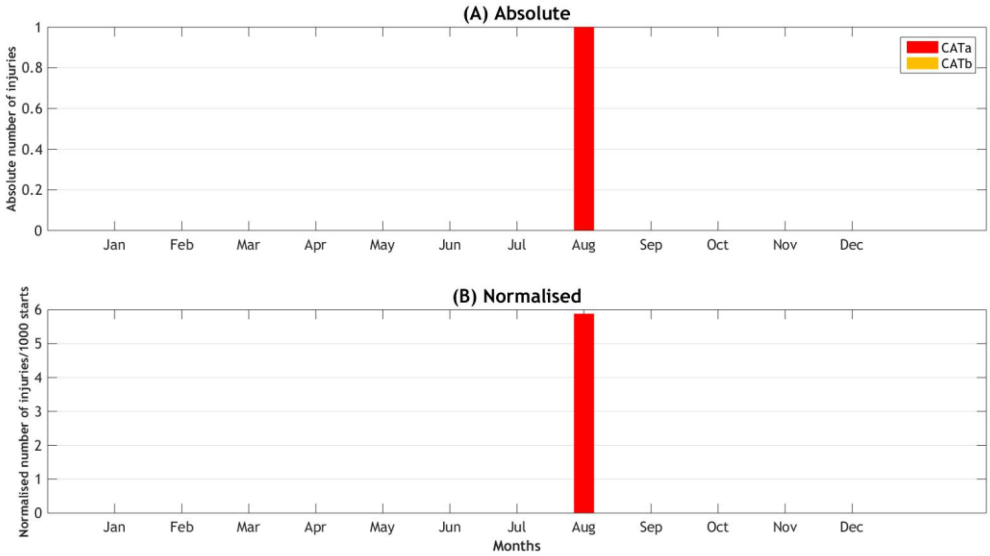

Figure 4.148: Young track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

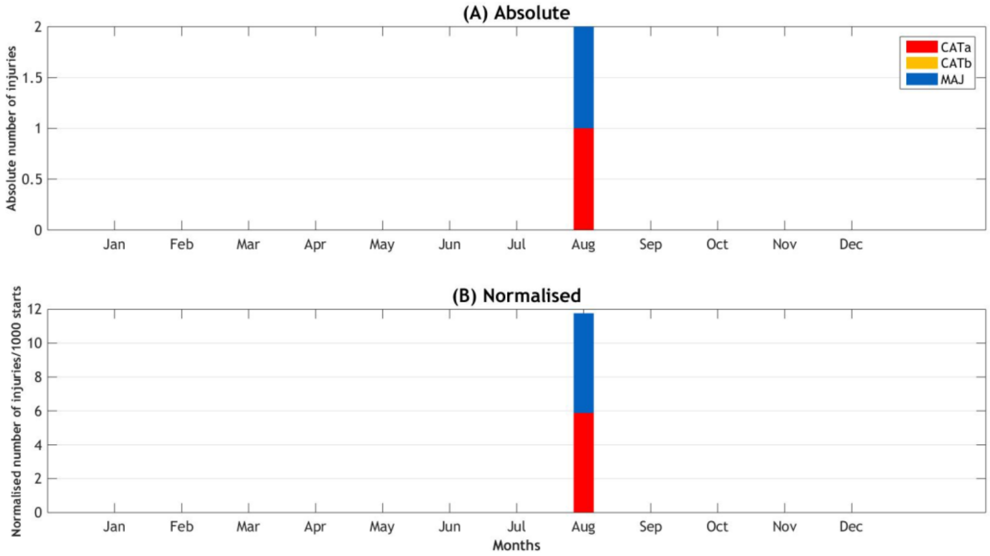

Figure 4.149: Young track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

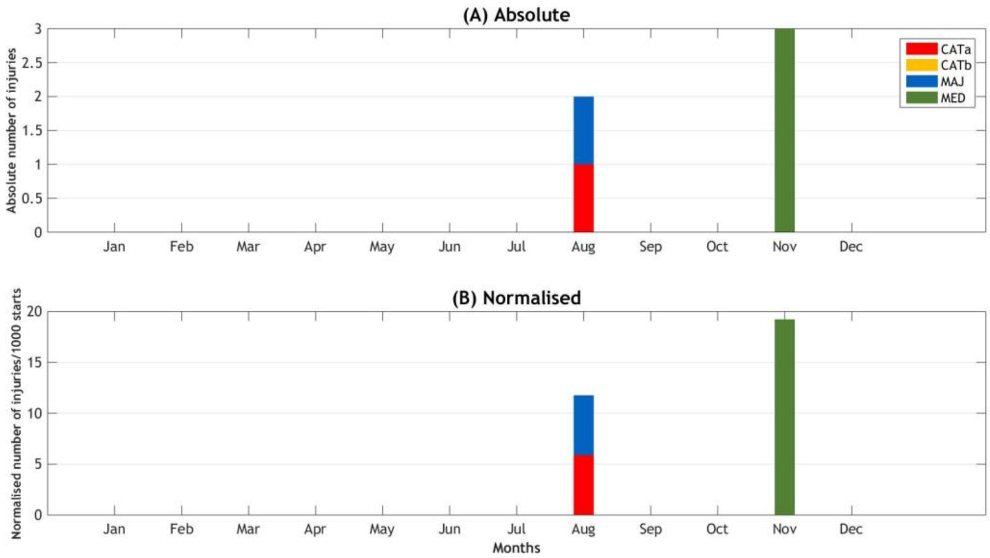

Figure 4.150: Young track Level 3 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

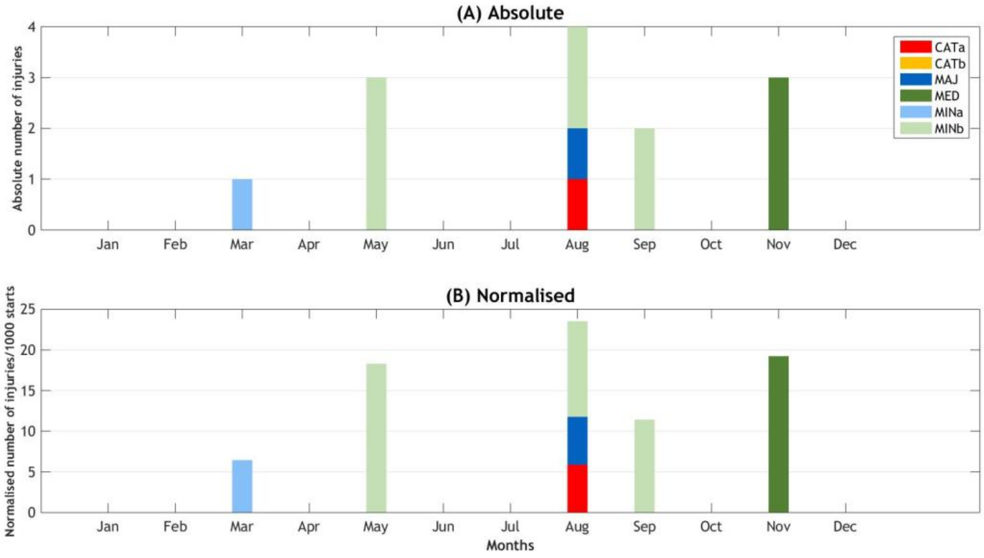

Figure 4.151: Young track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

COWRA

COWRA - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.760 Figures 4.152 to 4.155 contain Cowra Level 1 to Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.761 There were no race events at the Cowra track in February, July, August and September.

4.762 Absolute Level 1 injury rates for Cowra are shown in Figure 4.152.A.

4.763 October has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.764 Normalized Level 1 injury rates for Cowra are shown in Figure 4.152.B.

4.765 Absolute Level 2 injury rates for Cowra are shown in Figure 4.153.A.

4.766 April and October have the highest absolute Level 2 injury rate with 1 injury. All other months have 0 absolute Level 1 injuries.

4.767 Normalized Level 2 injury rates for Cowra are shown in Figure 4.153.B.

4.768 April has the highest normalized Level 2 injury.

4.769 Absolute Level 3 injury rates for Cowra are shown in Figure 4.154.A.

4.770 January, April and October have the highest absolute Level 3 injury with 1 injury.

4.771 Normalized Level 3 injury rates for Cowra are shown in Figure 4.154.B.

4.772 April has the highest normalized Level 3 injury.

4.773 Absolute Level 4 injury rates for Cowra are shown in Figure 4.155.A.

4.774 January has the highest absolute Level 4 injury rate with 3 injuries.

4.775 Normalized Level 4 injury rates for Cowra are shown in Figure 4.155.B.

4.776 January has the highest normalized Level 4 injury.

4.777 CATb does not include all the data.

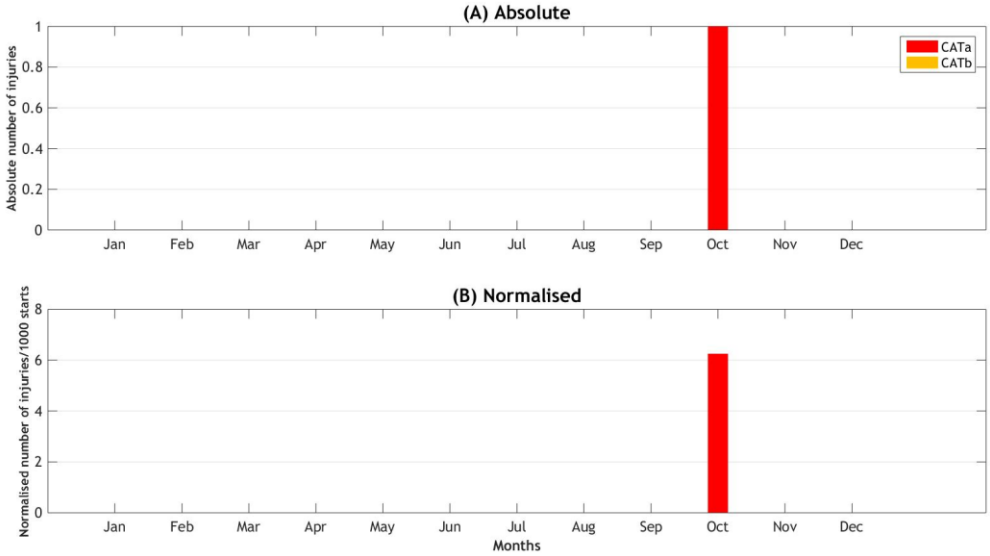

Figure 4.152: Cowra track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

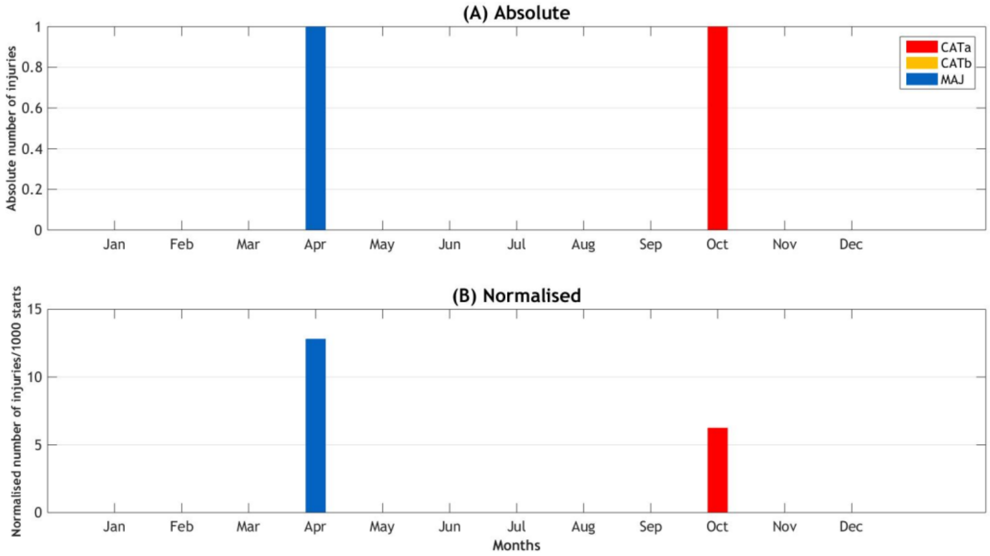

Figure 4.153: Cowra track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

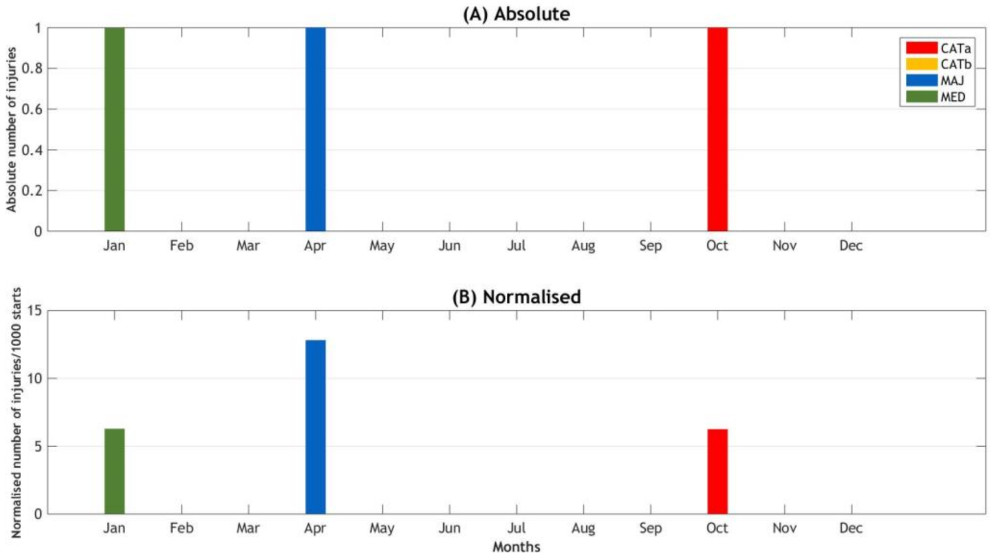

Figure 4.154: Cowra track Level 3 *absolute* (A) and *normalized* (B) injury rates - 1 Jan to 31 Dec 2016.

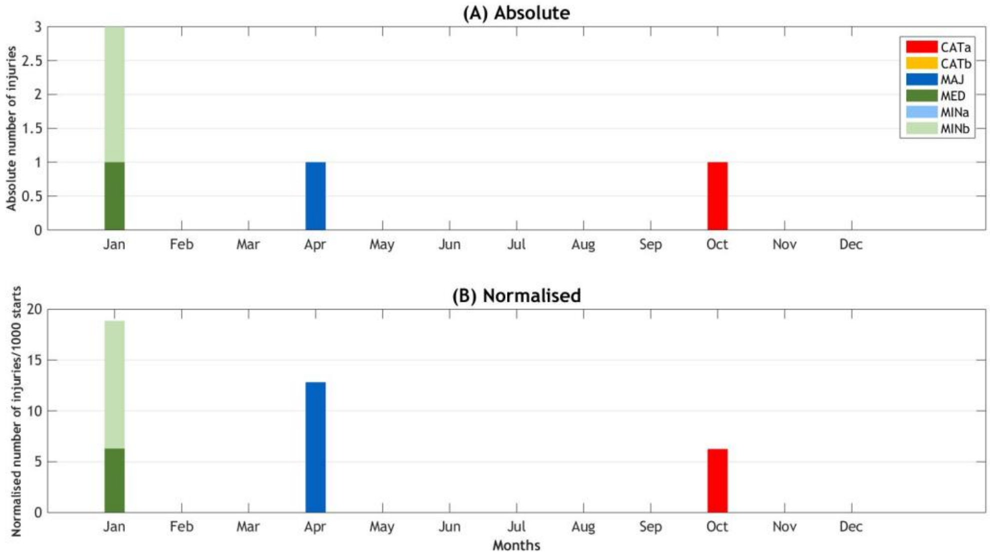

Figure 4.155: Cowra track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

ARMIDALE

ARMIDALE - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.778 Figures 4.156 to 4.158 contain Armidale Level 1, Level 3 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.779 There were no race events at the Armidale track in, July, August, September, October and November.

4.780 Absolute Level 1 injury rates for Armidale are shown in Figure 4.156.A.

4.781 December has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.782 Normalized Level 1 injury rates for Armidale are shown in Figure 4.156.B.

4.783 Absolute Level 3 injury rates for Armidale are shown in Figure 4.157.A.

4.784 June and December have the highest absolute Level 3 injury rate with 1 injury. All other months have 0 absolute Level 3 injuries.

4.785 Normalized Level 3 injury rates for Armidale are shown in Figure 4.157.B.

4.786 December has the highest normalized Level 3 injury.

4.787 Absolute Level 4 injury rates for Armidale are shown in Figure 4.158.A.

4.788 June has the highest absolute Level 4 injury with 2 injuries.

4.789 Normalized Level 4 injury rates for Armidale are shown in Figure 4.158.B.

4.790 December has the highest normalized Level 4 injury.

4.791 CATb does not include all the data.

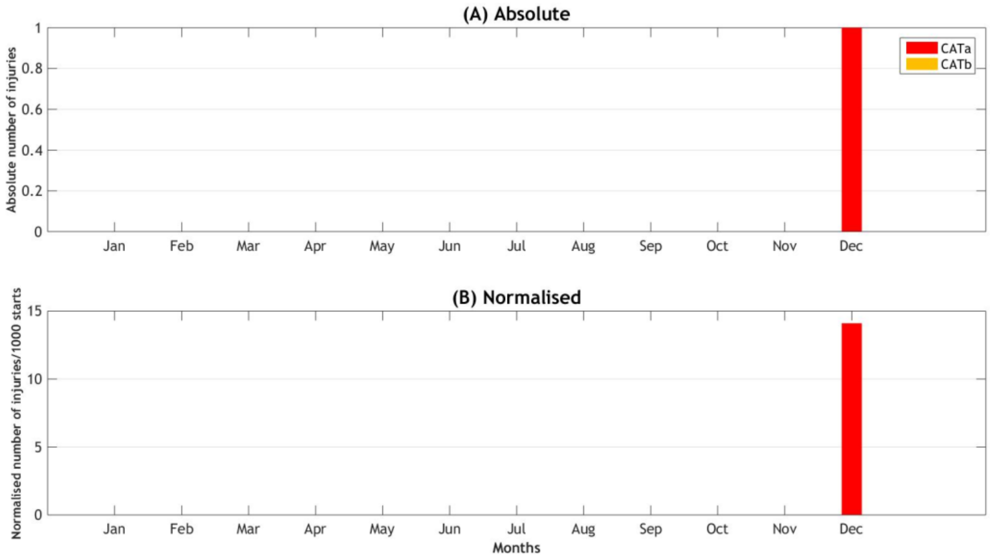

Figure 4.156: Armidale track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

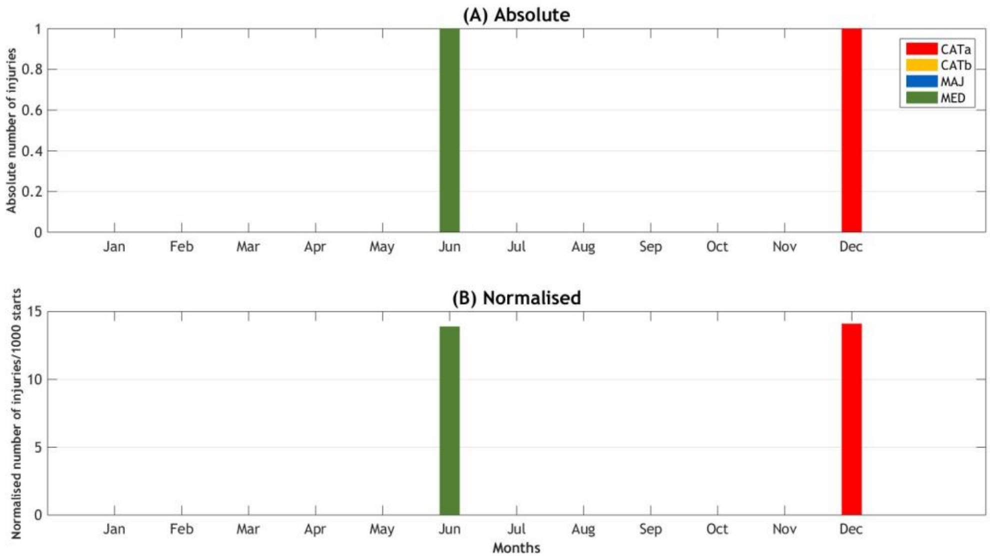

Figure 4.157: Armidale track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

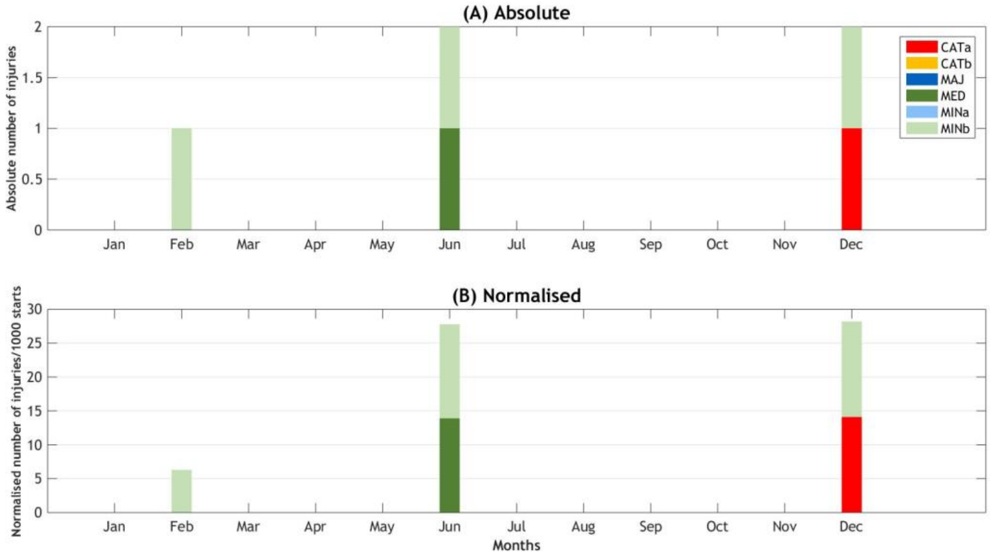

Figure 4.158: Armidale track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

Broken Hill

Broken Hill - Absolute and normalised injury rates - 1 Jan to 31 Dec 2016

4.792 Figures 4.159 to 4.160 contain Broken Hill Level 1 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.793 There were no race events at the Broken Hill track in January, February, July and August.

4.794 Absolute Level 1 injury rates for Broken Hill are shown in Figure 4.159.A.

4.795 December has the highest number of absolute Level 1 injuries with 2 injuries.

4.796 Normalized Level 1 injury rates for Broken Hill are shown in Figure 4.159.B.

4.797 Absolute Level 4 injury rates for Broken Hill are shown in Figure 4.160.A.

4.798 April, September and December have the highest absolute Level 4 injury with 2 injuries.

4.799 Normalized Level 4 injury rates for Broken Hill are shown in Figure 4.160.B.

4.800 September has the highest normalized Level 4 injury.

4.801 CATb does not include all the data.

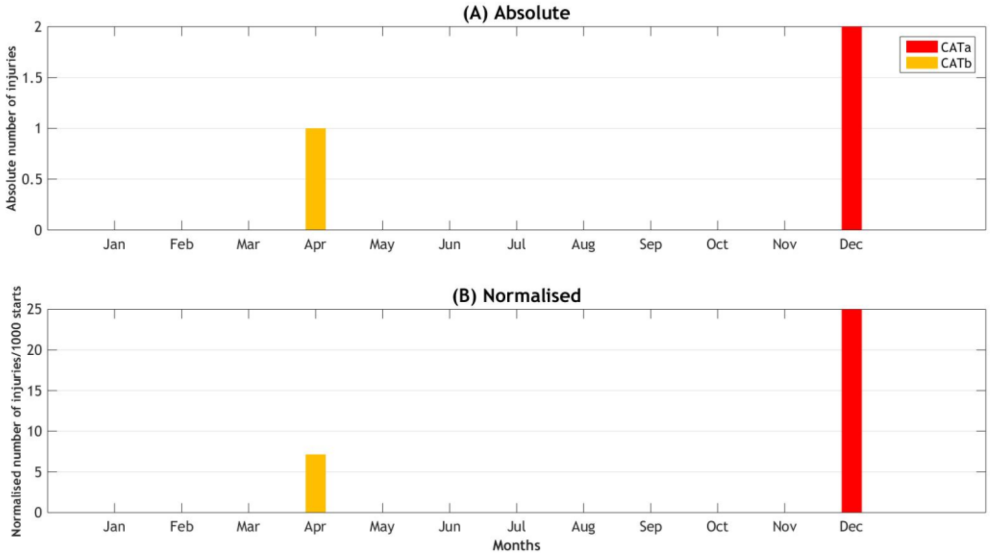

Figure 4.159: Broken Hill track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

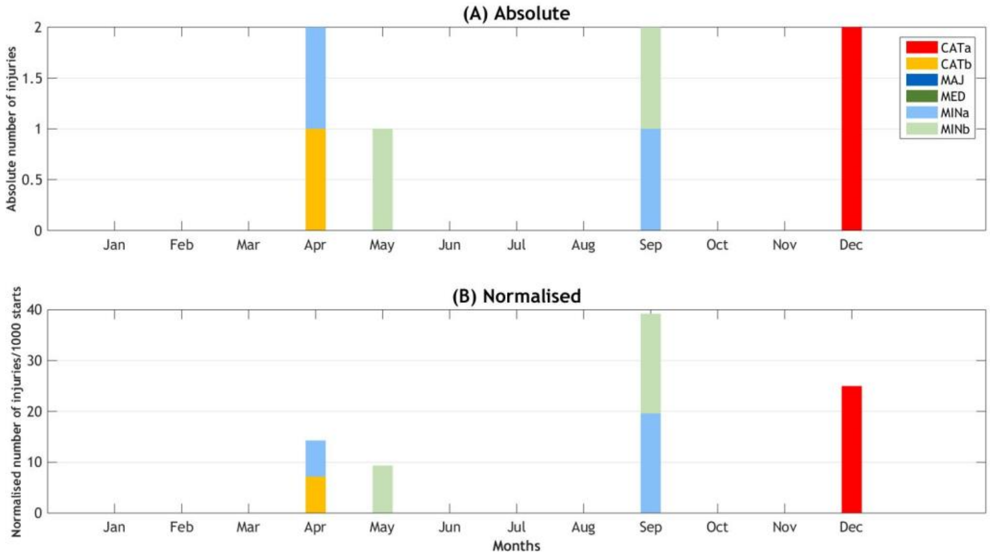

Figure 4.160: Broken Hill track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

WAUCHOPE

WAUCHOPE - ABSOLUTE AND NORMALISED INJURY RATES - 1 JAN TO 31 DEC 2016

4.802 Figures 4.161 to 4.163 contain Wauchope Level 1, Level 3 and Level 4 injury data for each month in the period 1 Jan to 31 Dec 2016, respectively.

4.803 There were no race events at Wauchope in July.

4.804 Absolute Level 1 injury rates for Wauchope are shown in Figure 4.161.A.

4.805 December has the highest number of absolute Level 1 injuries with 1 injury. All other months have 0 absolute Level 1 injuries.

4.806 Normalized Level 1 injury rates for Wauchope are shown in Figure 4.161.B.

4.807 Absolute Level 2 injury rates for Wauchope are is shown in Figure 4.162.A.

4.808 Normalized Level 3 injury rates for Wauchope are shown in Figure 4.162.B.

4.809 Absolute Level 3 injury rates for Wauchope are is shown in Figure 4.163.A.

4.810 Normalized Level 3 injury rates for Wauchope are shown in Figure 4.163.B.

4.811 Absolute Level 4 injury rates for Wauchope are shown in Figure 4.164.A.

4.812 August has the highest absolute Level 4 injury with 3 injuries.

4.813 Normalized Level 4 injury rates for Wauchope are shown in Figure 4.164.B.

4.814 September has the highest normalized Level 4 injury.

4.815 CATb does not include all the data.

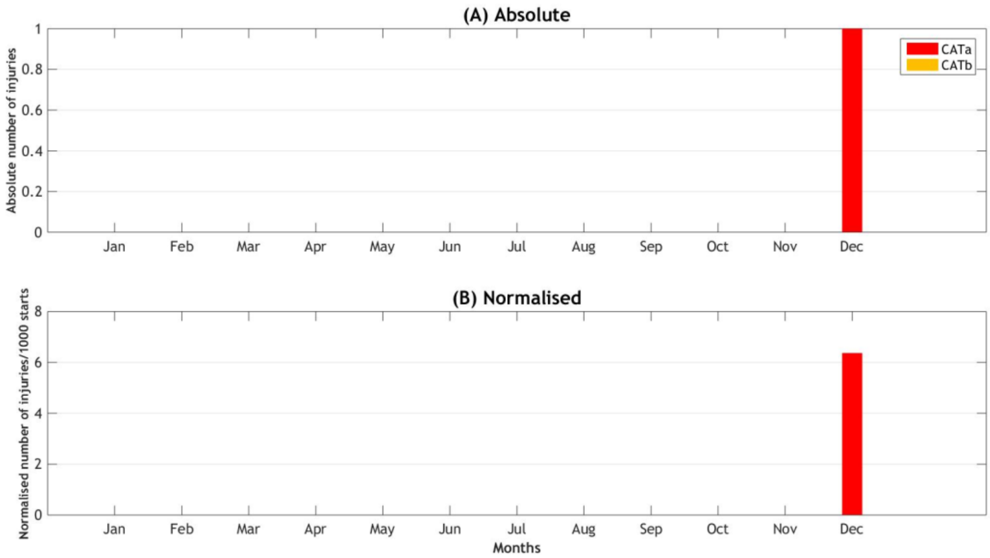

Figure 4.161: Wauchope track Level 1 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

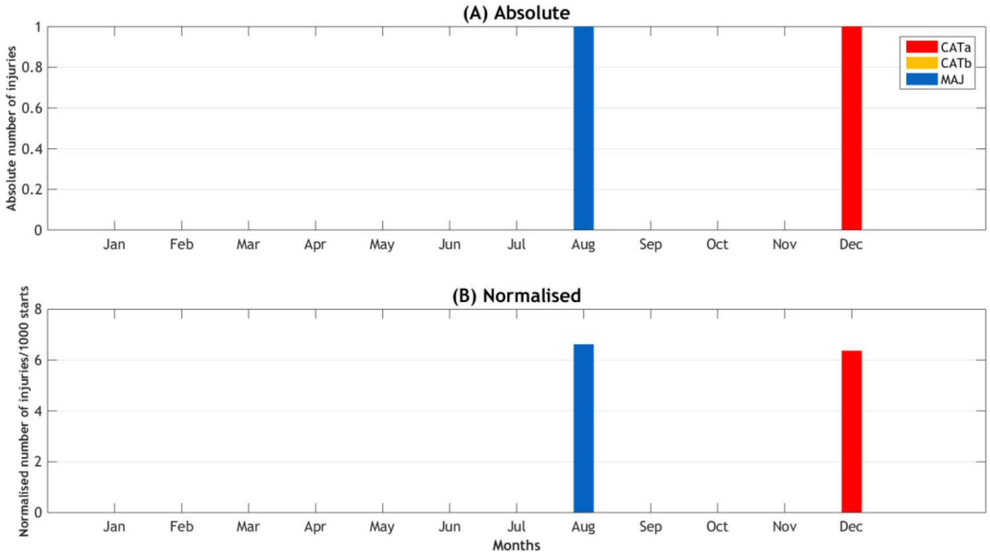

Figure 4.162: Wauchope track Level 2 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

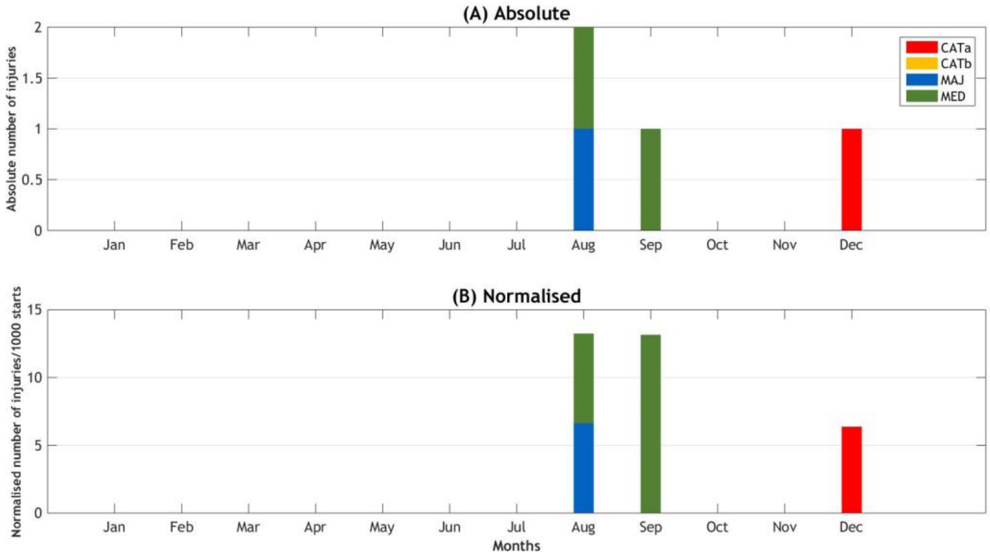

Figure 4.163: Wauchope track Level 3 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

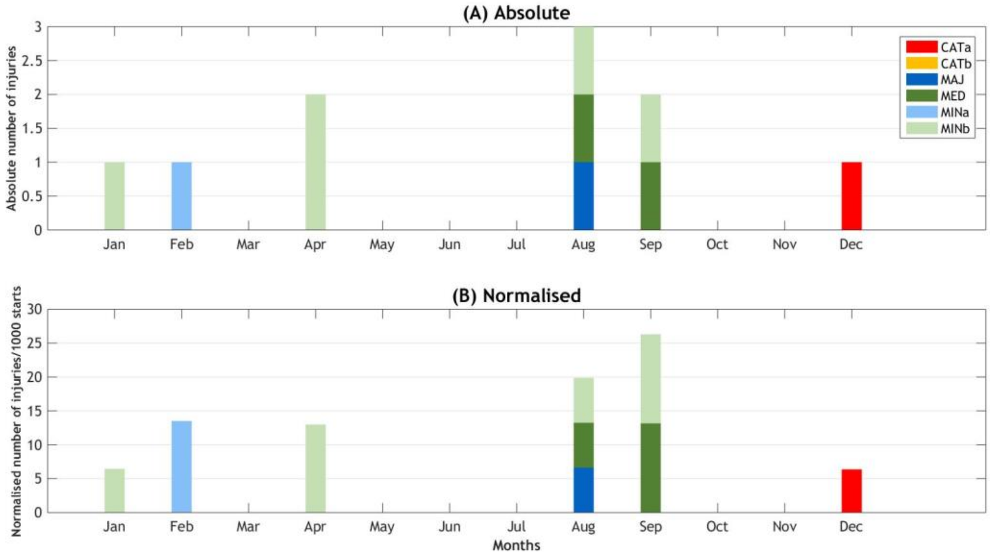

Figure 4.164: Wauchope track Level 4 *absolute* (A) and *normalized* (B) injury rates – 1 Jan to 31 Dec 2016.

5.0 TRACK MODELING AND SIMULATION

INTRODUCTION

5.1 This chapter outlines major findings of computer simulation and modeling of greyhound racing during the year 2016. The chapter will also briefly state the goals which were set for the simulation and modeling, the progress in relation to the defined goals, significant achievements in regards to the goals, the obstacles and the issues faced during task completion, future project expectations and work plans based on newly identified tasks and problems.

5.2 Computer simulation and modeling should be considered because it is a tool that allows efficient and cost-effective generation of evidence to justify major changes to track design.

SIMULATION AND MODELING AIMS

5.3 The primary goals of the greyhound racing simulation and modeling are to identify and analyse major variables which define individual greyhound's motion in racing, rule out racing conditions which have minor impacts on greyhound's motion and eventually derive optimum greyhound environment conditions which favor safer racing.

SIMULATION AND MODELING PROGRESS

IDENTIFICATION OF MAJOR VARIABLES DEFINING GREYHOUND MOTION

5.4 Observation has confirmed that the greyhounds' line of sight to the lure (Figure 5.1) is a major guiding influence for their motion on the track. This influence is primarily responsible for the paths they would ideally follow around the tracks in the absence of other influences such as congestion. The line of sight influence is verifiable from various on-site greyhound running videos. For example, the videos at the following links show that instead of keeping going straight before approaching the bend, the greyhounds follow a path which is defined by lure line of sight[2]:

https://cloudstor.aarnet.edu.au/plus/index.php/s/gDMs0XuIr8a7YQJ
https://cloudstor.aarnet.edu.au/plus/index.php/s/8XwW1jdPDNPpcXE

5.5 Furthermore, the lure line of sight path approximates a quadratic curve. As a result, lateral dynamics of greyhound motion can be solved using quadratic equations.

5.6 The hypothesis is that greyhounds barely plan their route ahead along a track, but rather they spontaneously use their senses which includes following the lure by line of sight.

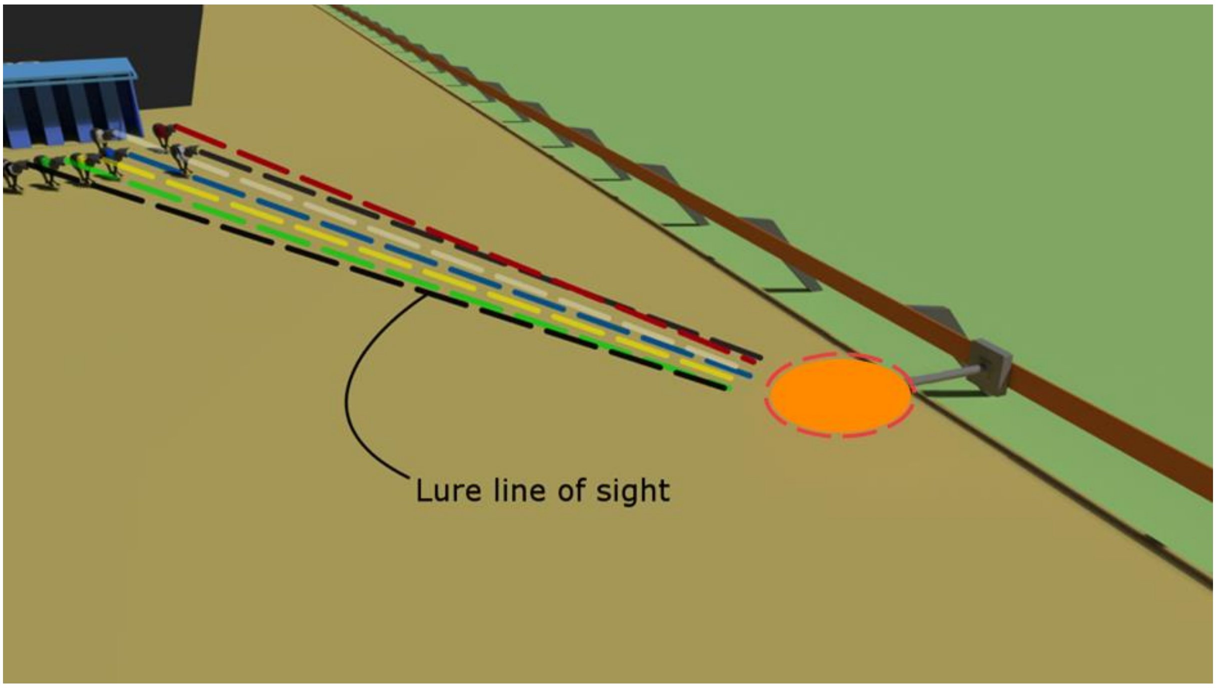

Figure 5.1: Greyhounds following the lure by line of sight.

5.7 Figure 5.2 shows paw prints of a greyhound as obtained from Wentworth Park greyhound track.

[2] All the UTS simulations are unique as a random number generator seeds them.

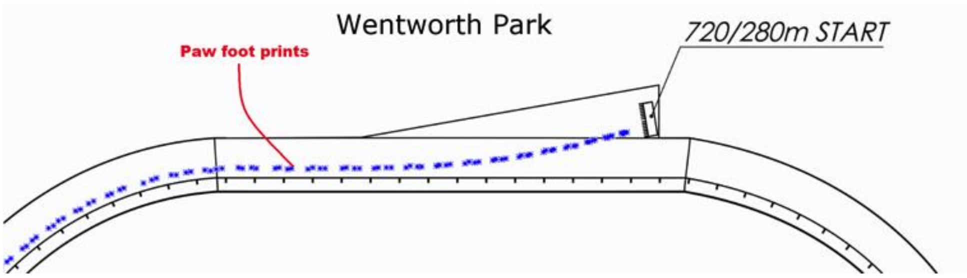

Figure: 5.2: Wentworth Park example of surveyed greyhound paw prints plan view.

5.8 Figure 5.3 shows the simulated path of a single greyhound on the GRSA Murray Bridge greyhound track (proposed new track) while following lure line of sight as produced by the computer simulation.

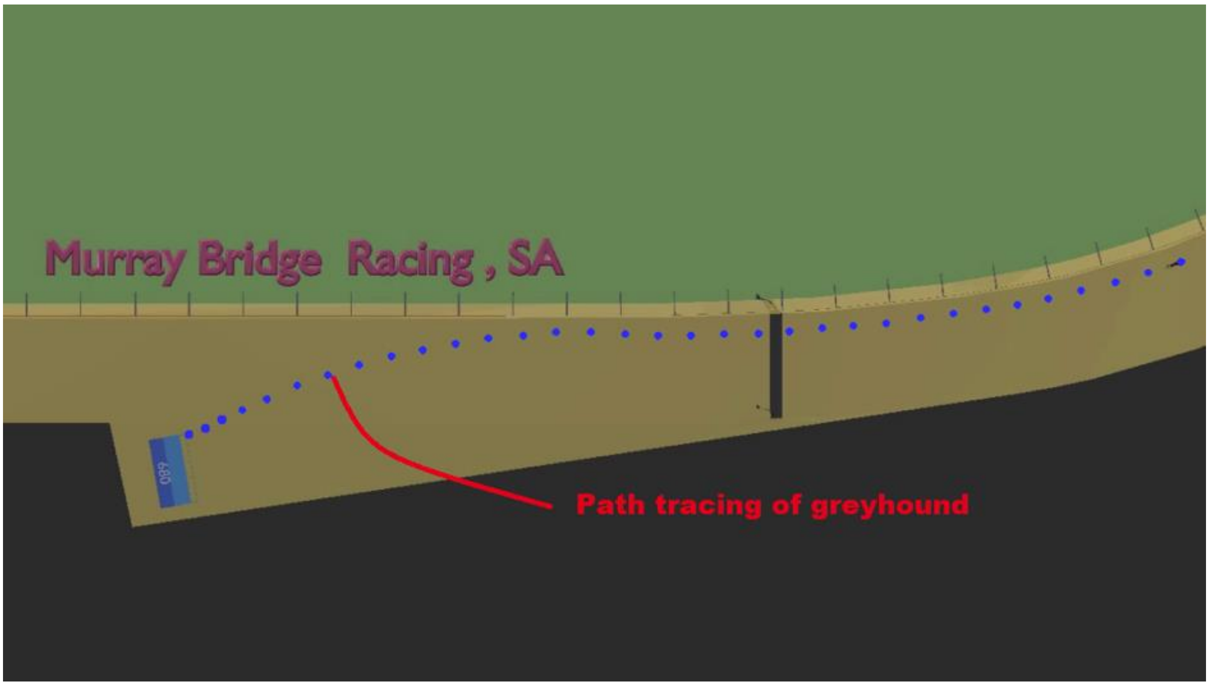

Figure 5.3: Murray Bridge track, a simulation of the path of greyhound following a lure by line of sight.

5.9 The following video shows the path of a single greyhound on the proposed GRSA Murray Bridge track while following lure by line of sight as produced by the computer simulation:

https://cloudstor.aarnet.edu.au/plus/index.php/s/Fbp3nMSUGLSWwLw

5.10 It is also verifiable through simulation and real data that the main guiding influence of the lure by line of sight is manipulated as a result of variable greyhound heading clearance, variable acceleration of individual greyhounds and variable orientation of racing surfaces, which results in variable racing motion outcomes. For example, the following video shows the white greyhound being displaced from its original path by the green greyhound immediately behind because of the green greyhound's lack of heading space clearance:

https://cloudstor.aarnet.edu.au/plus/index.php/s/eFfcNiIl4Wu2kFo

5.11 A similar situation is observable in the following computer simulation in which the black greyhound is displaced by the green greyhound:

https://cloudstor.aarnet.edu.au/plus/index.php/s/pT3OqLI0bWBlsFj

5.12 The computer modeling of tracks reveals how overall shape of a track especially the lure running path influences the lateral dynamics of greyhounds on the track. This occurs because the centrifugal force and acceleration which are experienced by every racing greyhound are directly proportional to the curvatures of greyhounds' running paths. Different tracks have different curvatures and cambers, so the centrifugal forces and accelerations experienced by greyhounds are also diverse[3].

5.13 Changes in curvatures of a greyhound's running path result in equivalent changes in centrifugal forces and accelerations. Rapid changes in the centrifugal force create jerk in racing greyhounds which leads to fatigue failure of racing greyhounds. Gradual changes in the centrifugal force are more predictable and adaptable for greyhounds racing on tracks and statistically will result in fewer injuries.

[3] This assumes that greyhounds follows an ideal path, whereas in reality their path is less than ideal and this less than ideal path adds higher forces and jerks which will further increase the probability of injuries occurring.

5.14 The following video shows that the white greyhound is not aware of or prepared for incoming significant centrifugal force at the bend resulting in it being deviated from its original path:

https://cloudstor.aarnet.edu.au/plus/index.php/s/JpuZ1QlzbLx6FYl

5.15 Figure 5.4 illustrates a hypothetical track shape which has gradual change in the radius of curvature.

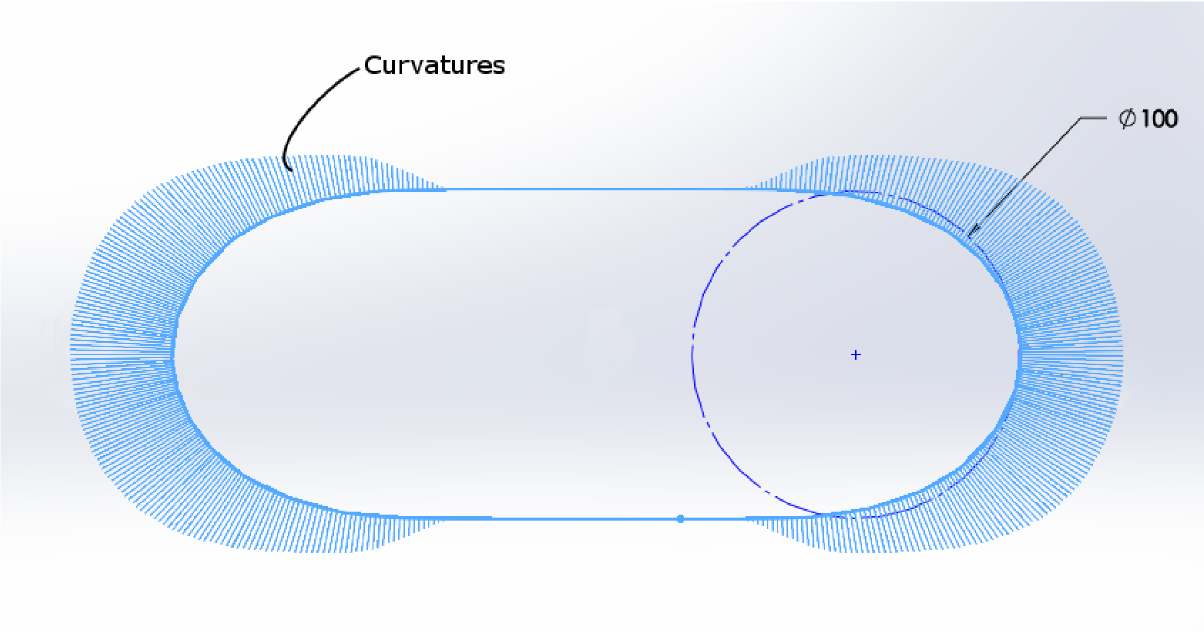

Figure 5.4: Plan view of a hypothetical track with gradual curvatures.

SIMULATION AND MODELING RESULTS FOR THE PROPOSED MURRAY BRIDGE TRACK

5.16 The provided Murray Bridge and Horsham track design files contain track data such as overall track shape, location and orientation of starting boxes, and reduced levels[4] which are essential for precisely generating greyhound motion in computer simulations. The developed computer simulations of greyhound racing approximate greyhounds' final locations on the track in 0.04 second increments based on factors which are derived from the track

[4] The reduced levels (RLs) are extracted from track survey plans and provide information such as the change in camber, the rate of change of the camber, track surface gradients such as the transition from the boxes to the track, and the rate of change of this gradient.

data. Moreover, every computer simulation race is statistically unique since greyhound speed remains variable for the entire race duration.

RACE SIMULATION

5.17 The proposed Murray Bridge track has four starts, namely: 395 m; 455 m; 530 m; and 680 m. For each start a number of computer simulation races was produced. Only races with no significant anomalies such as greyhounds jumping into the rail or failure to race because of catastrophic incidents were kept for investigating greyhound motion. A sample of the computer simulated races for the proposed Murray Bridge track can be viewed from the following link where the configurations and the naming convention for simulated races are shown in Table 5.1, Figures 5.5 and 5.6:

https://cloudstor.aarnet.edu.au/plus/index.php/s/IYGauFGCjj9ApR9

Table 5.1: Murray Bridge track simulation configurations.

Lure initial velocity	72.0 km/h
Lure offset because of delayed box opening along the inside rail (see Figure 5.24)	0 m
Maintained lure and leading greyhound separation distance over the duration of race	5.0 ± 1.8 m
Maximum greyhound speed	72.0 km/h
Minimum greyhound speed	59.4 km/h

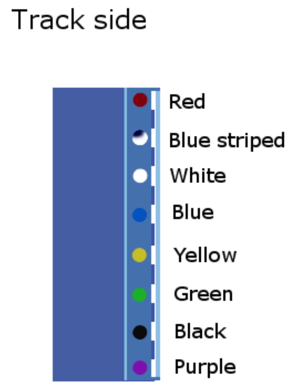

Figure 5.5: Greyhound track positions in starting boxes in simulated races.

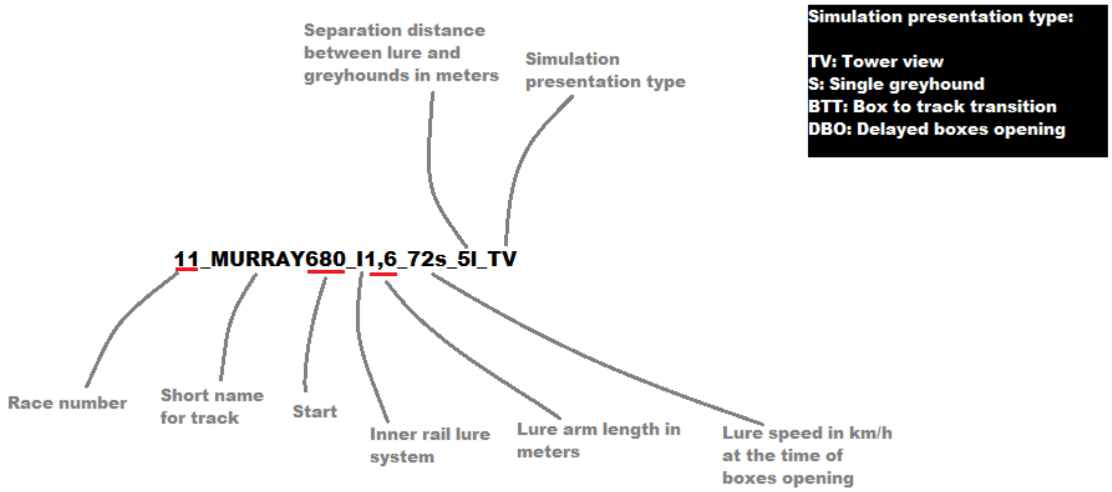

Figure 5.6: Murray Bridge track naming convention for simulated race video files.

ANALYSING SIMULATED RACES

5.18 Since greyhounds come out from starting boxes with different velocities and accelerations, they create different formation patterns.

5.19 From the simulation videos the following major greyhounds formation patterns were observed (see Figures 5.7 to 5.15):

- Twin cluster;
- Large leading pack;

- Large lagging pack;
- Evenly spread;
- Almost a row;
- Cluster in middle;
- Tightly packed;
- Single leading; and
- Single lagging.

5.20 In a simulated race a number of greyhound formations was observed. The formations went through various transformations such as a large leading pack to an even spread and then an even spread to a twin cluster and then finally a twin cluster to a single leading greyhound at the finish line. These formation transformations are triggered at different points on the track especially at various transitions such as straight to bend and bend to straight transitions.

5.21 The nature of the above formations is illustrated in Figures 5.7 to 5.15.

Figure 5.7: Twin cluster.

Figure 5.8: Large leading pack.

Figure 5.9: Large lagging pack.

Figure 5.10: Evenly spread.

Figure 5.11: Almost a row.

Figure 5.12: Cluster in middle.

Figure 5.13: Tightly packed.

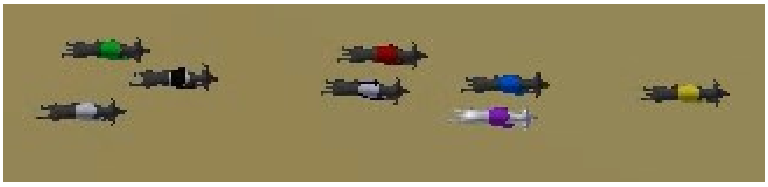

Figure 5.14: Single leading.

Figure 5.15: Single lagging.

5.22 The first formation occurred within seconds while greyhounds made their way from starting boxes to the track, and by this time all greyhounds had reached their respective maximum speeds. Figures 5.16 to 5.23 depict paths of greyhounds while transitioning from starting boxes to the track for the proposed Murray Bridge track.

5.23 For the 680 m start, with current starting box placement which is approximately 8.64 degrees relative to the straight section of the track, the final positions of greyhounds are well off the inner rail (see Figure 5.16). However, there is a deviation of about 17.00 degrees by greyhounds towards the lure running rail.

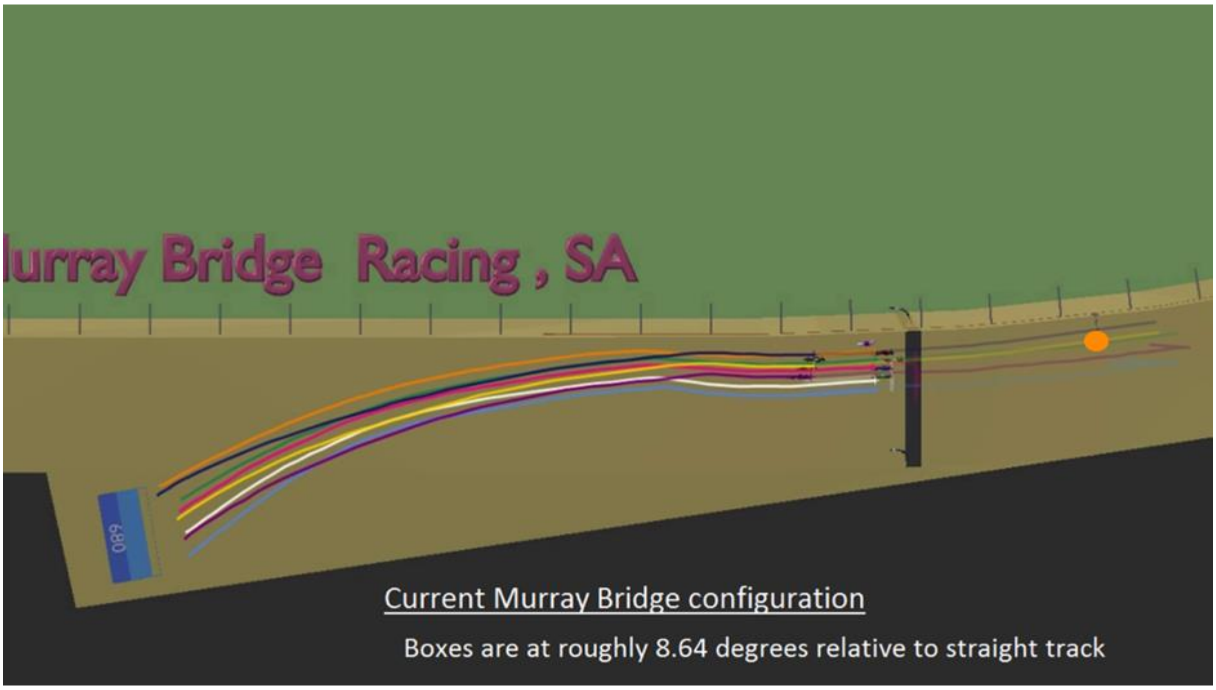

Figure 5.16: Murray Bridge track greyhound paths while transitioning from 680 m boxes to track.

5.24 When the boxes are roughly parallel to the straight part of the track, the final positions of greyhounds were still well off the inner rail (see Figure 5.17). However, the deviation is now increased to about 26.00 degrees by greyhounds towards the lure running rail.

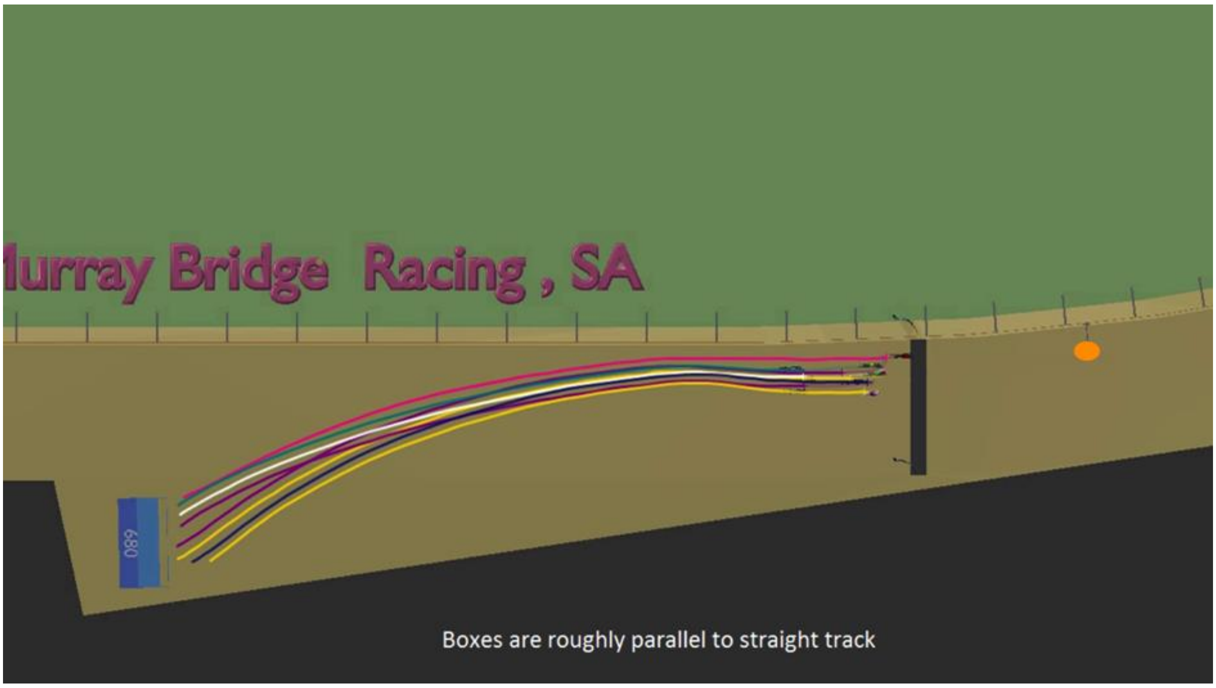

Figure 5.17: Murray Bridge track greyhound paths while transitioning from 680 m boxes to track.

5.25 When boxes are at a steep 26.84 degrees relative to the straight part of the track, greyhounds are almost crashing into the inner rail (Figure 5.18). Furthermore, the deviation is of about 22.00 degrees by greyhounds towards the lure running rail.

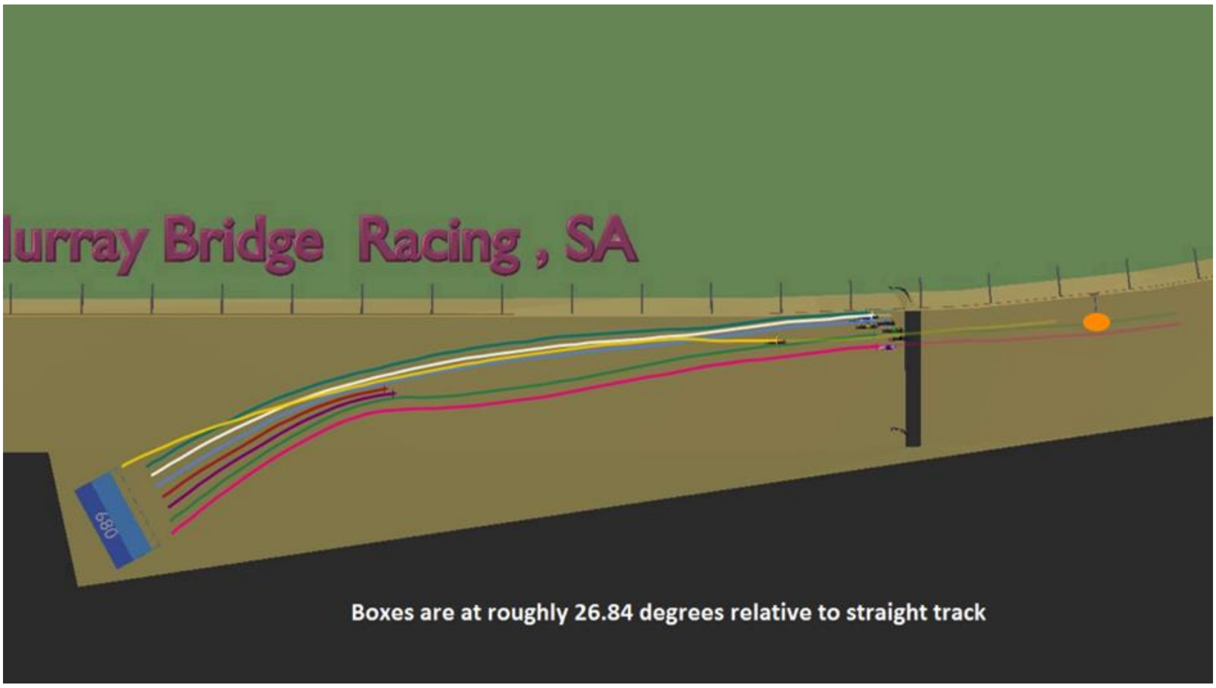

Figure 5.18: Murray Bridge track greyhound paths while transitioning from 680 m boxes to track.

5.26 For the 530 m start, with current starting box placement, the paths of greyhounds are relatively straight and the final positions of greyhounds are well off the inner rail (see Figure 5.19).

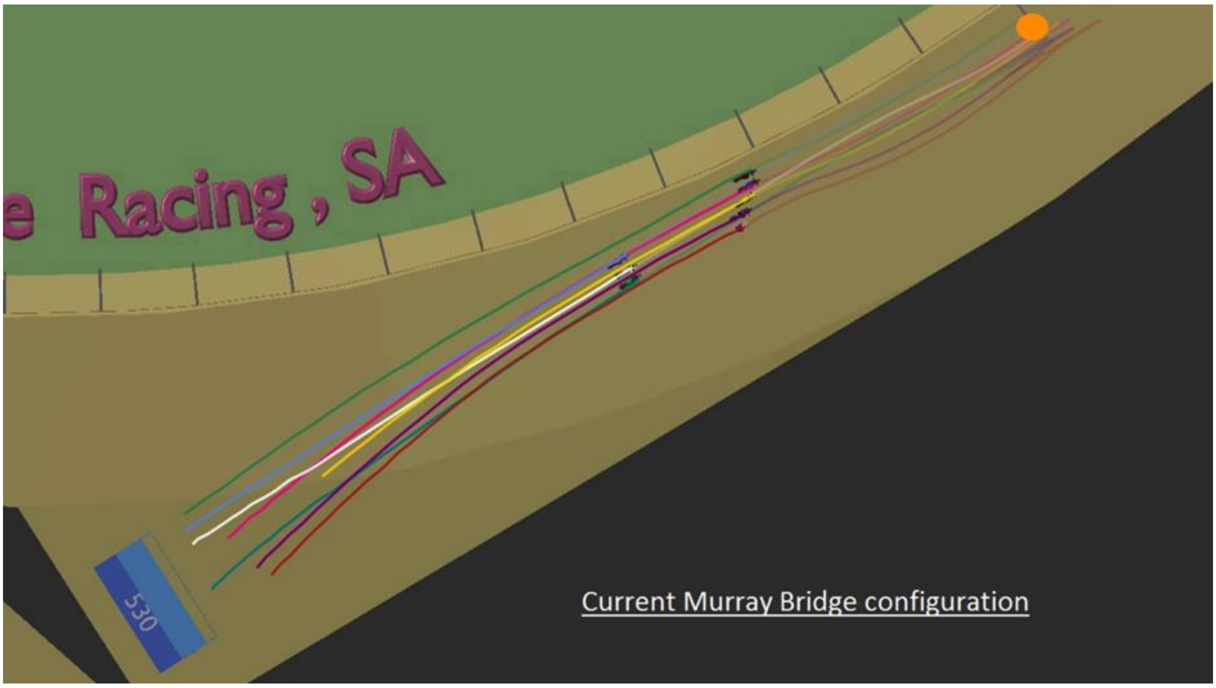

Figure 5.19: Murray Bridge track greyhound paths while transitioning from 530 m boxes to track.

5.27 For the 455 m start, with current starting box placement which is roughly parallel to the straight part of the track, the final positions of greyhounds are similar to that of the 680 m start (see Figure 5.20). However, there is a lesser deviation of about 15.00 degrees by greyhounds towards the lure running rail.

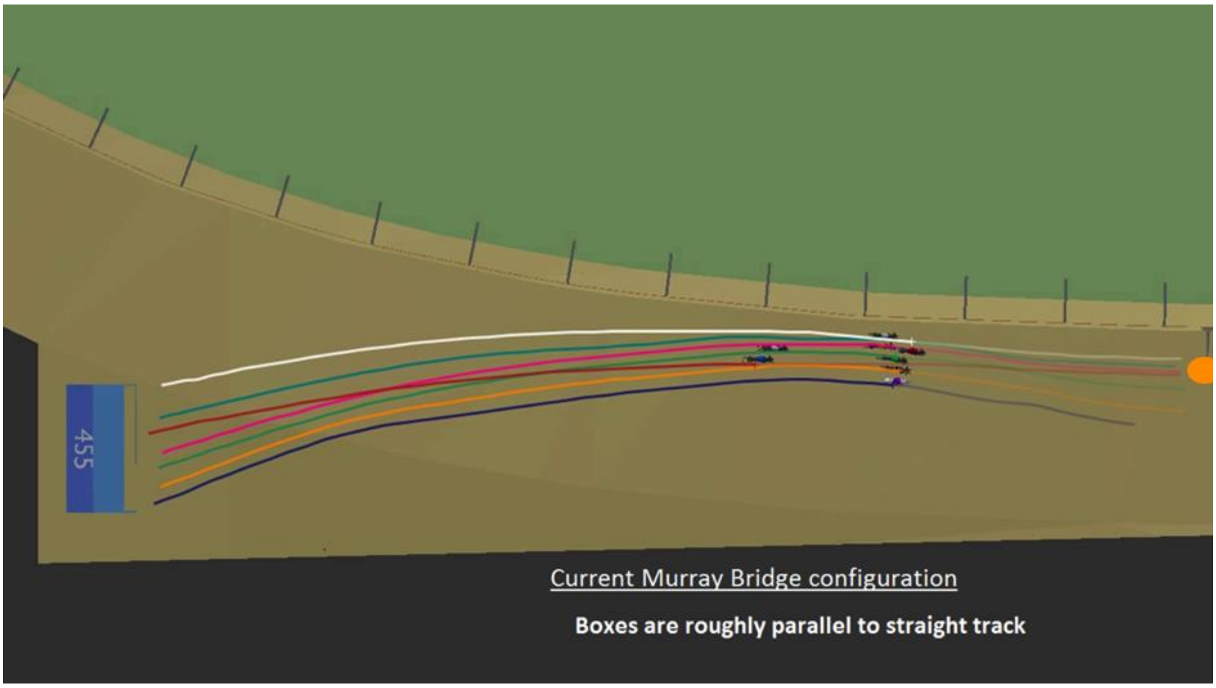

Figure 5.20: Murray Bridge track greyhounds paths while transitioning from 455 m boxes to the track.

5.28 When boxes are at roughly 11.63 degrees relative to the straight part of the track, the final positions of greyhounds are still similar to that of the 680 m start (see Figure 5.21). However, there is a significantly lesser deviation of about 11.00 degrees by greyhounds towards the lure running rail.

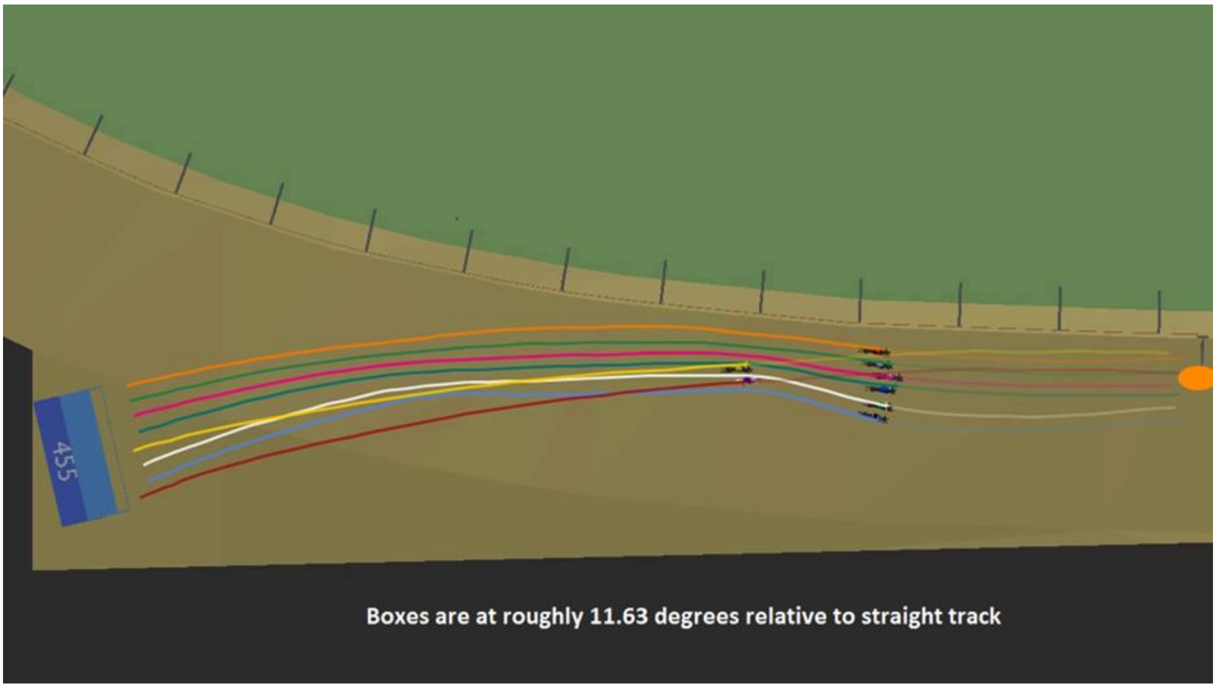

Figure 5.21: Murray Bridge track greyhound paths while transitioning from 455 m boxes to the track.

5.29 For the 395 m start, with current starting box placement which is roughly at 6.80 degrees relative to the straight part of the track, the final positions of greyhounds are still similar to that of the 680 m start (see Figure 5.22). However, there is a significantly sharper deviation of about 21.00 degrees by greyhounds towards the lure running rail.

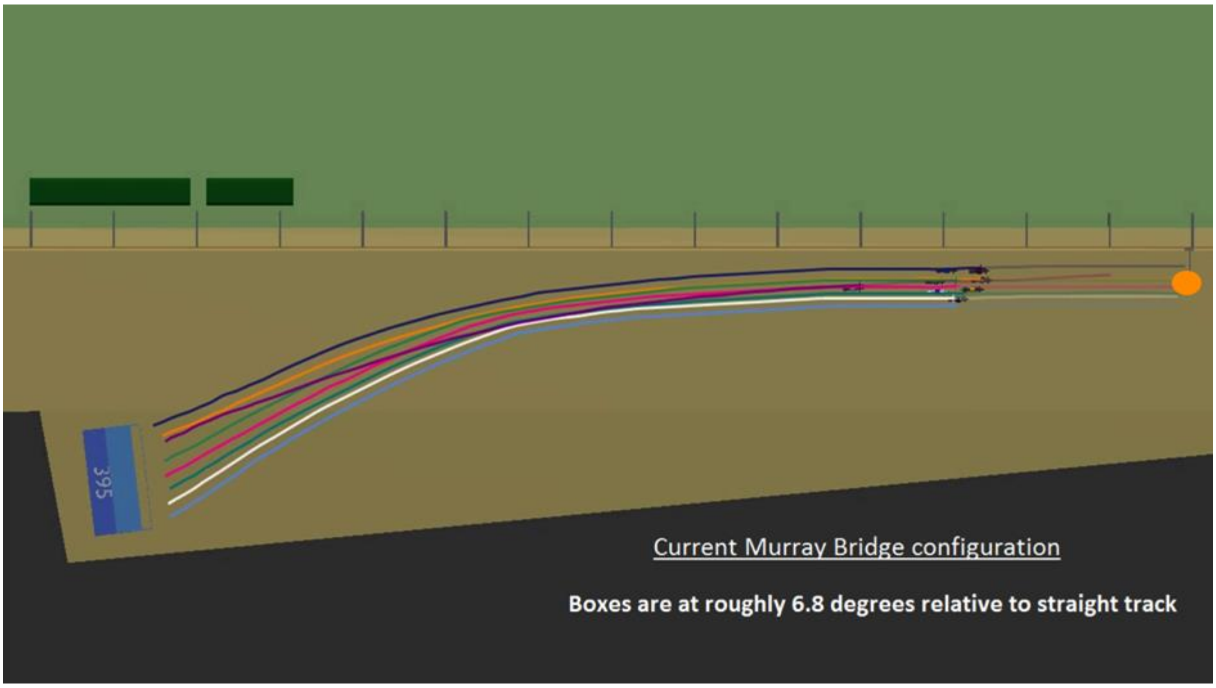

Figure 5.22: Murray Bridge track greyhound paths while transitioning from the 395 m boxes to the track.

5.30 When boxes are at roughly 19.50 degrees relative to the straight part of the track, the final positions of greyhounds are nearer to the lure running rail than that of the 680 m start (see Figure 5.23). Furthermore, there is a significantly sharper deviation of about 23.00 degrees by greyhounds towards the lure running rail.

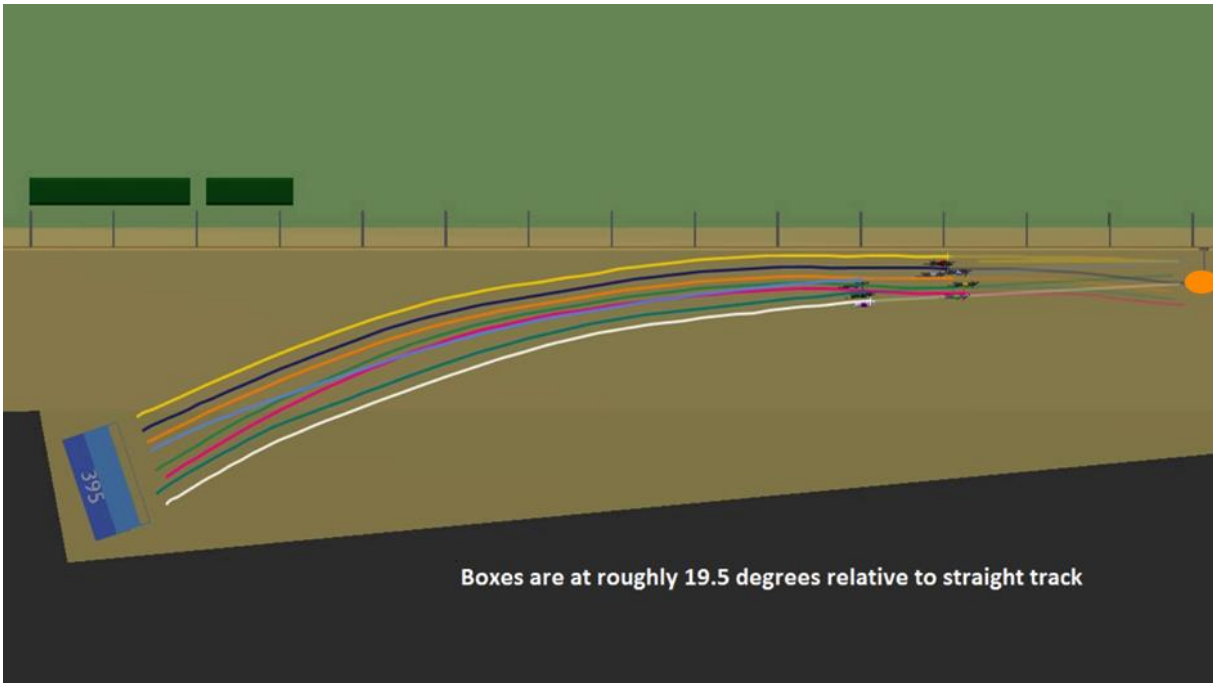

Figure 5.23: Murray Bridge track greyhound paths while transitioning from the 395 m boxes to the track.

5.31 It has been verified from actual race videos that sharp deviation and convergence of greyhounds from starting boxes is a precursor to congestion and undesirable incidents such as those shown in the following videos:

https://cloudstor.aarnet.edu.au/plus/index.php/s/wCeSiuhy7haDGTV

https://cloudstor.aarnet.edu.au/plus/index.php/s/cqppT1Rm3PnrQzN

5.32 Sharp deviation from the starting boxes can be alleviated by a delayed starting box opening as shown in the Figure 5.24. When the opening of starting boxes is delayed the lure is moved ahead of the starting boxes by an offset along the inside rail.

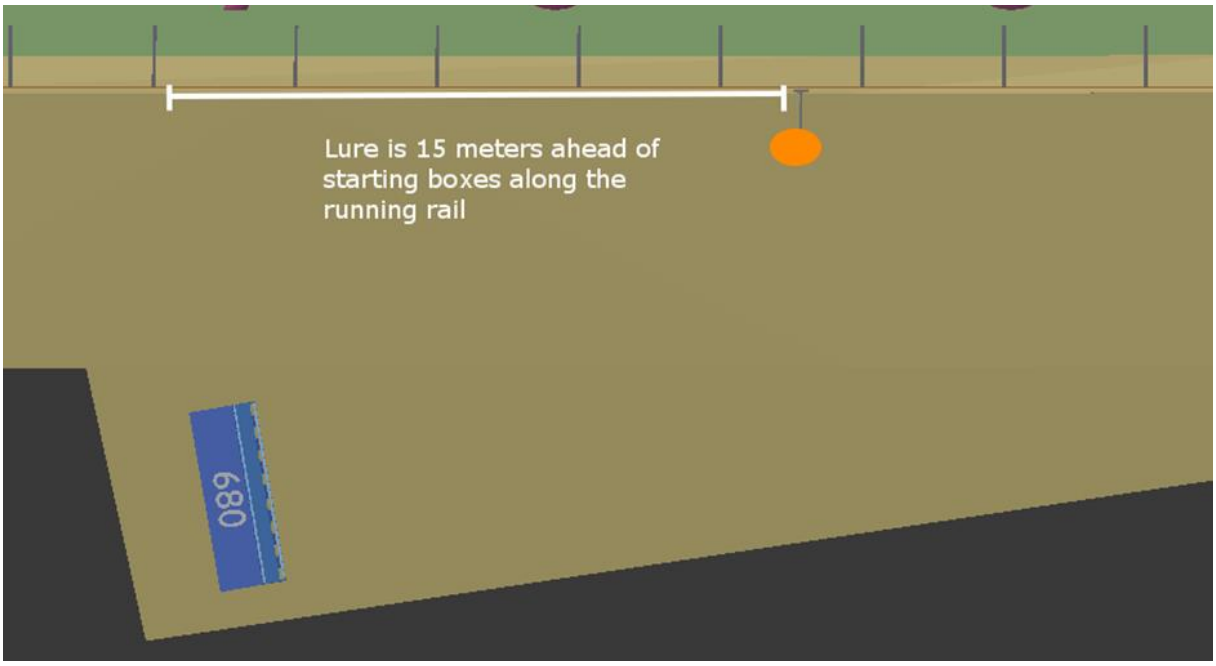

Figure 5.24: Lure offset because of delayed box opening along the inside rail.

5.33 In the simulation, the effect of the delayed box opening can be observed in Figures 5.25 to 5.29. While greyhounds make their transition from starting boxes to the track they have to change their direction rapidly towards the inside rail if boxes are opened without any delay. For delayed box openings when the lure is 10 m past the boxes along the inside rail greyhounds deviate more gradually (Figure 5.28).

5.34 Figure 5.25, the trajectory of greyhounds leaving the boxes is similar to their trajectory when going around a bend.

5.35 Figure 5.26, with delayed box openings greyhound paths are less abrupt.

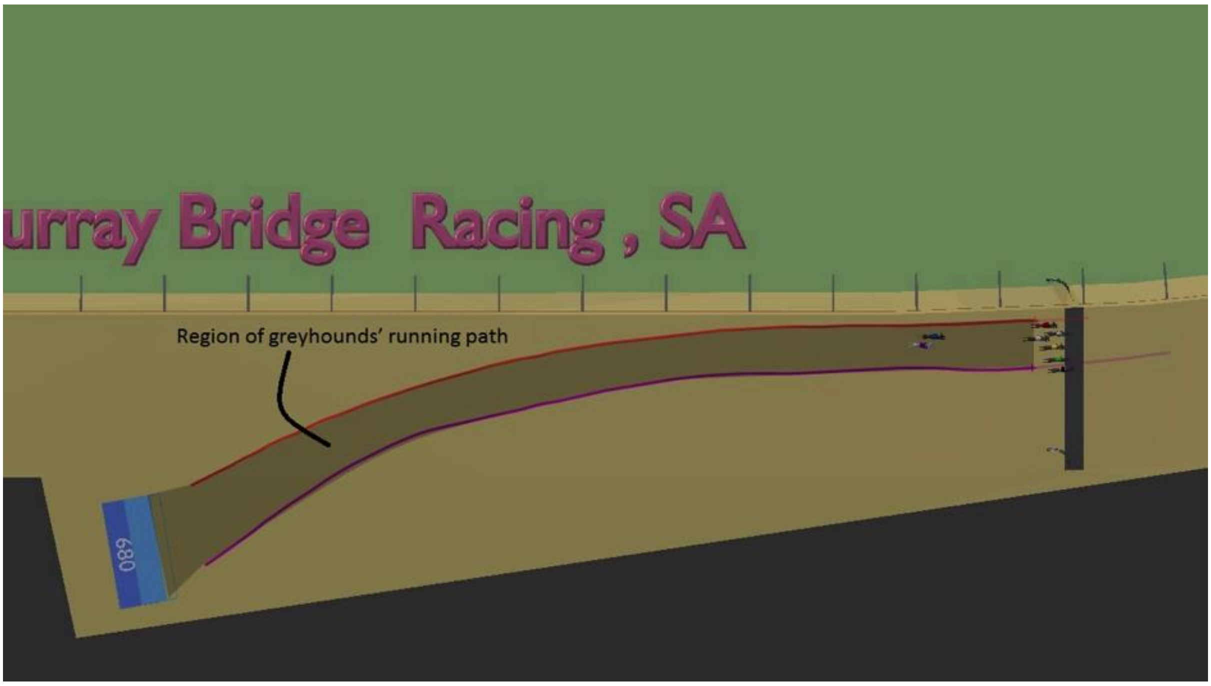

Figure 5.25: Murray Bridge track when there is no delay in box openings. The trajectory of the greyhounds is similar to going around a bend.

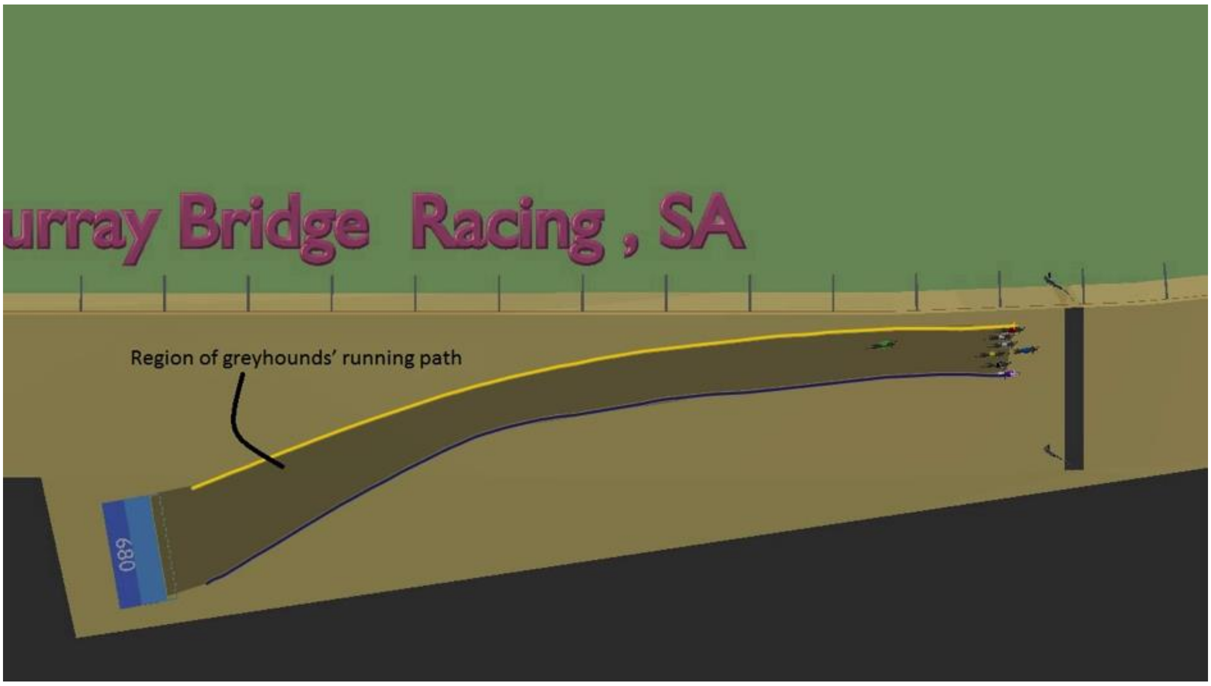

Figure 5.26: Murray Bridge track greyhounds paths when box openings are delayed and the lure is 5 m past the boxes along the rail.

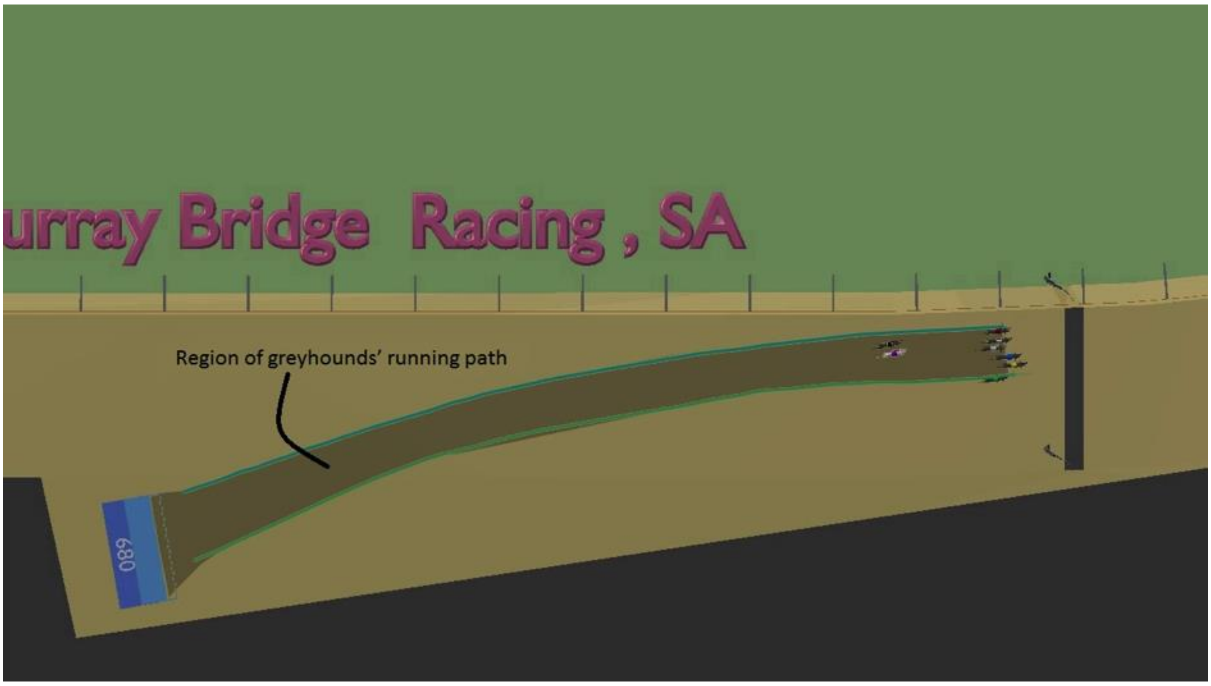

Figure 5.27: Murray Bridge track greyhounds paths when box openings are delayed and the lure is 8 m past the boxes along the rail. It should be noted that the deviation in greyhound trajectories are starting to be less abrupt.

5.36 Figure 5.27, when the lure is 8 m past the boxes along the rail because of delayed box openings greyhound deviations are starting to get gradual and less abrupt.

5.37 Figure 5.28, when the lure is 10 m past the boxes along the rail because of delayed box openings greyhound deviations are approaching the equivalent of a straight because of the very large radius of curvature.

5.38 Figure 5.29, when the lure is 15 m past the boxes along the rail because of delayed box openings greyhound paths are converging and deviations are gradual in nature.

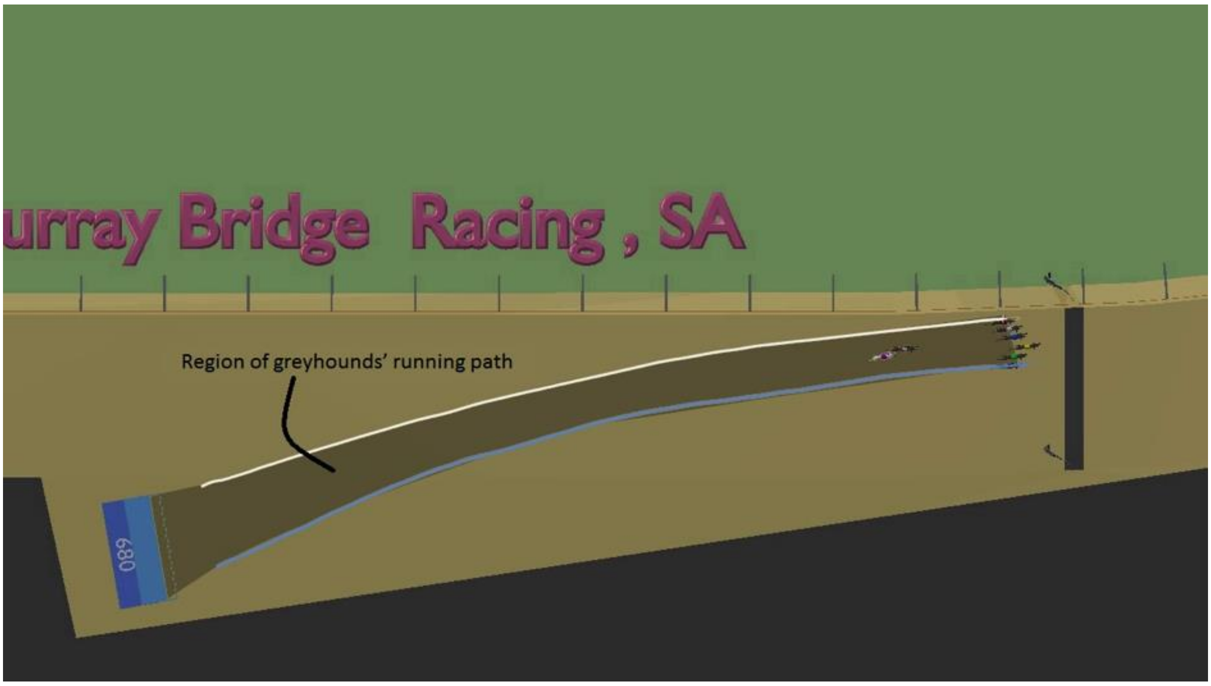

Figure 5.28: Murray Bridge track greyhound paths when boxes openings are delayed and lure is 10 m past the boxes along the rail.

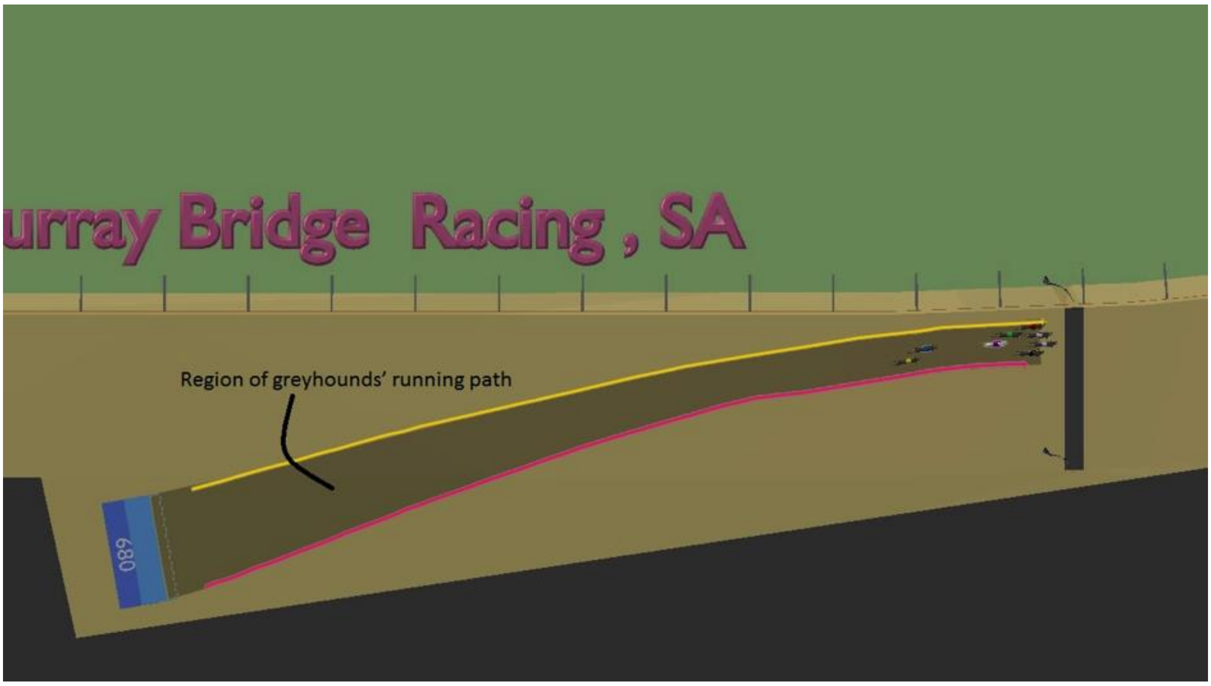

Figure 5.29: Murray Bridge track greyhound paths when boxes openings are delayed and lure is 15 m past the boxes along the rail.

5.39 The 5_MURRAY680_I1,6_72s_5l_DBO* files which are available through the following link show greyhound positioning on the track for a lure which is further along the rail once the boxes are opened as shown in the Figure 5.24.

https://cloudstor.aarnet.edu.au/plus/index.php/s/rx0o973epxYpsfP

5.40 From the racing simulations it was observed that, for a lure which is close to the inside rail, for greyhounds lagging behind, the lure sight remains obscured most of the time by greyhounds in the front and by the fence while going around the bend. When the lure sight is obscured, greyhounds change their original running courses, increasing probability of congestion and bumping into other greyhounds nearby. This can be seen in following racing simulation (lure arm length is 1.0 m):

https://cloudstor.aarnet.edu.au/plus/index.php/s/kr4uzgI8CcpG4LF

5.41 However, obscuring of the lure sight can be mitigated by increasing the lure arm length or placing the lure further away from the inside rail of a track as shown in the following racing simulation where the lure arm length is 1.6 m:

https://cloudstor.aarnet.edu.au/plus/index.php/s/7YW4as9NjnOErJx

5.42 The following graphs show velocity and acceleration magnitudes of the red greyhound while transitioning from a 680 m starting box to the track for the race depicted in Figure 5.16:

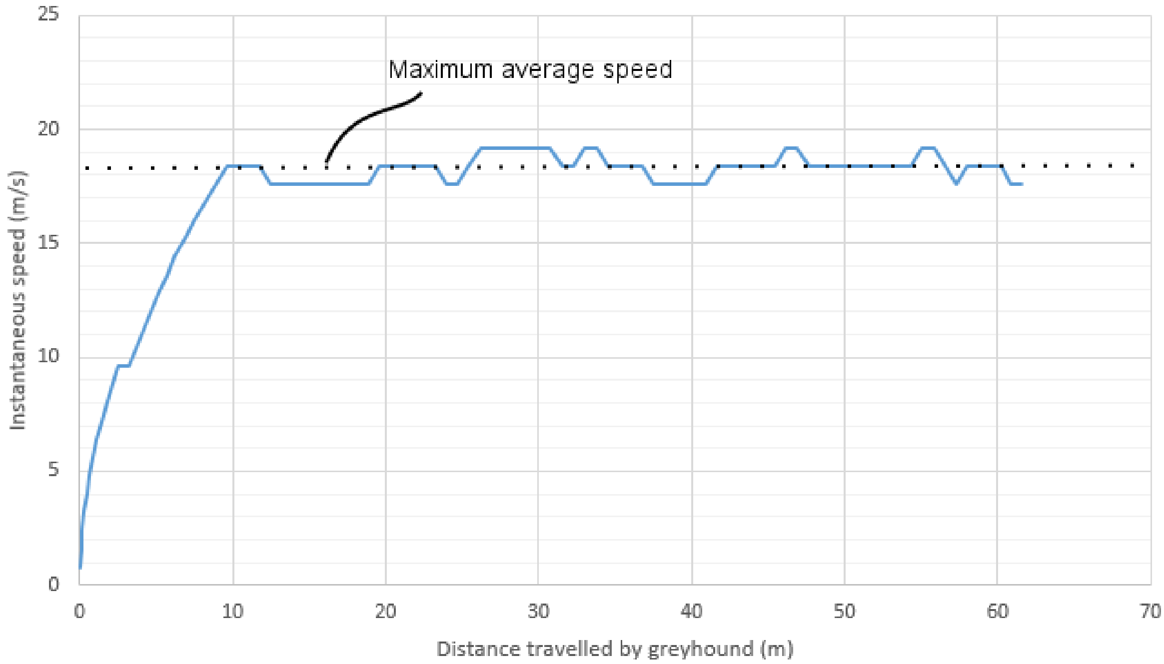

Figure 5.30: Murray Bridge track instantaneous speed of the red greyhound while transitioning from a 680 m starting box to the track.

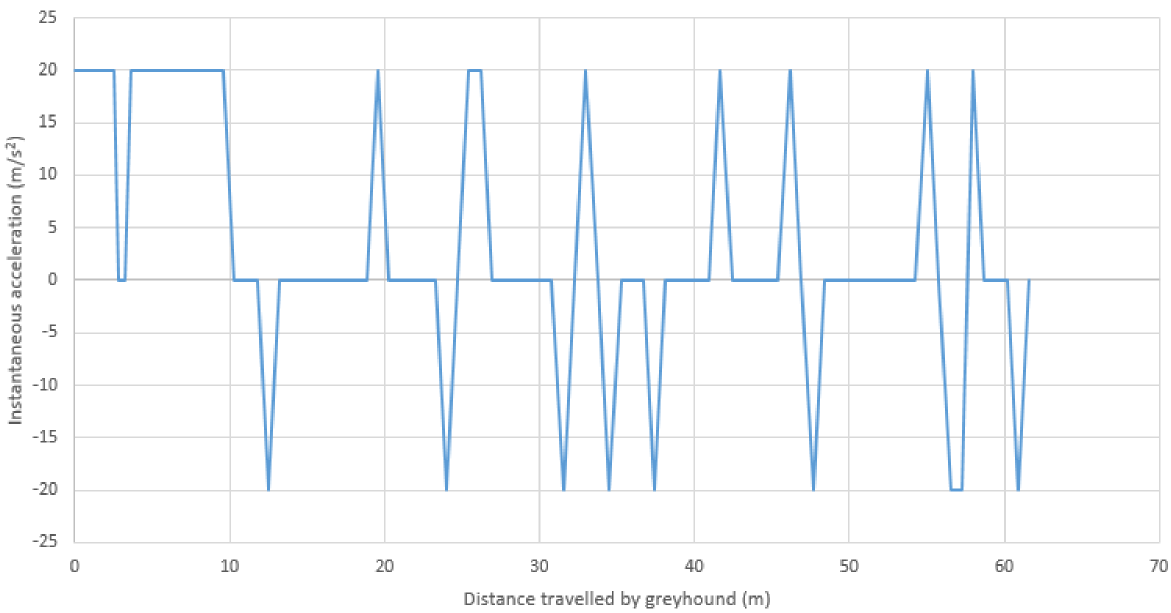

Figure 5.31: Murray Bridge track instantaneous tangential acceleration magnitude of the red greyhound while transitioning from a 680 m starting box to the track.

5.43 Table 5.2 shows the time taken for individual greyhounds to achieve maximum average speed as shown in Figure 5.30 while transitioning from different starting boxes to the track for races corresponding to Figures 5.16, 5.19, 5.20 and 5.22. For a smooth transition from the starting boxes to the track, individual greyhounds would take less time to reach maximum average speed. On the other hand, interference due to congestion would increase the required time for individual greyhounds to achieve maximum average speed. However, maximum average speed is not only affected by congestion but also by track gradients, track surface and individual greyhound characteristics.

5.44 As can be seen from Table 5.2, greyhounds racing from 395 m starts take on average 1.315 seconds to reach maximum average speed, which is an indicator of least congestion compared to 455 m, 530 m and 680 m starts.

Table 5.2: Murray Bridge track time in seconds for each greyhound to reach maximum average speed while transitioning from starting boxes to the track.

Distances	Red	Blue stripped	White	Blue	Yellow	Green	Black	Purple	Average time (s)
680 m start	1.28	1.6	1.28	1.44	1.56	1.28	1.56	1.4	1.43
530 m start	1.28	1.56	1.6	1.24	1.2	1.6	1.32	1.28	1.39
455 m start	1.44	1.64	1.44	2.08	1.32	1.36	1.32	1.28	1.49
395 m start	1.36	1.2	1.6	1.28	1.28	1.28	1.24	1.28	1.32

5.45 Figure 5.32 shows the average speed of a single greyhound as it follows the lure around the track starting from the 680 m box.

5.46 The average speed remains less than 16.95 m/s until the greyhound has traveled 162 m.

5.47 During this period the rate of change of average speed is high thus increasing the probability of incidents on the track.

5.48 The region of the track where this high rate of change of average speed occurs is shown in the Figure 5.33.

5.49 It is also verifiable from actual race data from different tracks that most injuries occur within the region where a high rate of change of average speed occurs.

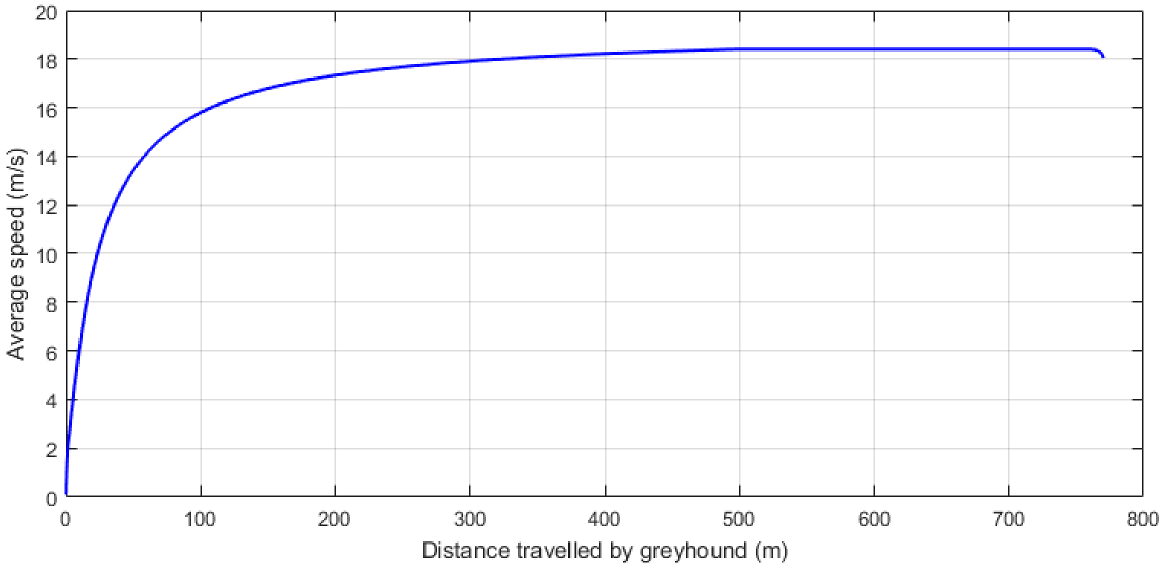

Figure 5.32: Murray Bridge track showing the average speed of a single greyhound for a 680 m start.

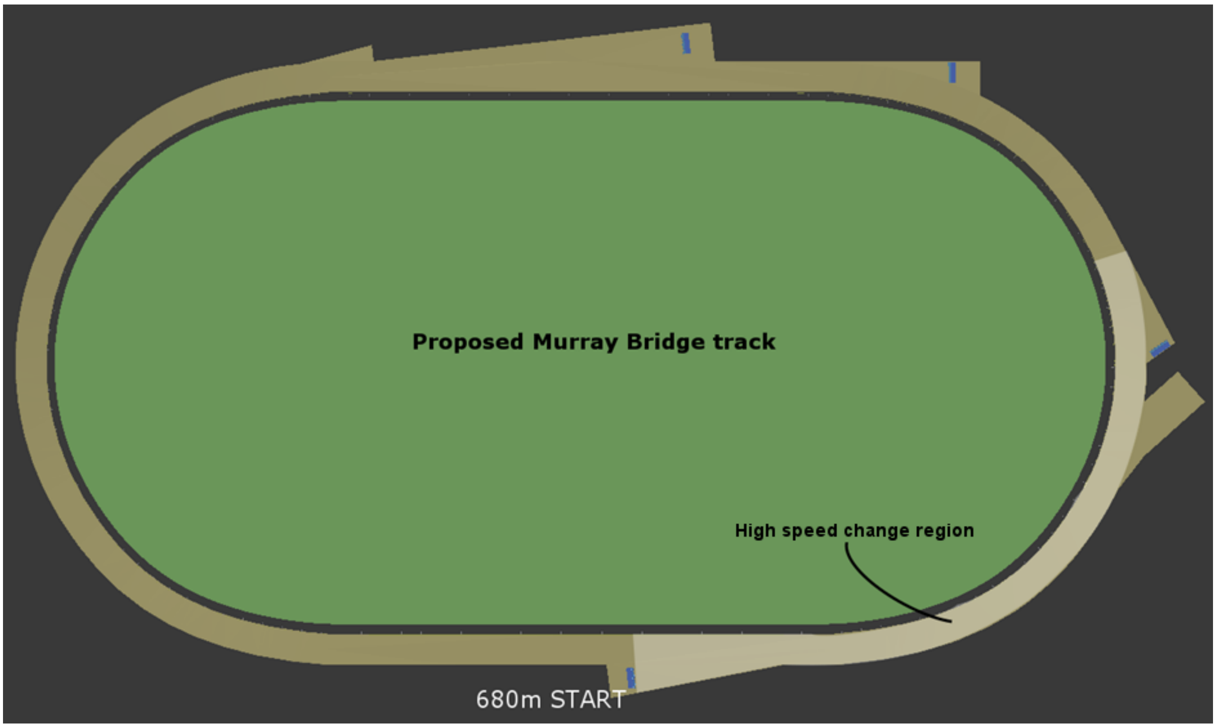

Figure 5.33: Murray Bridge track diagram showing the high speed change region for a 680 m start.

MODELING OF TRACKS

5.50 From the plans and survey data of the Murray Bridge and Horsham tracks the contours of the lure running paths have been extracted to produce curvature data of the tracks.

5.51 The curvatures of a track depict how sharply the path of a greyhound is deviating as it traverses the track. For an absolutely straight track the curvature is zero. Higher values represent greater curvature of the track path.

5.52 Figure 5.34 depicts features of the Murray Bridge track in terms of overall track shape.

5.53 The Murray bridge track has a straight to bend transition length of approximately 40.0 meters (Figure 5.34).

5.54 The Murray bridge track has relatively gradual curvatures and almost constant curvatures around the bends (Figure 5.34).

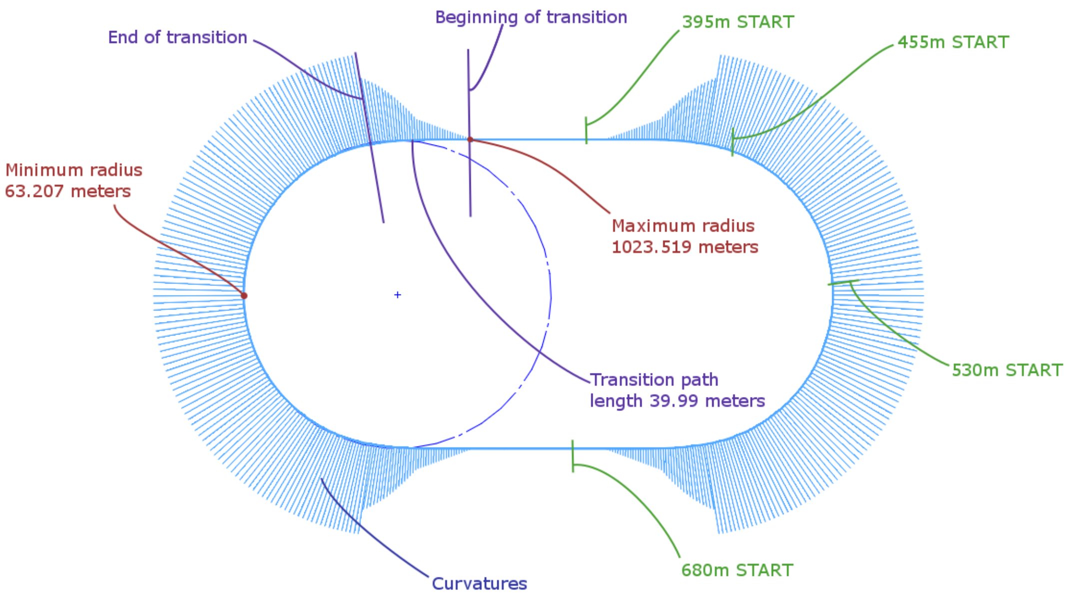

Figure 5.34: Plan view of the proposed Murray Bridge track showing track curvatures and transitions.

5.55 A number of greyhound lateral dynamics-related graphs have been generated from the curvature data and the transition from box to track path data.

5.56 The centrifugal force graphs illustrate the magnitude of centrifugal force resulting from centrifugal acceleration of the track path as it is traversed.

5.57 The jerk graphs illustrate the rate of change of centrifugal acceleration of the track path as it is traversed. A more gradual change in centrifugal acceleration will result in the more gradual appearance and disappearance of centrifugal forces. High jerk magnitude is directly related to an increase in the probability of fatigue failures occurring.

5.58 The snap graphs illustrate the rate of change of jerk of the track path as it is traversed. The snap is a good indicator of transient centrifugal forces.

5.59 As can be seen from Figure 5.36, greyhounds racing from the 395 m starting boxes of the proposed Murray Bridge track would experience greater forces than racing from the 455 m, 530 m and 680 m starting boxes while transitioning from the starting boxes to the track.

5.60 As can be seen from Figures 5.37 and 5.38, greyhounds racing from the 455 m starting boxes would experience the least amount of transient lateral centrifugal forces while transitioning from the starting boxes to the track.

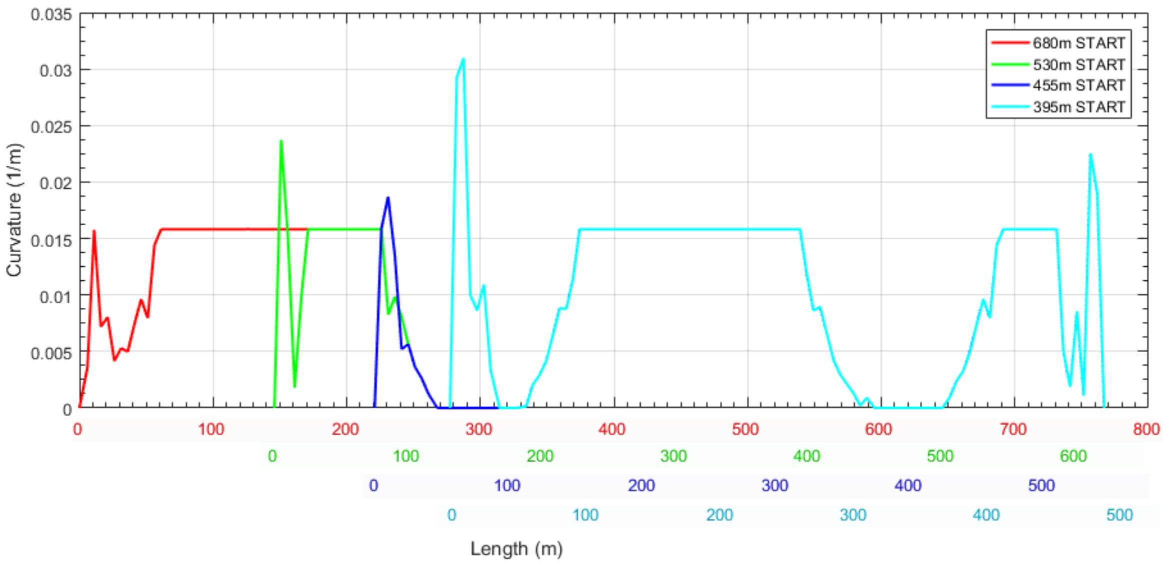

Figure 5.35: Murray Bridge track curvatures for different race starts.

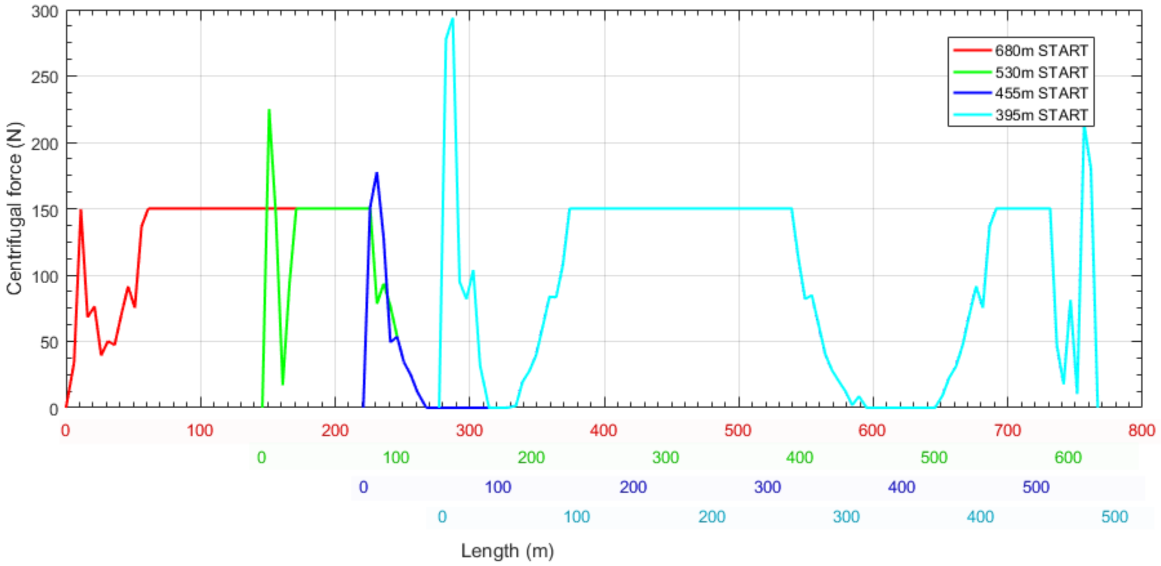

Figure 5.36: Murray Bridge track centrifugal forces for different race starts.

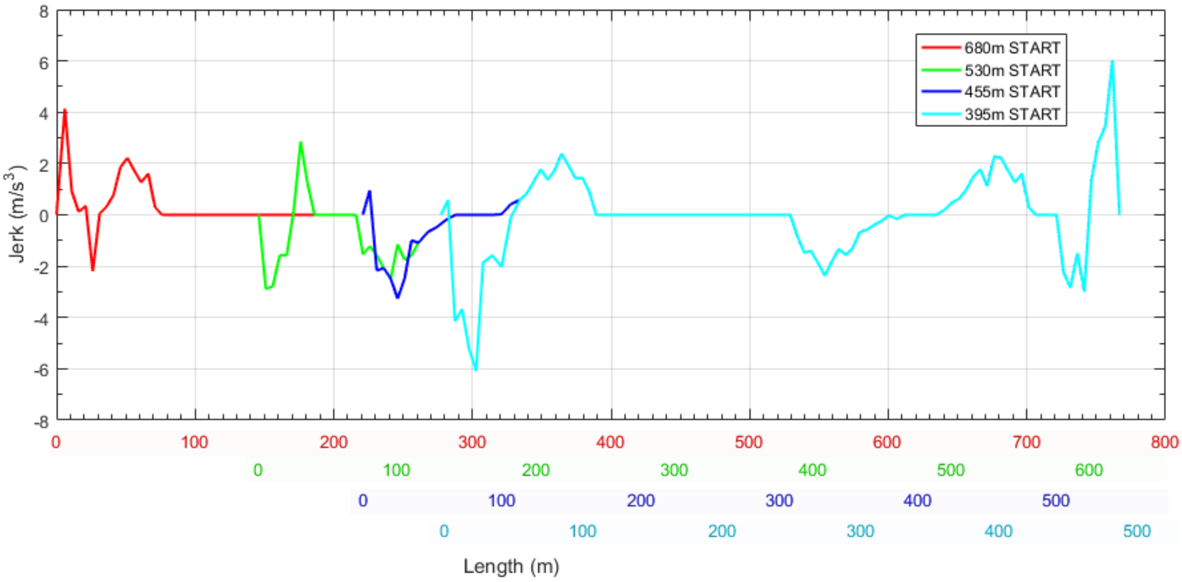

Figure 5.37: Murray Bridge track jerk for different race starts.

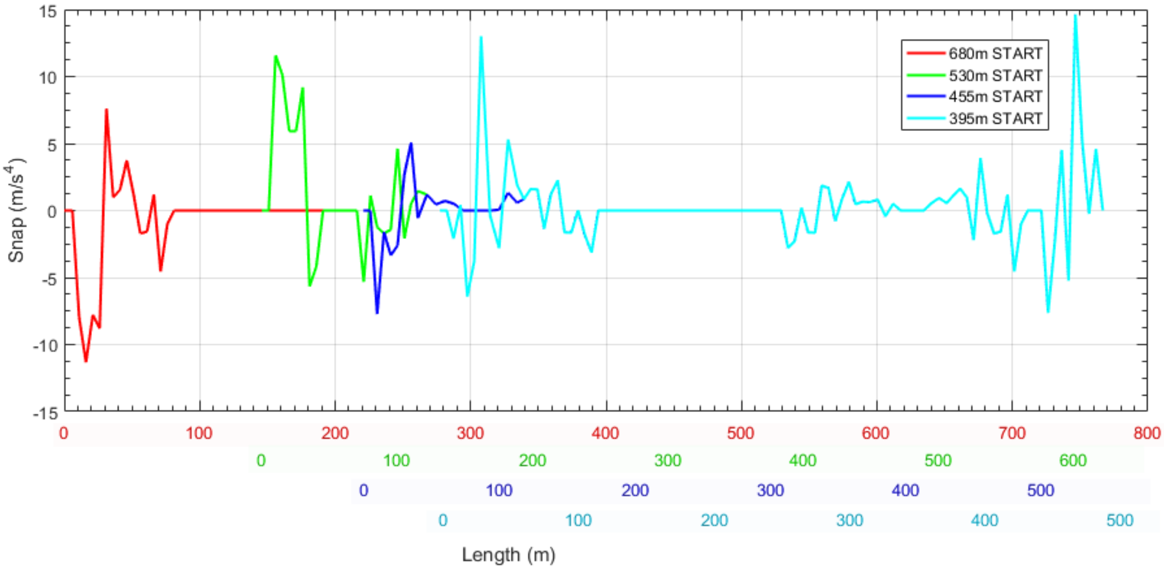

Figure 5.38: Murray Bridge track snap for different race starts.

5.61 Figure 5.39 depicts features of the Horsham track (pre-modification) in terms of overall track shape.

5.62 The Horsham track (pre-modification) has abrupt track curvatures where there is no gradual curvature from straight to bend (Figure 5.39).

5.63 However, compared to the Murray Bridge track, the Horsham track (pre-modification) has a longer straight to bend track transition length of approximately 64.1 meters (Figure 5.39).

5.64 The longer straight to bend transition of the Horsham track (pre-modification) allows greyhounds to accommodate centrifugal forces more efficiently.

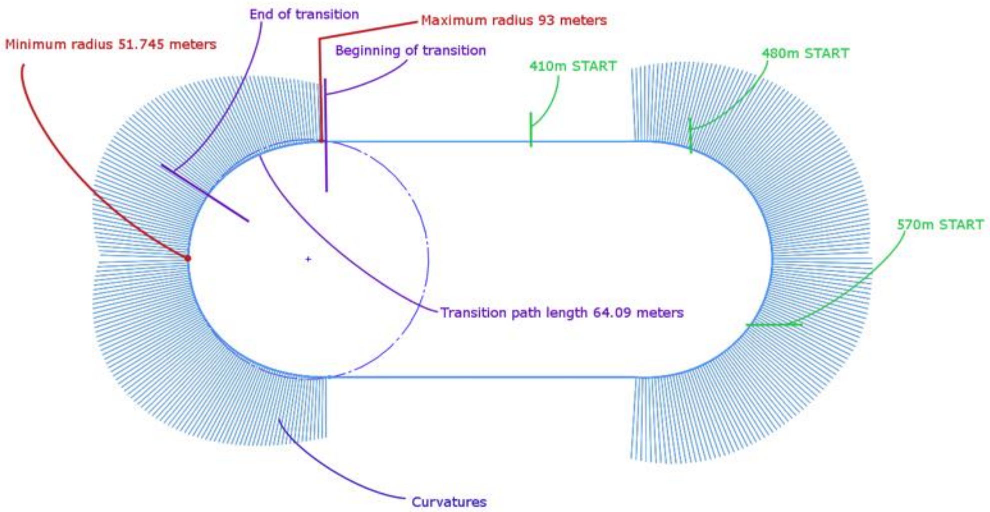

Figure 5.39: Horsham track (pre-modification) plan view showing track curvatures and transitions.

5.65 The Horsham track (pre-modification), among all three starts, namely: 410 m; 480 m; and 570 m, greyhounds racing from the 410 m starting boxes would experience the least amount of centrifugal force (Figure 5.41).

5.66 As can be seen from the curvature graphs (Figures 5.35 and 5.40) of the Horsham track (pre-modification) and the proposed Murray Bridge track, the Horsham track (pre-modification) is 33% more curved around the bends.

5.67 As a result centrifugal force is approximately 33% greater for the Horsham track (pre-modification) compared to the proposed Murray Bridge track around the bends (Figures 5.36 and 5.41).

5.68 The average jerk and snap for the Horsham track (pre-modification) and the proposed Murray Bridge track are nearly identical.

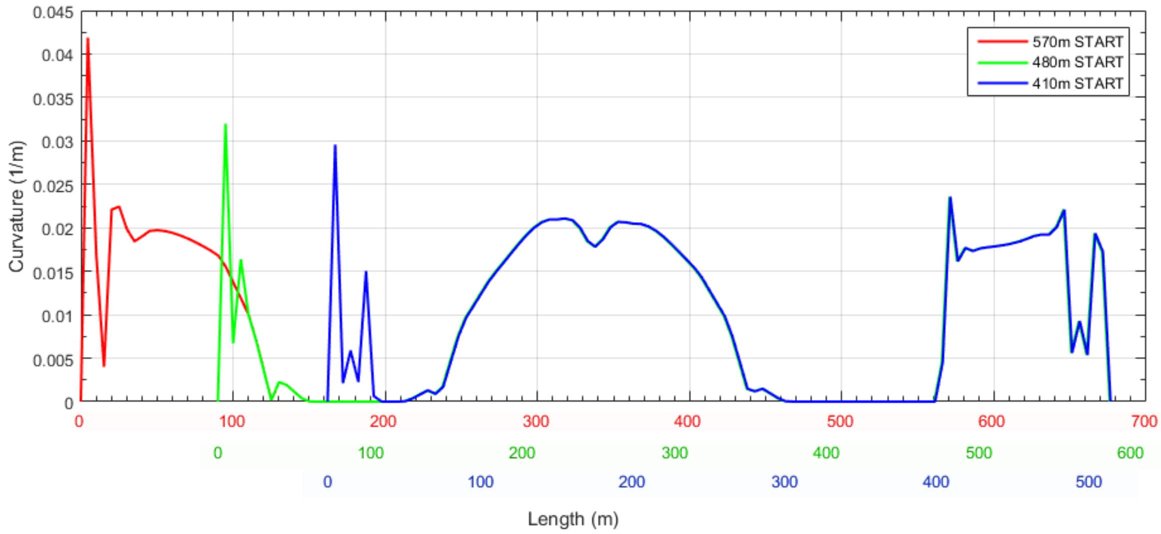

Figure 5.40: Horsham track (pre-modification) curvatures for different race starts.

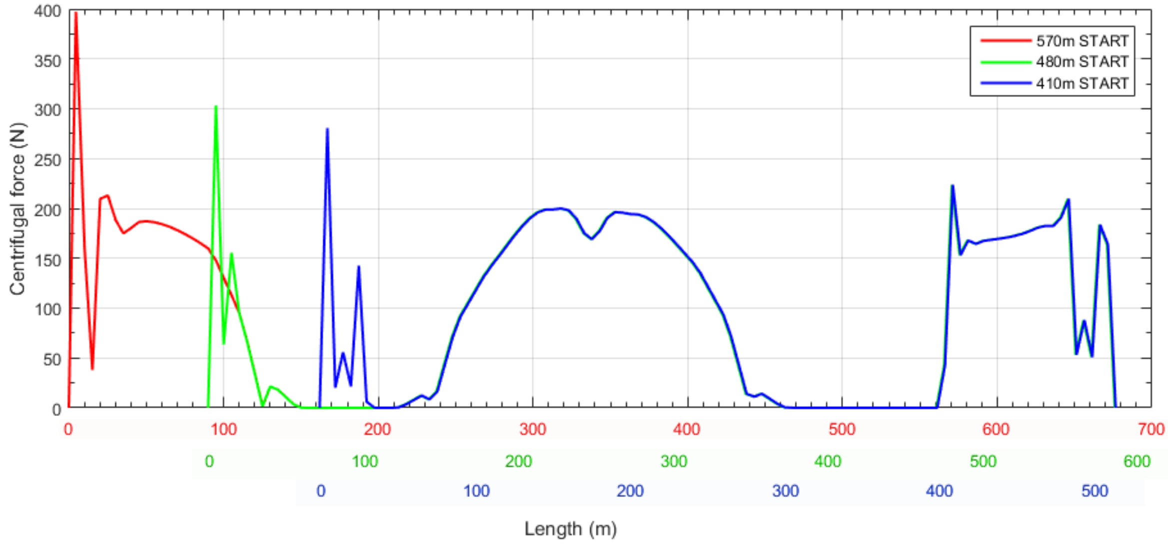

Figure 5.41: Horsham track (pre-modification) centrifugal forces for different race starts.

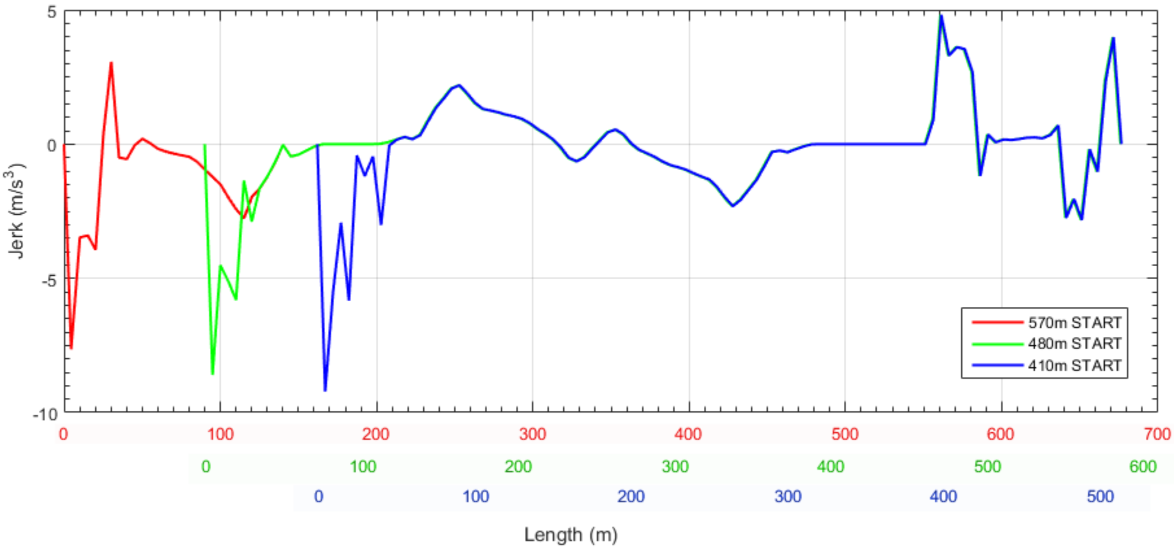

Figure 5.42: Horsham track (pre-modification) jerk for different race starts.

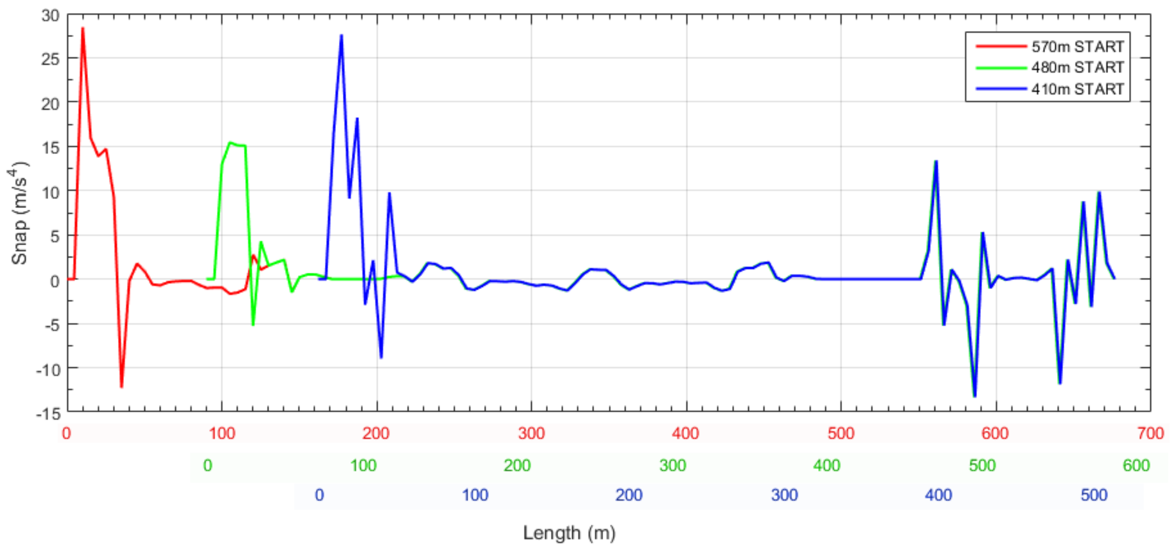

Figure 5.43: Horsham track (pre-modification) snap for different race starts.

5.69 Figures 5.44 to 5.47 show features of the Horsham track after proposed modifications.

5.70 Compared to the Horsham track (pre-modification), the proposed modifications to the Horsham track will reduce centrifugal forces by approximately 11% around the bends (Figures 5.41 and 5.45).

5.71 Likewise, the proposed modifications to the Horsham track will reduce average jerk and snap by 10% (Figures 5.42, 5.43, 5.46 and 5.47).

5.72 Similarly, the proposed modifications to the Horsham track will reduce peak transient centrifugal forces for the 410 m, 480 m and 570 m starts by roughly 73%, 5%, and 28% respectively (Figures 5.41 and 5.45).

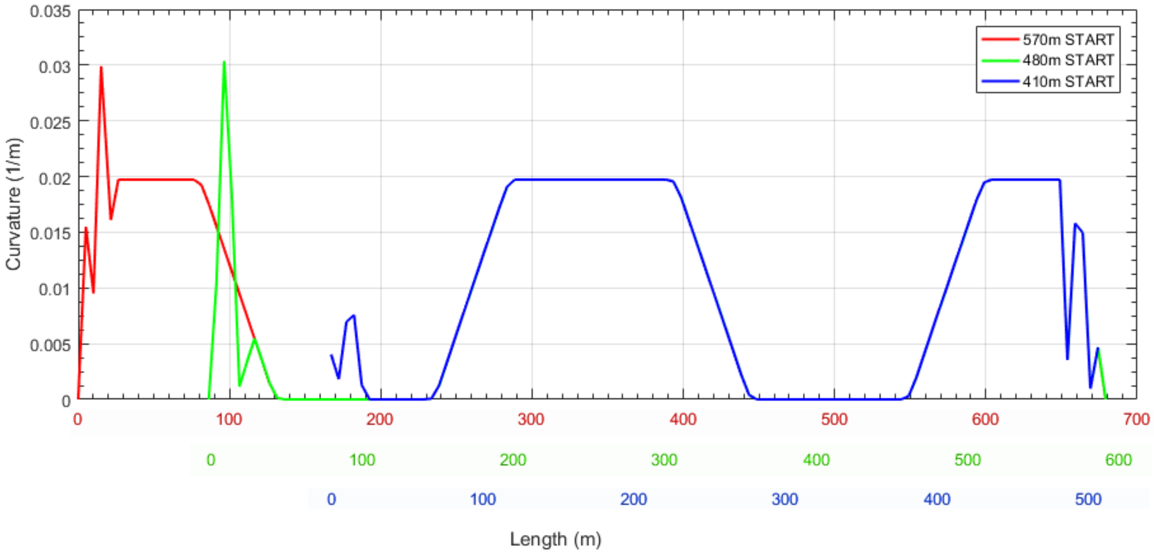

Figure 5.44: Horsham track (proposed modification) curvatures for different race starts.

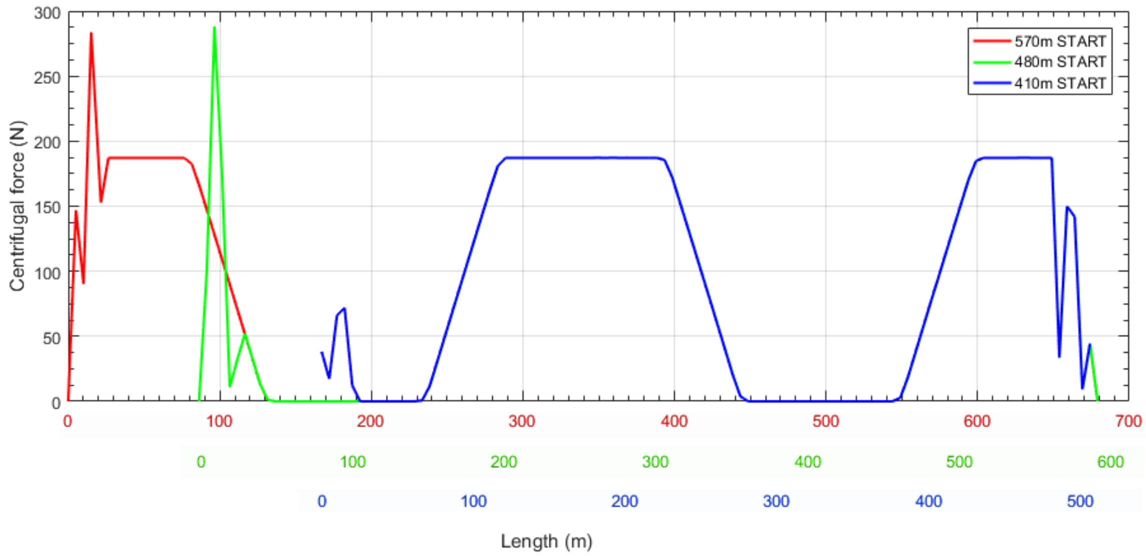

Figure 5.45: Horsham track (proposed modification) centrifugal forces for different race starts.

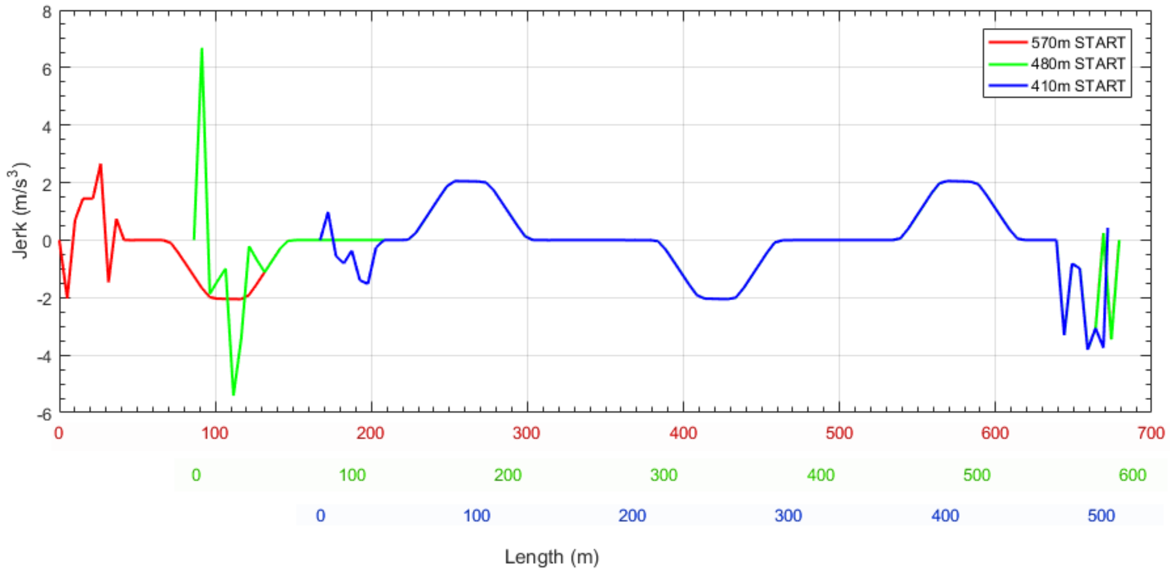

Figure 5.46: Horsham track (proposed modification) jerk for different race starts.

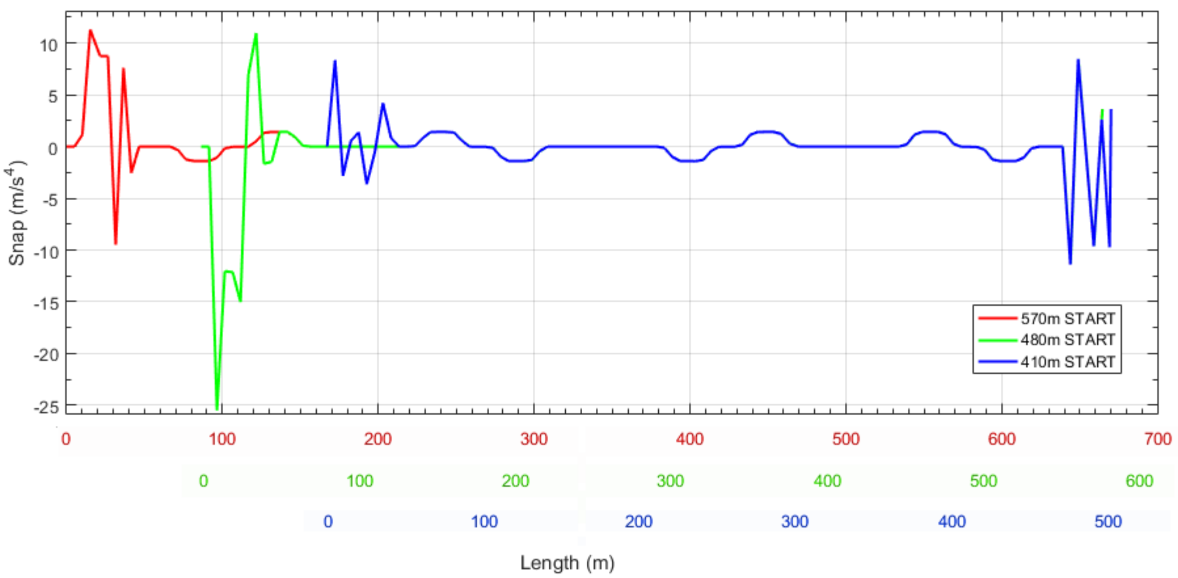

Figure 5.47: Horsham track (proposed modification) snap for different race starts.

Simulation and modeling methodology

Greyhound race simulation

5.73 The motion of greyhounds in racing can be simulated by knowing which factors induce the motion as well as which factors modify the motion in some way or other. The factors which induce greyhound motion are greyhound stride and the factors which alter this motion are greyhound natural steering limits towards an object, greyhound collision, track surface orientation and condition, lure line of sight and track boundaries. In the simulation, the superposition principle is applied to these factors to determine the final positions of the greyhounds. The following diagram shows the main processing flowchart of greyhound racing simulation:

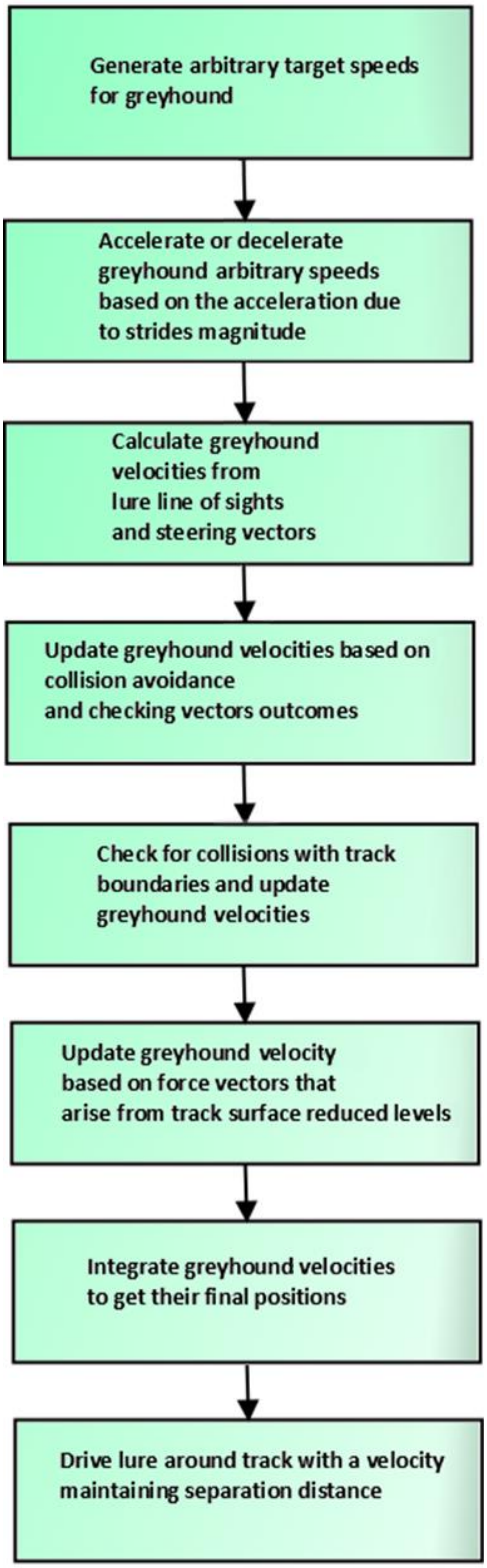

Figure 5.48: Greyhound racing simulation processing flowchart.

5.74 At each stage of the above processing flowchart a number of variables is derived to calculate a greyhound's final position based on the above-mentioned factors.

VARIABLE FOR GREYHOUND STRIDE

$$\sum F = ma_G$$

5.75 In the above Newton's equation of motion, ΣF is sum of all the forces exerted by a greyhound's stride, m is mass of a greyhound and a_G is acceleration of a greyhound's body. According to above equation, for a constant greyhound mass, a greyhound's acceleration a_G is directly proportional to its stride forces ΣF. For the purposes of simulation, it is assumed that a greyhound's exerted stride force remains constant for the entire race duration[5]. Now, since acceleration is proportional to stride force, it also needs to be constant for the entire race duration. From the available field data the magnitude of average acceleration a_G of a greyhound is calculated to be roughly 20 m/s^2. In simulation, this is the acceleration a_G due to stride which moves a greyhound from one point to another point within the track. Finally, greyhound speed v due to stride acceleration a_G is calculated as follows:

$$v = v_o + a_G t$$

5.76 Where, v_O is speed at previous time instant and t is elapsed time between v and v_O. Note that, only magnitude of a_G is used for calculating greyhound speed.

VARIABLE FOR LURE LINE OF SIGHT

5.77 In simulation, the speed v due to a greyhound's stride acceleration a_G is applied to a vector constructed from the lure and the greyhound's positions along the track as shown in Figure 5.50 below.

[5] This approximation does not take account of the change in the acceleration vector's magnitude as the greyhound traverses around the bend or any other deviations in its trajectory.

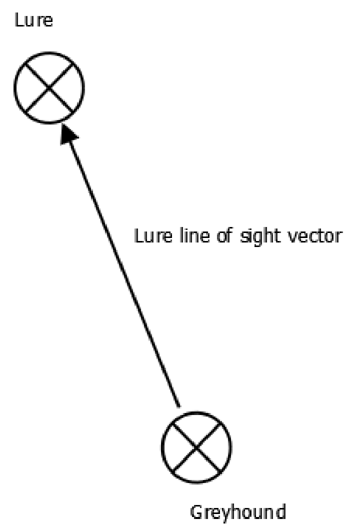

Figure 5.49: Lure line of sight vector.

5.78 The purpose of this vector is to give a direction to the stride acceleration a_G derived speed *v*, which is responsible for moving a greyhound along the track. Without the lure line of sight vector a greyhound will not have a direction to move on the track. Furthermore, this vector represents the outcome of lateral and stride forces such as centrifugal force, frictional force of the track ground and stride force by a greyhound acting on the greyhound's body as shown in the following equation:

Lure line of sight vector = centrifugal force + paw and track ground frictional force + stride force

VARIABLE FOR SMOOTHLY STEERING GREYHOUNDS TOWARD THE LURE

5.79 Although the lure line of sight vector is sufficient for setting a direction for a greyhound's movement, using just the lure line of sight vector alone will create unnatural greyhound movement behaviour . The reason for this is the lag between the greyhound looking at the lure and changing its heading direction. In other words, there is always a time gap between a greyhound sighting the lure and changing its heading towards the lure. Furthermore, greyhounds have physical limitations regarding the degree to which they can change their heading at an instant as shown in Figure 5.50.

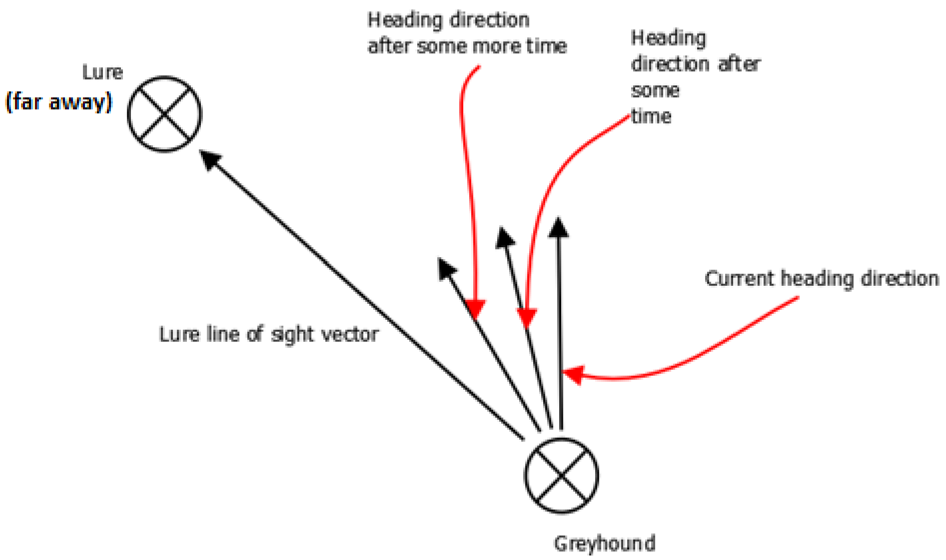

Figure 5.50: A greyhound gradually changing its heading towards the lure.

5.80 To achieve greyhound natural heading behaviour as shown in Figure 5.50 above a steering vector can be used together with the lure line of sight vector (Figure 5.49) for a greyhound's heading as shown in Figure 5.50.

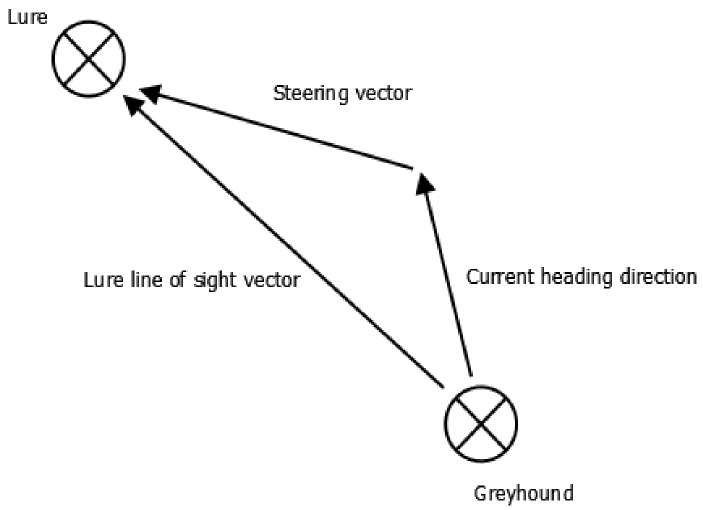

Figure 5.51: Steering vector for a greyhound's heading towards the lure.

5.81 This vector is calculated as follows:

Steering vector = lure line of sight vector – current heading direction

VARIABLE FOR CHECKING AND COLLISION AVOIDANCE

5.82 Although acceleration a_G due to the stride of individual greyhounds remains unchanged throughout a race duration, factors such as checking and collision avoidance tendency within a greyhound result in variable final velocities. This behaviour in greyhounds is simulated by using a collision avoidance vector (Figure 5.52) which successively checks for greyhounds in proximity (Greyhound ahead in Figure 5.52) and through a number of iterations finds a clearance vector (New heading in Figure 5.52).

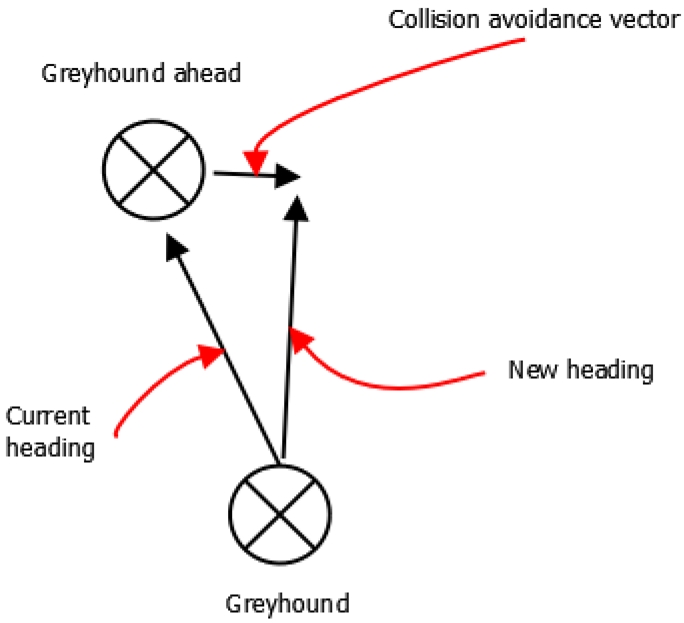

Figure 5.52: A greyhound's collision avoidance vector.

5.83 The clearance vector is calculated as follows:

Collision avoidance vector = position vector of greyhound in proximity – position vector of greyhound

Clearance vector = current heading direction vector – collision avoidance vector

VARIABLE FOR TRACK GRADIENTS

5.84 The surface orientation of a track gradient can be defined in terms of triangles since each triangle defines a plane with a normal vector as illustrated in the Figure 5.53 below.

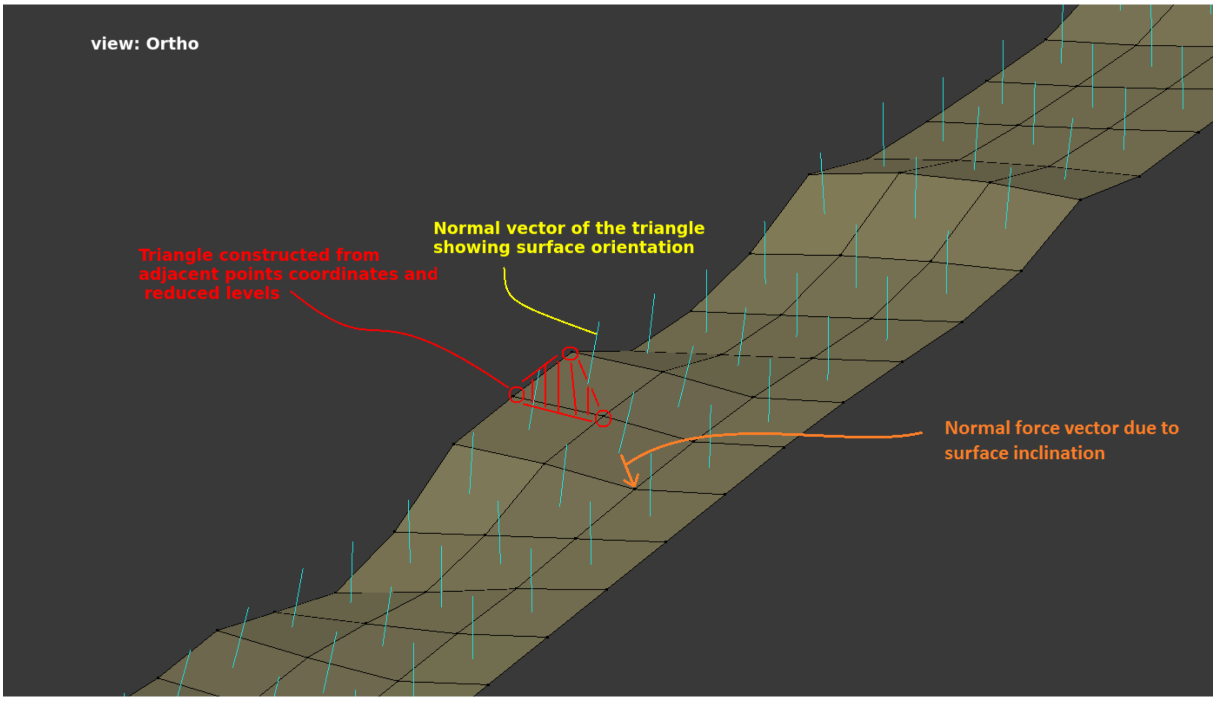

Figure 5.53: Representation of gradients in terms of triangles.

5.85 By formatting the track surface data into triangles and extracting corresponding normal vectors and applying a calibrated force vector (normal force vector, Figure 5.53) to greyhound heading velocities the effect of track cambers and super elevations are incorporated into the greyhound velocity vectors. Furthermore, the normal force vector represents the outcome of greyhound weight force and normal force on the track as shown in the following equation:

Normal force vector = greyhound weight + normal force on track

VARIABLE FOR TRACK BOUNDARIES

5.86 Greyhounds try to avoid colliding with track boundaries such as the inside lure rail. In simulations, this is achieved by continuously finding track boundary points which are nearest to the greyhounds and applying the corresponding track boundary and greyhound collision avoidance vector to a greyhound's heading as shown in the Figure 5.54 below.

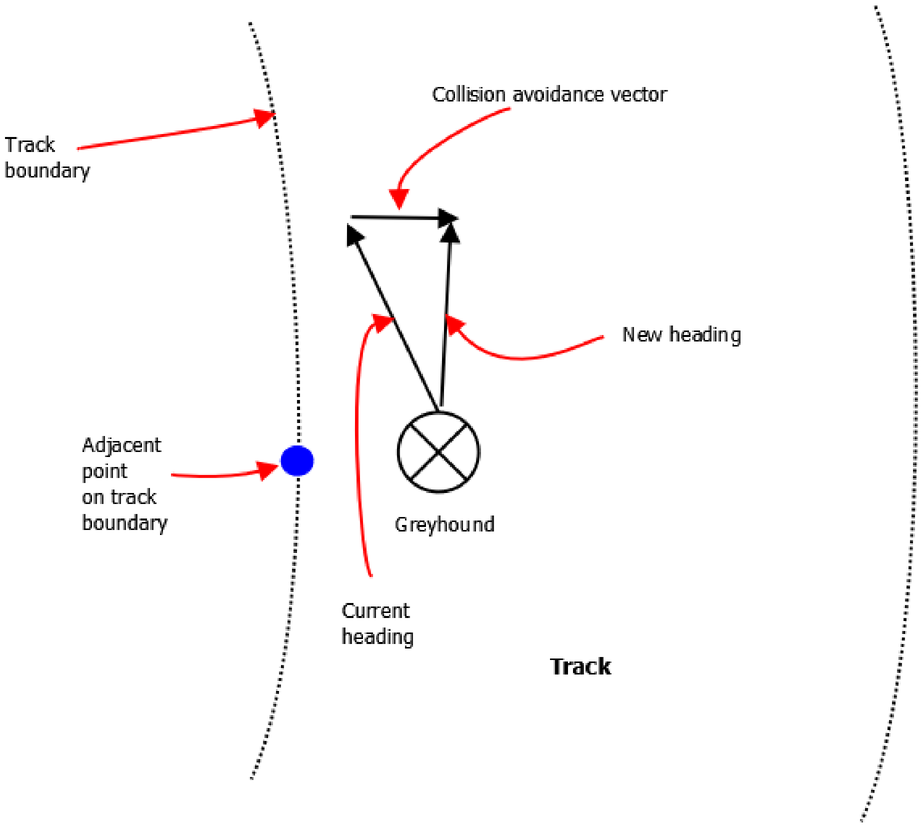

Figure 5.54: A greyhound avoiding collision with the inside lure rail.

5.87 This vector is calculated as follows:

Collision avoidance vector = position vectors of adjacent points on track boundaries – position vector of greyhound

New heading vector = current heading direction vector - collision avoidance vector

VARIABLE FOR TRACK SURFACE CONDITIONS

5.88 Races in simulation are maintained to be completely random in terms of final outcomes and not predefined in any way other than the following programming:

- Final speeds of individual greyhounds are set variably during entire race periods; and
- Speeds of greyhounds are accelerated or decelerated according to acceleration due to greyhound stride a_G.

5.89 Arbitrary speeds of greyhounds at different points in races simulate the outcomes of track surface conditions. Despite identical stride (acceleration due to greyhound stride a_G) from a greyhound over the race periods, the track surface conditions such as hardness, softness, and coefficient of friction determine greyhound speeds.

VARIABLE FOR MINIMUM RAIL OFFSET

5.90 When greyhounds are further away from the lure, they tend to move away from the inside rail to get a better view of the lure, which is shown in the following simulated races:

https://cloudstor.aarnet.edu.au/plus/index.php/s/8W5Xoet6M4XMR9S

https://cloudstor.aarnet.edu.au/plus/index.php/s/8ehqiYcNgoxb23o

5.91 However field data indicate that this behaviour varies from greyhound to greyhound. The following real racing videos show similar case scenarios where greyhounds at the back are further away from the inside rail:

https://cloudstor.aarnet.edu.au/plus/index.php/s/PD4QmYTPiaeq9KL

5.92 At 0:53 seconds in the above video, the last two greyhounds (red and striped blue) distanced themselves from the inside rail to get a better view of the lure:

https://cloudstor.aarnet.edu.au/plus/index.php/s/w8OKJVzx73ZHBhb

5.93 At 2:19 seconds in the above video the last greyhound (blue) is furthest away from the inside rail.

5.94 In the simulation this behaviour of greyhounds is simulated by adding a rail offset vector to the rail collision avoidance vector (Figure 5.54). This vector is calculated as follows:

Rail offset vector = minimum offset from inside rail * (distance from lure / offset from rail factor)

5.95 Where minimum offset from inside rail is 0.5 m, and offset from rail factor is calibrated to be 5 m.

MODELING OF TRACKS

5.96 A greyhound's locations remains in close proximity to the lure running path so the curvatures of lure's path are useful for finding the approximate curvatures of a greyhound's running path.

5.97 From the curvatures of a greyhound's running path the lateral dynamics as experienced by a greyhound are calculated. For this purpose, the lure path was extracted from track survey data and used in an algorithm to generate the greyhounds heading direction.

5.98 The number of points was re-sampled in such a way as to calculate the changes in the greyhound's heading direction. It was assumed that greyhounds change their heading direction with every stride and their average stride length to be 5 m.

5.99 Figure 5.55 shows an example of the re-sampled location coordinates of lure path as used for determining the approximate greyhound locations on the Horsham track.

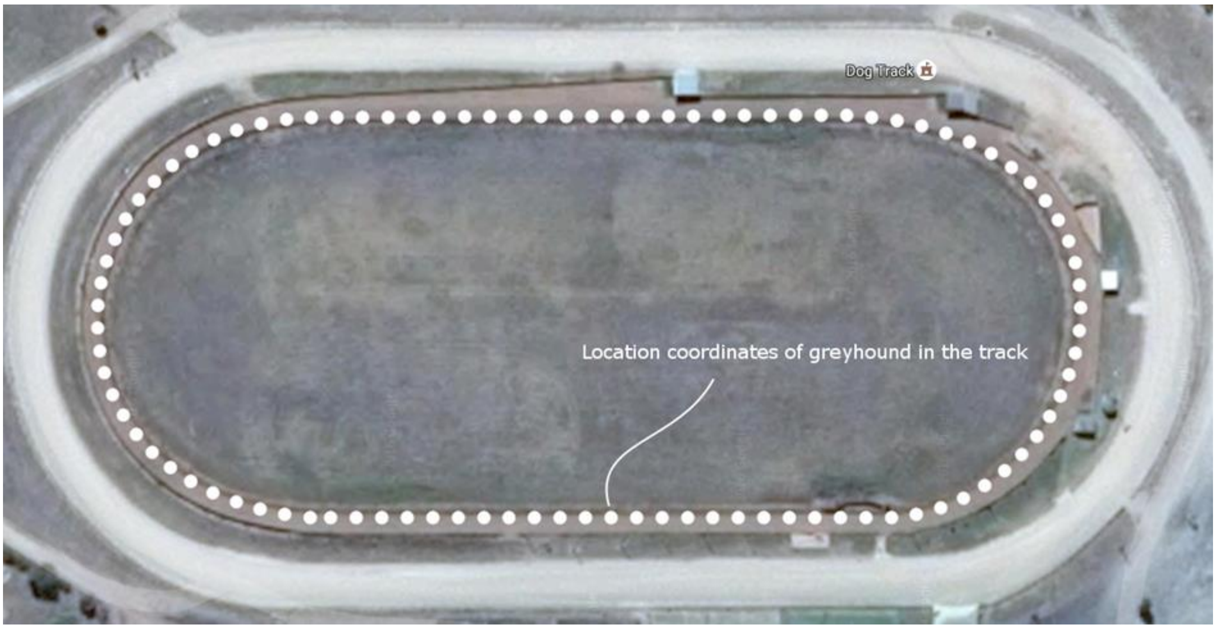

Figure 5.55: Greyhound location coordinates (white dots) within the track while following the lure.

5.100 For the purposes of calculating centrifugal accelerations and forces, it is assumed that greyhounds would be galloping with a constant speed of 62 km/h and the mass of individual greyhounds is assumed to be 32 kg.

5.101 Now, to calculate curvatures of greyhound location coordinates as shown in Figure 5.55, the circumradius formula is utilised where vertices of triangles are assigned from a greyhound's location coordinates as illustrated in Figure 5.56.

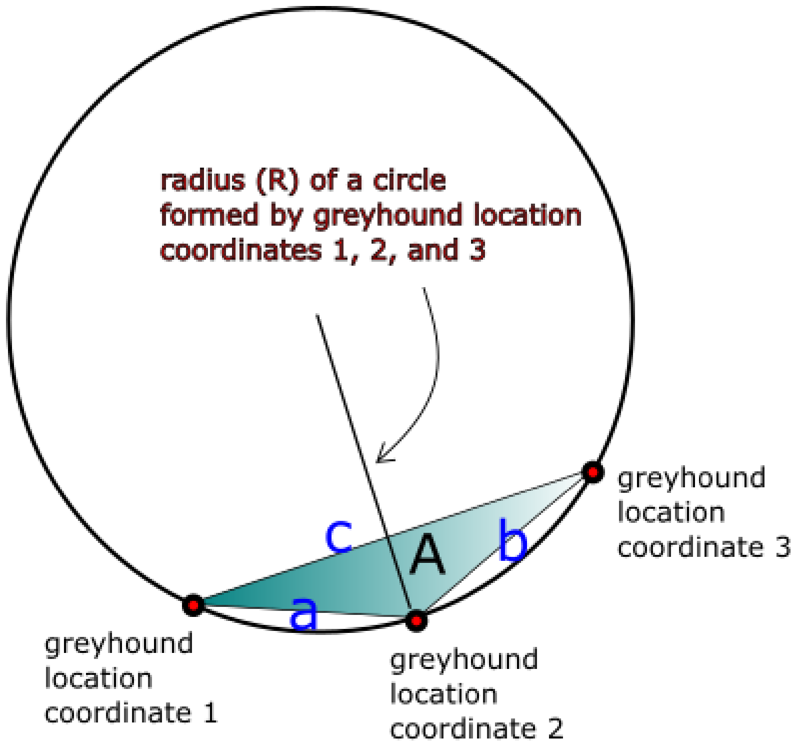

Figure 5.56: Circumcircle of a triangle formed from a greyhound's location coordinates.

5.102 Here, the radius of circumcircle (R) is equal to the radius of curvature (*p)* for the greyhound's travelling path defined by the greyhound's location coordinates. The circumcircle formula is given by:

$$R = \frac{abc}{4A} = p$$

5.103 Here, a, b, and c are the lengths of the triangle sides, and A is the area of the triangle

5.104 The curvature of a greyhound's location coordinates is the reciprocal of the radius of curvature. Thus,

$$curvature = \frac{1}{p}$$

5.105 The magnitude of centrifugal acceleration a_C is inversely proportional to the radius of curvature (p), which can be calculated by using the following formula:

$$a_C = \frac{v^2}{p}$$

5.106 Here, *v* is the magnitude of the greyhound's galloping speed.

5.107 The centrifugal force, F_C is found by the following equation:

$$F_C = ma_C$$

5.108 Here, *m* is the mass of individual greyhounds.

5.109 The jerk is derived from the rate of change in the centrifugal acceleration.

5.110 The snap is derived from the rate of change in the jerk.

PROBLEMS ENCOUNTERED IN SIMULATING GREYHOUND RACING

5.111 In a real race faster moving greyhounds from the back try to avoid bumping into the greyhounds ahead while other greyhounds attempt to overtake by jumping straight into the greyhounds ahead. This behaviour by the greyhounds is unpredictable and requires more investigation. Currently in the simulation only the behaviour of greyhounds which try to avoid bumping into greyhounds ahead is considered. Collision between greyhounds is controlled by finding the overlap of a number of identical spheres as shown in Figure 5.58. This approach provides near-perfect collision control although it could be further improved by increasing the number and size of spheres or using a different control algorithm.

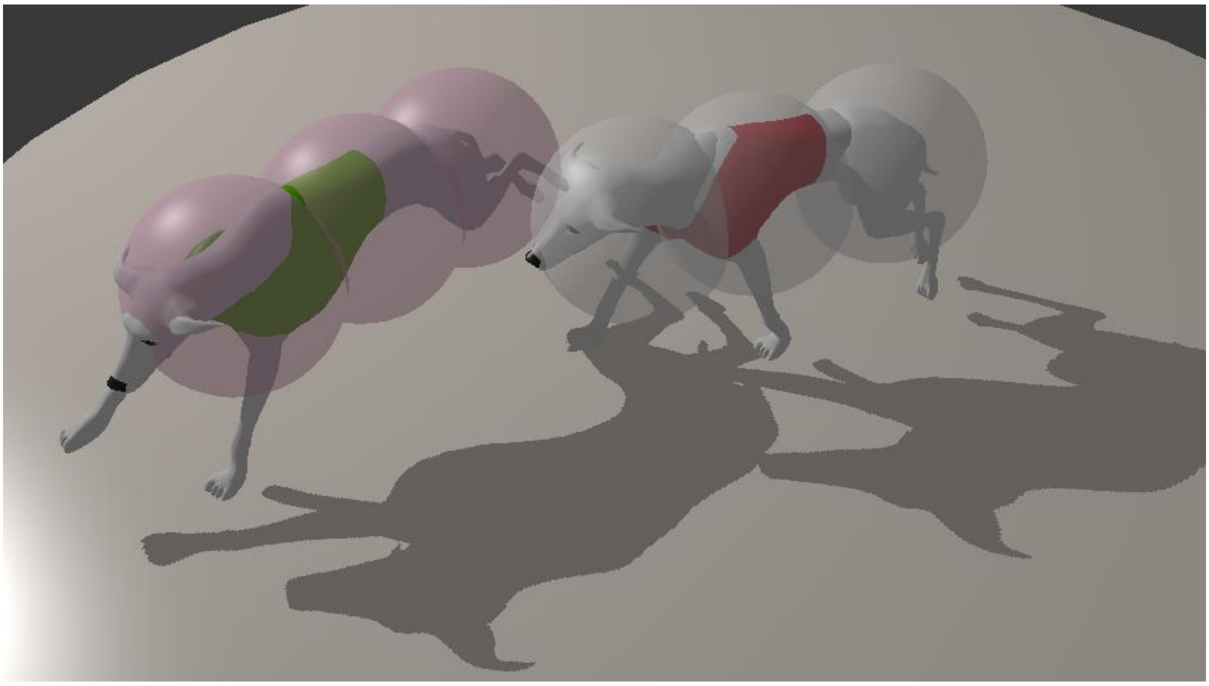

Figure 5.57: Greyhound collision controlled using spheres.

5.112 In the real race it is also noticeable that some greyhounds maintain an extended offset from the inside rail while following the lure. This can be viewed from the following race video:

https://cloudstor.aarnet.edu.au/plus/index.php/s/Z28gK5cWHifEyib

5.113 At the 1:16 second position in the above video the leading greyhound (red) maintains an excessive offset from the inside rail while following the lure.

5.114 This behaviour of greyhounds can be attributed to several factors such as individual greyhound preferences due to physical capabilities.

5.115 Since this behaviour of greyhounds is still not thoroughly understood and random in nature, no factors for this behaviour have been added to greyhound motion in the simulation.

Simulation and modeling work plans

5.116 The following immediate tasks have been identified to progress the greyhound racing simulation and modeling to *stage 2* and *stage 3*:

Major tasks:

- Classify starting boxes based on outcomes and attributes;
- Find statistically significant numbers for probability of accidents for different starts;
- Quantify the probability of checking and bumping associated to each formation pattern; and
- Minimize rate of rotation of greyhounds by finding optimum track shapes and box positions, since rate of rotation is linked to jerk.

Minor tasks:

- Modify the software code to handle 'out of balance' greyhounds in the race as shown by the yellow greyhound in the video below: https://cloudstor.aarnet.edu.au/plus/index.php/s/kxnYsJOWaCodoLV
- Modify the software code to handle 'pushed into the rail' greyhounds like the white greyhound shown in the video below: https://cloudstor.aarnet.edu.au/plus/index.php/s/GfjFaOtsTvbEix2
- Calibrate greyhound steering behaviour more precisely (for this an overhead view of greyhounds racing recorded by a race-following drone would be useful and/or IMU data from the greyhound);
- Improve collision avoidance methods of greyhounds using tree data structures; and
- Calculate ground reaction forces in the racing simulation.

6.0 RECOMMENDATIONS AND FUTURE WORK

EVIDENCE-BASED STUDY

6.1 It is important that all track safety decisions are evidence-based.

6.2 The gathering of evidence is not a trivial matter as the causality of injuries in most cases is multi-variable and in most instances cannot be attributed to a single source or action.

6.3 The other complicating factor is the relatively small sample size. As previously stated the injury data sources prior to 1 January 2016 were inaccurate and could not be relied upon as a reliable source of evidence.

6.4 To-date evidence has been obtained both directly and indirectly from a variety of sources, including: injury data; steward reports; video footage; direct observation; measurements; race simulation; modeling; and analytical calculation of the forces, jerk and snap.

6.5 As a general rule the interventions that are known to reduce injuries, or are known to have a high probability of reducing injuries, should be deployed **at all tracks (both within NSW and other jurisdictions)**. This is important as different equipment and/or procedures have the potential to send confusing messages to the greyhounds. It is important that no matter which track the greyhounds race upon the experience is consistent so the injury preventing behaviour is reinforced over time.

6.6 The McHugh Report [33] made it abundantly clear that GRNSW must instigate injury prevention measures in a timely manner. To delay the rollout of known or highly probable interventions for evidence gathering purposes will expose more greyhounds to unnecessary risk and potential Catastrophic and Major injuries. To delay goes against the clear intent of the McHugh Report.

6.7 From a research perspective the concurrent deployment of multiple interventions complicates the study as it prevents the isolation and analysis of single variables (interventions).

6.8 This Report contains a number of interim recommendations.

6.9 It should be noted that the interim recommendations contained within this Report are based on data that are statistically insignificant.

6.10 Some of the interim recommendations contained herein may be 'noise' in the data due to the small size of the data set.

6.11 Nevertheless it remains the intent of the UTS Project Research Team that the final greyhound track design will be evidence-based and UTS will use the data that flows from recommendations contained herein to adjust, fine-tune and optimise the design during Phase II of this project.

STRAIGHT TRACK

6.12 Clearly using a straight track would eliminate all injuries that are directly associated with bends.

6.13 Bends are problematic for a number of reasons, including but not limited to: the centrifugal force causes the leading greyhound to slow down as it enters the bend and this slowing down results in increased congestion for the closely trailing greyhounds as they are also going through a transient phase in motion and this correction in travel cascades down through the pack; high concentrations of greyhounds such as occurs with races that have more greyhounds; elevated centrifugal forces; instability from changes in heading; only single paw in contact in full gallop; the lack of adequate camber to counteract necessity to lean into the bend; constant changes in the acceleration vectors applied to the greyhounds; and combinations of these reasons.

6.14 The greyhounds are running at the limit state of track and their bodies i.e. the system. Any aberration in their travel such as interference has the potential to result in a catastrophic failure of the system and if this occurs it will result in an injury.

6.15 It is strongly recommended that GRNSW and the Australian Greyhound Industry reconsider their aversion to straight tracks and consider developing purpose-built straight tracks.

6.16 This may require the purchase of land specifically for the purpose of developing one or more 'green-fields' straight TAB tracks.

6.17 It may also require running more races over shorter distances.

6.18 The low number of spectators attending race meets does not warrant or justify the continued usage of oval-shaped tracks.

6.19 Technology now exists to allow excellent live coverage from the boxes to the finish and nationwide broadcast in digital high definition quality.

Reduce track congestion

6.20 All the evidence reviewed to date confirms that the main cause of the Catastrophic and Major injuries is congestion i.e. traffic jam. Approximately 80% of all Catastrophic and Major injuries were caused by congestion and incidents such as checking, collision, galloping etc.

6.21 Congestion occurs for a variety of different reasons, including: lure position too close to the inside rail; greyhounds' short line of sight; inappropriate starting box positioning; lack of transition at the turn; poor track shape; high concentration of greyhounds at the start; and combinations of these factors.

6.22 Clearly using straight tracks would eliminate all injuries that are directly associated with the bend such as elevated centrifugal forces and the associated change in the acceleration vectors applied to the greyhounds.

6.23 The interventions recommended by UTS for the aforementioned injuries will now be discussed.

Install extended lure at all tracks

6.24 The evidence collected over the 12 months from 1 Jan 2016 to 31 Dec 2016 confirmed that the majority of Catastrophic and Major injuries are caused by congestion (approximately 80%).

6.25 Observation, modeling and simulations have confirmed that positioning the lure away from the inner rail and more importantly towards the middle of the track significantly reduces congestion.

6.26 It was concluded that the installation of an extended lure system will reduce the probability of greyhound aggregation and that moving the lure travel position to the centre of the track must be a primary injury reduction intervention.

6.27 The extended lure (coupled with delayed box opening) expands the sight line of the greyhounds particularly at the start but also while the greyhounds negotiate their way around the bend.

6.28 Extending the lure provides more space between the rail and the lure which in turn will reduce the probability of rail collisions.

6.29 At and around the bend the majority of the greyhounds can obtain better lure eye contact. Better eye contact leads to better following but also is less likely to draw them toward the inner rail both on the straight and also on the bend.

6.30 A 1.2 m quasi-extended lure (hereafter the **'hoop arm lure system'**) was installed at Richmond track on 1 July 2016.

6.31 It is understood that the hoop arm lure system is now in effect at all race meetings at The Gardens and Gosford.

6.32 It is also understood that the hoop arm lure system has been deployed at the Casino, Grafton and Lismore tracks on a trial basis.

6.33 It is further understood that the hoop arm lure system is in the final stages of pre-deployment at Dapto, Goulburn and Nowra and that the hoop arm lure system will be deployed progressively at the remainder of the GRNSW tracks.

6.34 Notwithstanding the installation of the hoop arm lure system UTS recommends (Interim Recommendation #01) that GRNSW plan for the installation of an extended lure system along the lines of the lure breaking system deployed by GRV when and if funding permits this intervention on a track by track basis. That GRNSW work collaboratively with GRV and other jurisdictions on a third generation design where the reach of the lure is increased to a distance greater than 2.0 m by incorporating a travelling counter balance into the design.

6.35 UTS recommends (Interim Recommendation #02) that in the longer term the Australian greyhound racing industry work towards modifying the lure system design so that the lure is centrally located.

6.36 There are a number of ways that a centrally located lure could be achieved, including:

- An overhead track mounted carriageway that is centrally located above the track and follows an optimized path of travel which includes Euler-shaped transitions[6];
- The use of an autonomous drone-based lure system[7]; and
- A heavy-duty fourth generation rail mounted hoop arm system that has the capability to extend to the centre of the track.

6.37 UTS recommends (Interim recommendation #03) that the Australian greyhound industry conduct a feasibility study into the viability of a centrally located lure system.

REPOSITION STARTING BOXES TO EXPAND THE LINE OF SIGHT AND PROVIDE MORE TRACK AREA FOR DISPERSION

6.38 The injury location evidence confirmed for the starting boxes that starts onto the turn are where the majority of incidents occur shortly after the start and for those starting onto a straight the majority of incidents occur at the first turn. The injury location evidence thus confirmed that less than optimum starting box positioning is correlated with and most probably causally linked to injury clusters.

[6] The lure would need to be suspended on a rigid arm from a rigid carriageway, as the system will be exposed to a centrifugal force that will result in non-rigid elements swinging at an angle of approximately 45 degrees in a similar manner to a swing on an amusement ride carousel.
[7] The drone and its control system would require high-level security that prevents hackers taking remote control.

6.39 As a case in point the Wentworth Park 520 m and 720 m starts provide sufficient evidence to warrant the initiation of a verification of evidence trial [52].

6.40 Although both race distances start onto a straight section of the track, the 720 m start had a lower injury rate than the 520 m start. The injury data suggest the box-positioning and the track configuration immediately after the start influence the injury rate.

6.41 UTS suggests a verification of evidence trial be conducted by mirroring the Wentworth Park 720 m box configuration for the 520 m start which effectively creates a pseudo shute-like start when the is no land to install a true shute start.

6.42 This trial will also provide valuable evidence regarding congestion reduction.

6.43 Even if this verification of evidence trial does not show a statistically significant drop in injuries it will provide evidence that can be incorporated into the design of the 'optimal track' configuration.

6.44 If this trial confirms that there is less interference at Wentworth Park for the 520 m 'new' start as the greyhounds enter the first turn then UTS recommends (Interim recommendation #04) where this configuration occurs on other tracks they be modified accordingly.

6.45 UTS recommends (Interim recommendation #05) that starting boxes currently located immediately before the turn, or that are on the turn, be progressively removed and that these race distances be discontinued as and when the opportunity to do so without major disruption presents itself.

6.46 UTS also recommends (Interim recommendation #06) a trial be conducted using a 'movable' box start that can be lowered onto the track at the start of a straight such as is done at Healesville.

INCREASING HEIGHT OF GRILLE ON ALL STARTING BOXES

6.47 Evidence by observation confirmed that the greyhounds adopt an unnatural posture immediately prior to the gates opening.

6.48 Prior to box opening when the greyhounds hear the distinct whirr of the lure it is common for greyhounds to lower their heads in an attempt to observe the approach of the lure.

6.49 The current GRNSW 300 mm grille configuration on the box gates induces the greyhounds to adopt an unnatural posture immediately prior to the gates opening.

6.50 The injury location data confirmed injuries are occurring at the start that are non-congestion related.

6.51 It is hypothesised that the awkward pre-start crouching position of the greyhounds is a contributing factor in a family of non-congestion related of injuries.

6.52 This intervention would expand greyhounds' line of sight from the start and assist with the dispersion of the greyhounds and thus assist with a reduction in the congestion shortly after the start.

6.53 UTS recommends (Interim recommendation #07) the height of the grille is increased on all the box gates to at least the height of the GRV 400 mm grille or even the height of the Florida boxes.

DELAYING THE OPENING OF STARTING BOXES

6.54 UTS recommends (Interim Recommendation #08) that a delayed starting box opening trial be conducted at a track that has an upgraded lure and braking system.

6.55 This intervention will require a coordinated implementation **at all tracks** both within NSW and other jurisdictions around Australia, as industry uniformity is paramount.

6.56 As a proof of concept it is proposed that the effects of this intervention are measured indirectly by conducting trials in which box opening is effectively delayed using the current trip position but increasing the speed of the lure at box opening from 50 km/h to 70 km/h. The perception from the greyhounds' perspective will be that they first observe the lure some 40% further along the rail than they do now.

6.57 Alternatively, or in addition, a second trip switch is installed at a set of boxes that is known to have congested starts and a trial be conducted.

6.58 If this trial confirms that there is less interference at the start and when entering the first turn a decision should be made at a national level to install a common second 'delayed' trip switch to every set of boxes in Australia and to separate maiden greyhounds into races where they are only ever exposed to a delayed start. Over time as the pre-delayed box opening cohort of greyhounds retire the industry will only run races with delayed opening boxes.

Upgrade lure drive and braking system

6.59 UTS recommends (Interim recommendation #9) upgrading the entire lure system mainly the drive and braking system.

6.60 Not being able to control a lure is considered a safety hazard.

6.61 The current lure system installed throughout NSW is considered a hazard as both humans and greyhounds are potentially at risk of serious injury or death because the lure driver is unable to stop the lure in a timely manner. The lure has inertia and currently the lure driver must rely upon internal friction within the system to bring it to a stop.

Reducing the number of starts per race from 8 to 6

6.62 One of the main reasons for congestion and traffic jam zones is an excessive number of greyhounds per race.

6.63 Other jurisdictions such as the UK and Ireland are examples where 6 start greyhound races are conducted.

6.64 As a direct intervention for reducing congestion and traffic jam zones UTS strongly recommends (Interim recommendation #10) trialing reducing the number of starts per race from 8 to 6.

6.65 It is suggested that boxes 3 and 6 are not used as a supplementary congestion lowering intervention.

6.66 If the results from this intervention trial confirm less interference at start and the first turn, this intervention should be progressively deployed nationally at all tracks.

OPTIMISING THE TRACK SURFACE

6.67 The evidence reviewed to date confirms that optimising the track surface, particularly at non-TAB tracks, will lower the probability of injuries and reduce the severity of injuries.

6.68 UTS recommends (Interim recommendation #11) investigating and implementing track preparation techniques and/or track materials that optimise the track surface.

6.69 The literature suggests [24] that a considerable proportion of musculoskeletal injuries in racing greyhounds is causally linked to a hard track surface.

6.70 Hard surface correlates with higher speed and greyhounds that travel at a greater speed are more likely to sustain more severe injuries should they fall. They are more prone to sustain musculoskeletal injuries [24].

6.71 With a soft surface the greyhounds are more likely suffer toe injuries and also have sand flung into the eyes by following greyhounds [19].

DATA ACQUISITION USING INERTIAL MEASUREMENT UNITS

6.72 Inertial Measurement Units (hereafter '**IMU**') are a type of electronic device used to measure the magnitude of force (in the form of G-force) during movement.

6.73 UTS intends to use IMU devices to measure the location on the track, displacement, velocity, acceleration, jerk and snap of individual greyhounds and multiple greyhounds.

6.74 These raw data will be processed to measure the dynamic variables acting on greyhounds.

6.75 The result of this experiment not only would precisely determine the hazardous sections of the track as greater magnitudes correlate with higher rates of injuries, but also would accurately determine magnitude of the dynamic variables acting on the greyhounds when an incident occurs.

DATA ACQUISITION USING PAW PRINT ANALYSIS

6.76 UTS intends to measure the precise location of the paw prints for individual greyhounds, multiple greyhounds and greyhounds during transient events such as traffic jams.

6.77 UTS also intends to analysis the shape of paw prints for individual greyhounds, multiple greyhounds and greyhounds during transient events such as traffic jams.

6.78 UTS also intends to temporally correlate individual paw prints with the IMU data.

6.79 The advantages of conducting a paw print analysis are: feedback on track preparation; feedback on track maintenance; studying shape of the paws on different sections of the track and correlating this with IMU data, studying the handedness strategies used by greyhounds and the location of this behaviour, and measuring stride length within different sections of the track.

6.80 Shape of paw print is a good indicator of amount and type of the forces acting on greyhounds' paws e.g. the imperfect shape of paw prints on a bend indicate excessive shear forces due to a high centrifugal force and jerk while turning. It can also provide insight into the track condition as experienced by the greyhound.

6.81 Changes in handedness of greyhounds may represent uneasiness or fatigue[8] of the greyhound as a result of excessive forces applied e.g. a change in handedness is seen when greyhounds enter and exit the bends.

6.82 Stride length and stride frequency are considered as speed indicators. Analysis of stride length on different sections of the track can lead to an estimate of the amount of forces acting on greyhounds.

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[8] The change in handedness observed in greyhounds during a race is analogous to carrying a bag of groceries to the car and changing it from your right hand to your left hand to give your right arm a rest. The greyhounds are running at their limit state and providing their primary propulsion from a single leg. It is hypothesised that as this leg fatigues the greyhounds swap the primary propulsion leg even though they are left or right handed.

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APPENDIX A – INTERIM RECOMMENDATIONS

A.1 Clearly the best option is to use only straight tracks.

A.2 The use of straight tracks would eliminate all injuries associated with greyhounds needing to negotiate their way safely around the bend.

A.3 Notwithstanding, oval tracks exist and while they exist they need to be designed so they are optimised to reduce the injury rates and the severity of these injuries to an absolute minimum.

A.4 This Report contains 11 Interim Recommendations, namely:

#01 GRNSW work collaboratively with GRV on a third generation lure design with a reach that is greater than 2.0 m by incorporating a travelling counter balance into the design.

#02 In the longer term the Australian greyhound racing industry modify the lure design so that the lure travels along the centre-line of the track.

#03 Australian greyhound industry conduct a feasibility study into the viability of a centrally located lure system.

#04 For the Wentworth Park 520 m start install a pseudo shute-like start.

#05 Progressively remove bend starts and discontinue the associated race distances.

#06 Conduct a trial using a 'movable' box start located at the beginning of a straight.

#07 Increase the height of the starting box grilles to at least 400 mm.

#08 Conduct one or more trials with a delayed starting box opening.

#09 Upgrade lure drives and add a braking system.

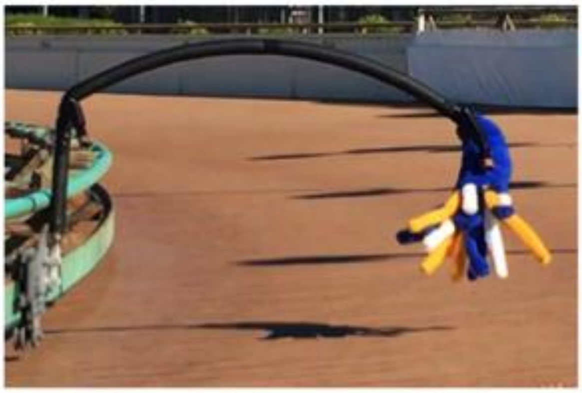
#10 Reduce the number of starts from 8 to 6.

#11 Optimise the track surface.

A.5 Chapter 6 of this Report contains discussion of the above Interim Recommendations.

APPENDIX B – GRV EXTENDED LURE PRESS RELEASE 7 SEP 2016

GRV GREYHOUND RACING VICTORIA



Hoop Arm lures to be implemented at all Victorian tracks

Wednesday, 7 September, 2016, by *Greyhound Racing Victoria*

Greyhounds racing in Victoria will be provided with improved safety outcomes as Greyhound Racing Victoria (GRV) commences implementing the use of the Hoop Arm lure for racing at all 13 tracks throughout the state.

To be phased in over the next six months, GRV will adopt the Hoop Arm lure for racing at all Victorian circle tracks after a series of trials conducted at Victorian racetracks over the past year.

"The hoop arm has produced cleaner and safer racing during the trial period. This improved safety was particularly evident with the latest version of the hoop arm lure which has been trialled at The Meadows," GRV General Manager of Racing Stuart Laing said.

The Hoop Arm lure was trialed at seven Victorian racetracks with the objective of reducing interference in races and subsequently racing incident injuries, as well as examining the motivations of greyhounds to chase the lure.

"In future for races run on the hoop arm in Victoria, the greyhounds will finish in the catching pen as opposed to continuing on and finishing on the lure into the back straight, as has been trialled at various tracks during the trial period," Mr Laing said.

"GRV was not satisfied that using the finish on method was in the best interests of greyhound safety at this time, however GRV is about to be involved in a 'Motivation to Chase' study and will further consider the use of finish on lure in this context."

GRV also accepts that there could be merit in exploring the use of other versions of finish on lure. These matters will be considered in the proposed study.

As well as being adopted at all 12 Victorian circle tracks, there will be a hybrid version developed for use at Healesville's straight track, incorporating the same colour schemes and design as the lures used on the hoop arm.

"The new GRV is doing all it can to provide a long, enjoyable life for every Victorian greyhound before, during and after its racing career and we anticipate this will be a major step towards this outcome", Mr Laing said.

This initiative is the latest in a series of reforms made to Victorian greyhound racing in the past 18 months to improve animal welfare outcomes and follows on from recommendations made in a report by the Office of the Racing Integrity Commissioner last year.

Further details on commencement dates for racing on the hoop arm lure at each Victorian track will be communicated in coming weeks.

Detailed of acceptable and unacceptable lures for training purposes can be found *here*.

< Previous

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APPENDIX C – PRELIMINARY PAW PRINT SERVEY WENTWORTH PAR

C.1 A preliminary paw print experiment was conducted at Wentworth Park track on 4 October 2016.

C.2 The aim of this experiment was to gather data so that a preliminary paw print analysis could be conducted and to compare the paw prints of different regions of the track, namely: a straight section (Home straight) with those on a turn (Northern Turn).

C.3 The trial started on a straight section (Back Straight) followed by a turn of 52 m radius, and then the second straight (Home Straight). The race was 280 m in length with a duration of approximately 26 seconds.

C.4 Figure C.1 shows a schematic view of Wentworth Park track. To compare the stride lengths of the straight and bend sections, ten strides were selected from the Home Straight (highlighted blue) and ten strides from the apex of the Northern Turn (highlighted green).

C.5 Figure C.2 shows a schematic view of Wentworth Park track depicting 2 strides on the Northern Turn.

C.6 Figure C.3 shows an expanded schematic view of Wentworth Park track depicting 3 strides on the Home Straight. A change in handedness is seen as the greyhound entered the Home Straight.

C.7 The mean stride lengths in Back Straight (M=5.53m, SD=0.03) and Northern turn (M=5.02m, SD=0.08) was calculated. The result of an ANOVA test showed a significant difference between the stride lengths in the straight and bend sections [$F(1,18)=20.7$, $P=0.0002$].

C.8 The result of a post ANOVA analysis (t-test: paired two samples for means) showed that stride lengths on the straight section are significantly longer than those on the turn section [$t(9)=4.1$, $P=0.001$].

C.9 This suggests the speed of the greyhounds decreases during the bend section.

C.10 This decrease in speed may be an auto control mechanism of the greyhounds to reduce excessive forces acting on their limbs while negotiating their way around the bend.

C.11 However more experimental results are needed to validate the accuracy of the results.

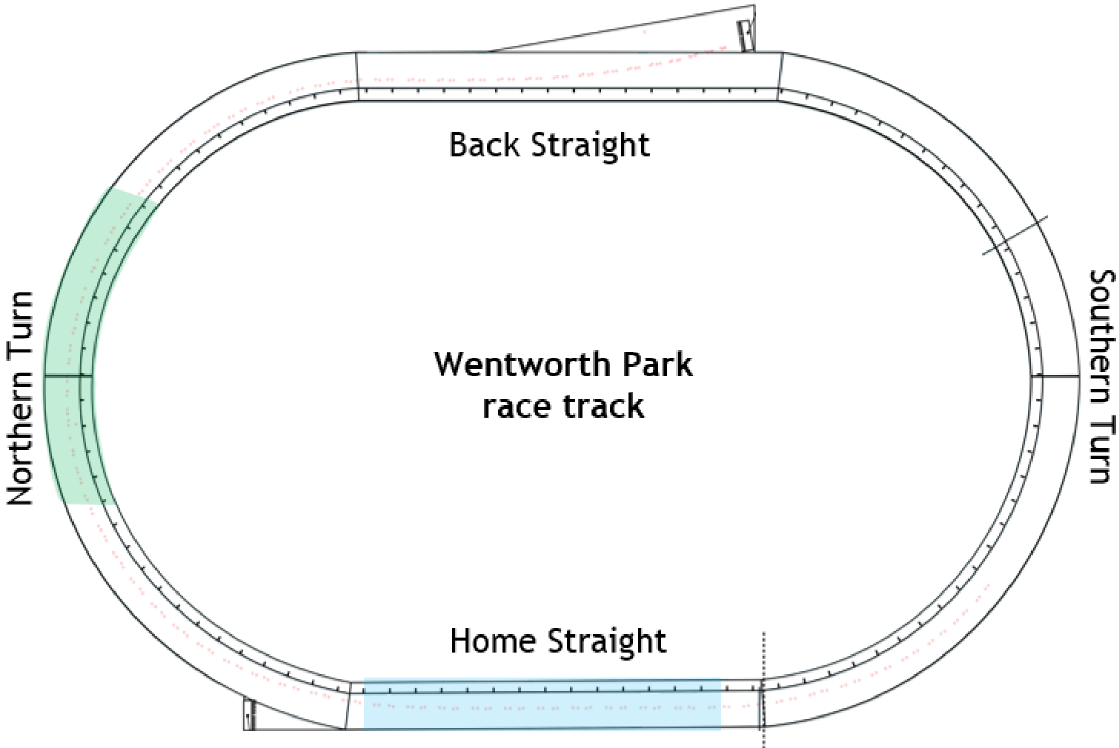


Figure C.1: Schematic view of Wentworth Park track. The blue and green highlighted areas depict 10 strides on Home Straight and Northern Turn.

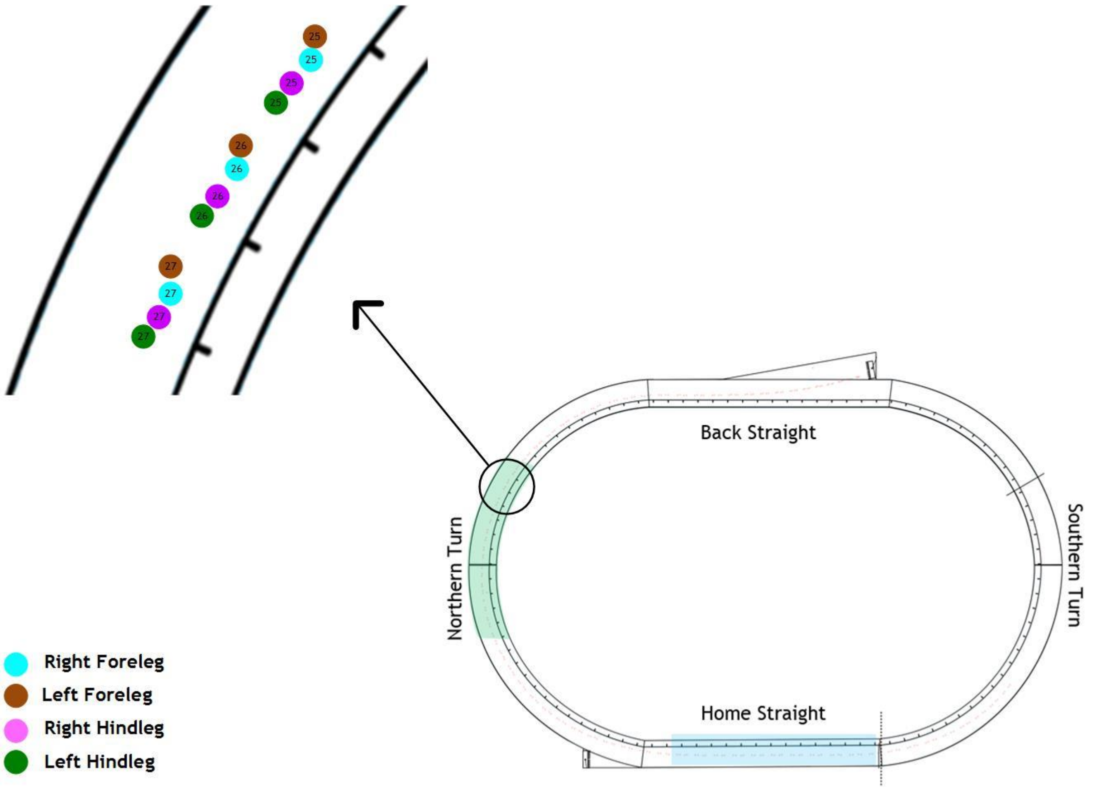


Figure C.2: Expanded schematic view of Wentworth Park track depicting 3 strides on the Northern Turn. Note the greyhound is leading with her left paw.

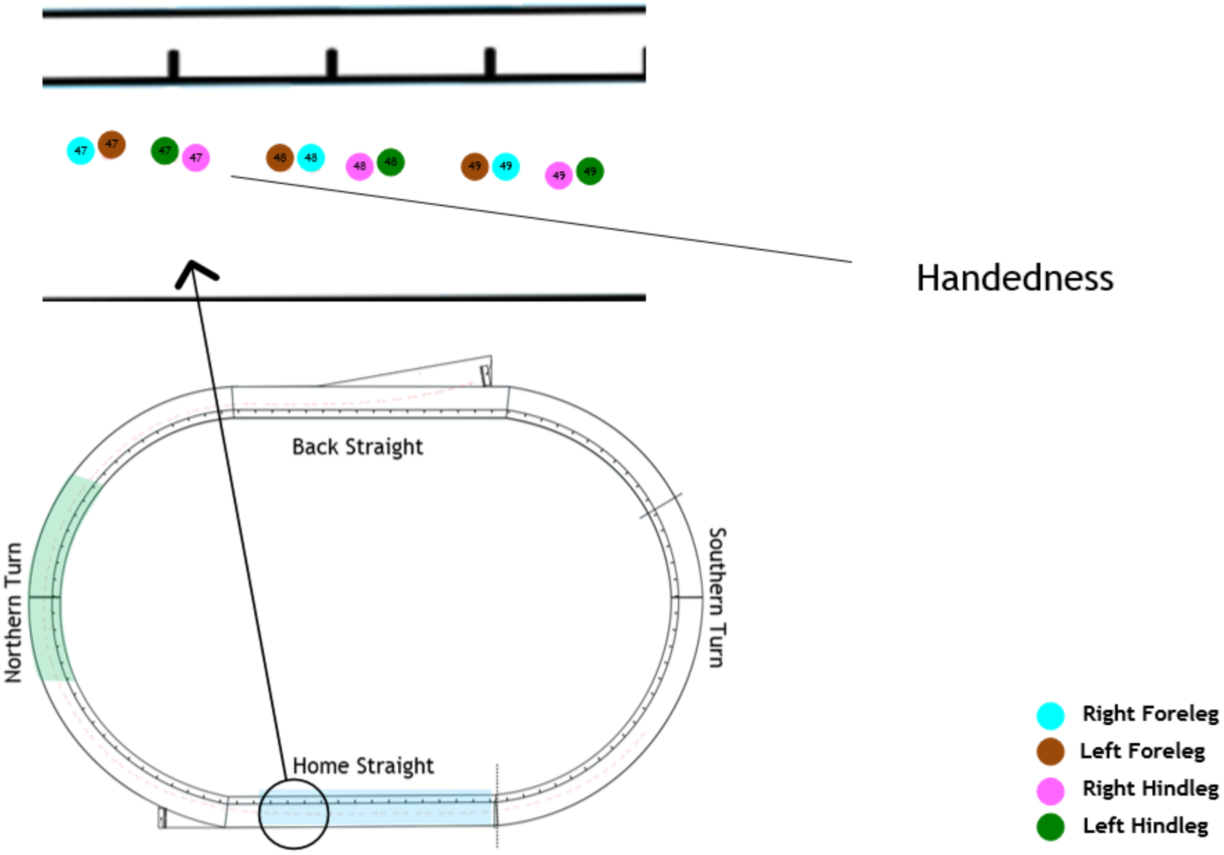
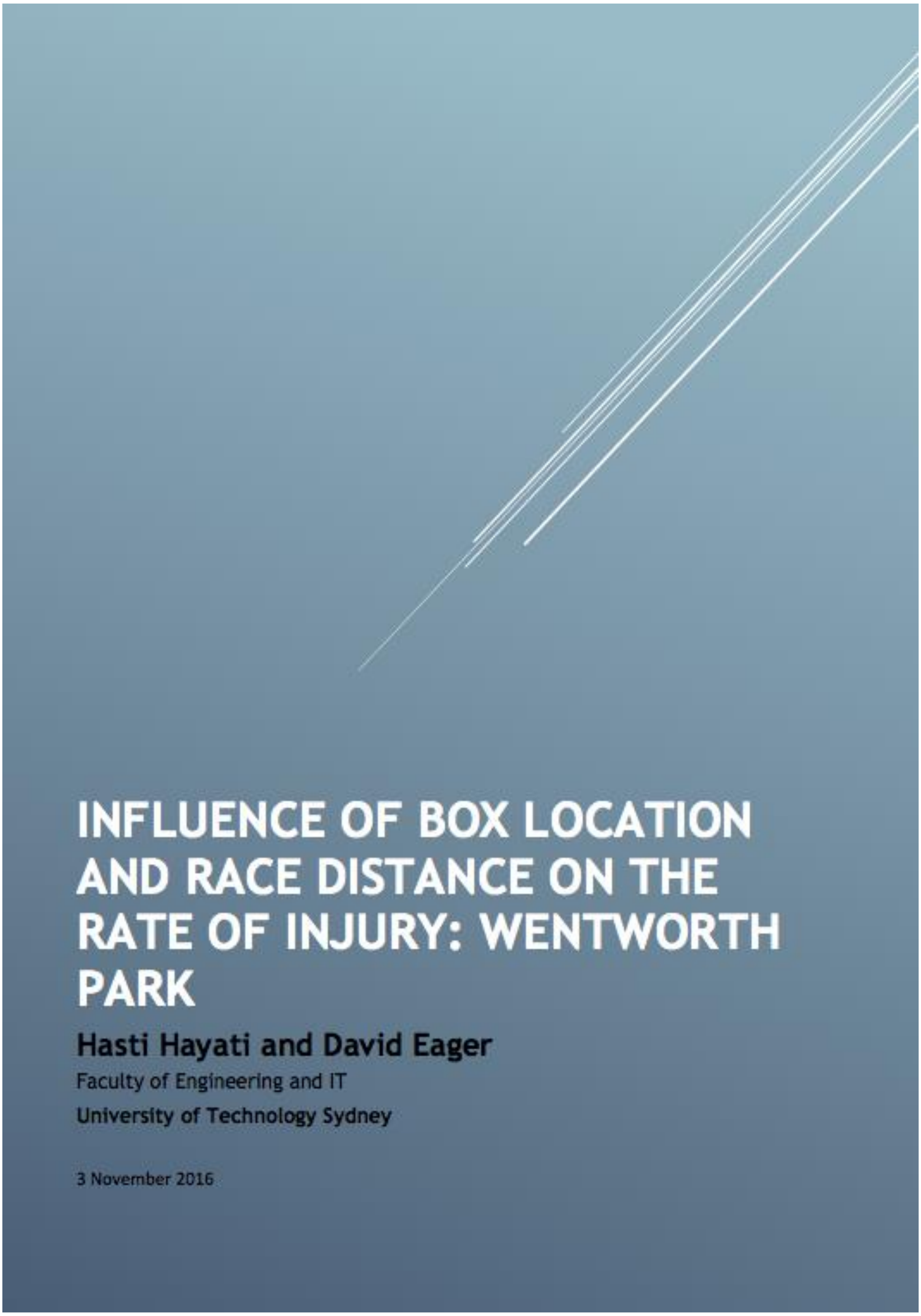


Figure C.3: Expanded schematic view of Wentworth Park track depicting 3 strides on the Home Straight. Noted how the greyhound changed her handedness at the beginning of the home straight from right paw to left paw between stride 47 and 48.

APPENDIX D – INFLUENCT OF BOX LOCATION AND RACE DISTANCE ON THE RATE OF INJURY: WENTWORTH PARK-3 NOVEMBER 2016



INFLUENCE OF BOX LOCATION AND RACE DISTANCE ON THE RATE OF INJURY: WENTWORTH PARK

Hasti Hayati and David Eager

Faculty of Engineering and IT

University of Technology Sydney

3 November 2016

PURPOSE OF STUDY

The purpose of this study is:

- Firstly, to ascertain whether there is any significant difference between the rate of injuries between 280 m, 520 m and 720 m race distances at the Wentworth Park track (hereafter '**WPK**') during the period from 01 of Jan 2016 to 30 of Sep 2016; and
- Secondly, to find problematic locations at racetrack in terms of absolute numbers and level of injuries.

The data obtained using the injury data were provided by Greyhound Racing NSW (GRNSW) and relevant websites[9]. Rate of injuries are defined based on the severity of the injuries which is given in Table 1.

The levels of injuries which are defined in this report are shown in Table 2.

[9] www.thedogs.com & www.ozchase.com

Table 1: Rate of injury definition.

Rating	Incapacitation period	Typical injury types
Minor Class I	0 days	Mild skin abrasions/grazes
Minor Class II	1- 10 days	Grade 1 muscle injury Mild skin laceration
Medium	11- 21 days	Joint /ligament sprain Skin laceration Grade 2 muscle injury
Major	Greater than 21 days	Grade 3 muscle injury Bone fractures
Catastrophic	Deceased or euthanized immediately	Severe skull or spinal trauma Complex /open/joint fractures

Table 2: Level of injury definition.

Level of injury	Definition
Level 1	Catastrophic
Level 2	Major Injuries
Level 3	Medium Injuries
Level 4	Minors Injuries

ABSOLUTE NUMBER AND RATE OF INJURY

RATE OF DIFFERENT LEVEL OF INJURIES FOR DIFFERENT RACE DISTANCES

The rate of injuries for different levels of injury are presented in Tables 3 to 6. The absolute numbers of injuries are also indicated in separate columns.

Table 3: Level 1 injuries WPK for different race distances Jan to Sep 2016.

Month (2016)						
Distance (m)	Numbe r of injuries	Rate of injury / 10 race s	Numbe r of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 race s
	520	520	280	280	720	720
Jan	1	0.12	0	0	0	0
Feb	0	0.00	0	0	0	0
Mar	0	0.00	0	0	0	0
Apr	1	0.12	0	0	0	0
May	1	0.13	0	0	0	0
June	1	0.13	0	0	0	0
July	0	0.00	n/a[1]	n/a[1]	0	0
Aug	0	0.00	0	0	0	0
Sept	0	0.00	0	0	0	0
Mean		0.06		0		0
[1] There was no race at 280 distance in July 2016						

To ascertain whether there is any significant difference between Level 1 injury rates at 280 m, 520 m and 720 m distances, a statistical test (One way Analysis of Variance test (hereafter the '**ANOVA test**')) was performed using MATLAB R16. The result showed a significant difference between rates of Level 1 injuries at different distances (F[6,3.4], P=0.008). Thus 520 m distance has the highest chance of sustaining Level 1 injuries compared to the 280 m and 720 m distances.

Table 4: Level 2 injuries WPK for different race distances Jan to Sep 2016.

Month (2016						
Distance (m)	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 races
	520	**520**	**280**	**280**	**720**	**720**
Jan	3	0.37	0	0	1	1.11
Feb	1	0.15	1	10	1	2.50
Mar	2	0.21	0	0	2	2.50
Apr	5	0.62	0	0	1	0.77
May	1	0.13	0	0	0	0
June	1	0.13	0	0	0	0
July	0	0	n/a[1]	n/a[1]	0	0
Aug	0	0	0	0	1	1
Sept	2	0.30	0	0	0	0
Mean		0.20		1.3		0.90
[1] **There was no race at the 280 m distance in July 2016**						

To ascertain whether there is any significant difference between Level 2 injury rates at 280 m, 520 m and 720 m distances, a statistical test (ANOVA test) was performed using MATLAB R16. The result did not show a significant difference between the Level 2 injury rates in different distances (F[0.56,3.4], P=0.57). Thus, the chance of sustaining Level 2 injuries is similar in different race distances.

Table 5: Level 3 injuries at WPK for different race distances Jan to Sep 2016.

Month (2016)						
Distance (m)	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 race s
	520	**520**	**280**	**280**	**720**	**720**
Jan	4	0.49	0	0	0	0
Feb	3	0.45	0	0	1	2.50
Mar	6	0.63	1	2.50	1	1.25
Apr	4	0.49	0	0	0	0
May	7	0.90	0	0	0	0
June	2	0.27	0	0	2	2.50
July	2	0.29	n/a[1]	n/a[1]	0	0
Aug	1	0.17	0	0	2	2.00
Sept	2	0.29	0		0	0
Mean		0.44		0.31		0.92
[1] **There was no race at the 280 m distance in July 2016**						

To ascertain whether there is any significant difference between Level 3 injury rates in 280 m, 520 m and 720 m distances, a statistical test (ANOVA test) was performed using MATLAB R16. The result did not show a significant difference between the rates of Level 3 injuries in different distances (F[1.2,3.4], P=0.3). Thus, the chance of sustaining Level 3 injuries is similar in different race distances.

To ascertain whether there is any significant difference between Level 4 injury rates in 280 m, 520 m and 720 m distances, a statistical test (ANOVA test) was performed using MATLAB R16. The result showed a significant difference between the rates of Level 4 injuries at different distances (F[12.6,3.4], P=0.008). However, as there was no Level 4 injury at the 280 m distance, which may affect the result of statistical test, a post-statistical test (t-test) was applied to the 520 m and 720 m distances to find which distance has the higher injury rate. The result showed no significant difference in Level 4 injury rates between the 520 m and 720 m distances. Accordingly, though the mean of Level 4 injury rates in the 520 m distance is higher than those in the 720 m distance, the difference is not statistically significant (P=0.19).

Table 6: Level 4 injuries WPK for different race distances Jan to Sep 2016.

Month (2016)						
Distance (m)	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 races	Number of injuries	Rate of injury / 10 races
	520	520	280	280	720	720
Jan	15	1.85	0	0	2	2.22
Feb	8	1.21	0	0	0	0.00
Mar	14	1.47	0	0	2	2.50
Apr	5	0.62	0	0	2	1.54
May	7	0.90	0	0	0	0.00
June	10	1.33	0	0	1	1.25
July	10	1.43	n/a[1]	n/a[1]	1	0.91
Aug	12	2.03	0	0	1	1.00
Sept	6	0.87	0	0	0	0
Mean		1.30				1.04
[1] There was no race at the 280 m distance in July 2016						

LOCATION OF INJURIES AT DIFFERENT RACE DISTANCES

The locations of injuries for each race distances for 280 m, 520 m and 720 m distances are presented in Figures 1 and 2[10] respectively.

LOCATION OF INJURIES FOR THE 520 M DISTANCE

Location of all level injuries at 520 m distance from 01 of Jan to 30 of Sep 2016 is presented in Figure 1.

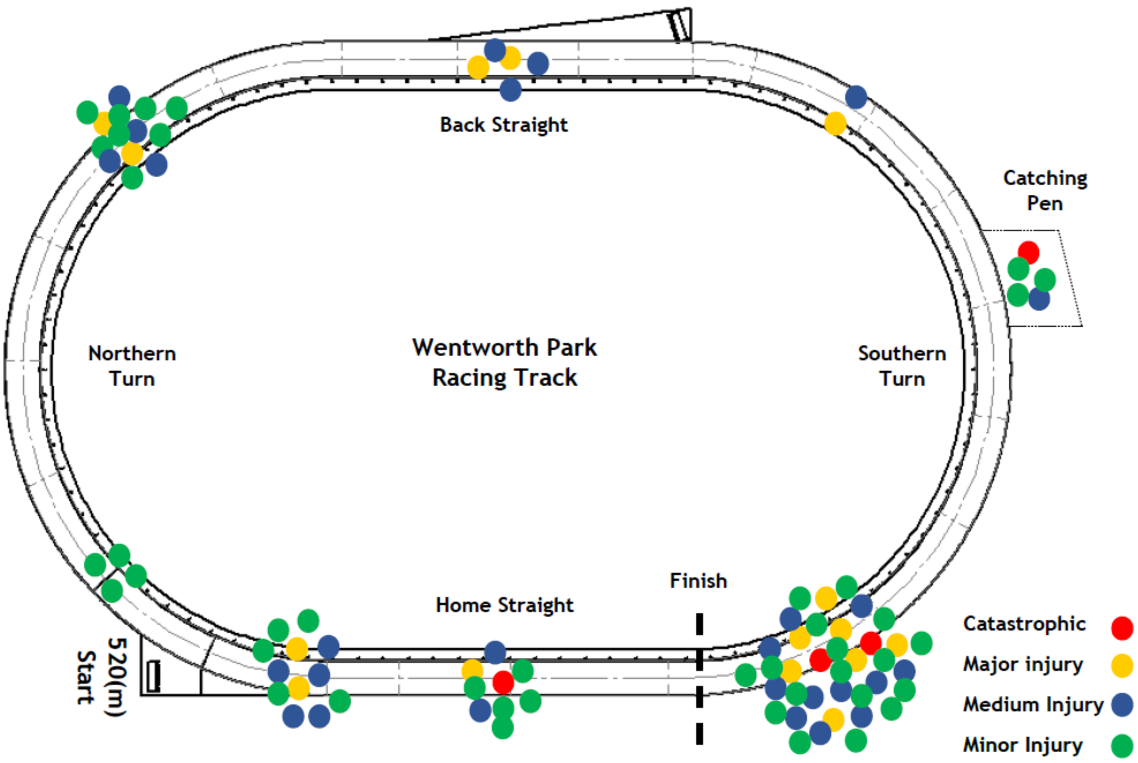


Figure 1: Location of injuries for the 520 m distance 01 Jan to 30 Sep 2016.

[10] Fig 2 shows locations of injuries for both 280 m and 720 m distances.

Where red dots denote Level 1 injury, yellow dotes denote Level 2 injury, blue dots denote Level 3 injury and green dots denote Level 4 injury. There were a couple of injuries of unknown location. However 90% of injuries with unknown location are Level 4 injuries.

To ascertain whether there is any significant difference between absolute numbers of injuries at different locations on the track for the 520 m distance, a statistical test (ANOVA test) was performed using MATLAB R16. The result showed a significant difference between the locations of injuries. The highest number of injuries of known location (43%) were at the Southern Turn (the turn after the Home Straight).

The percentage of injuries at different locations on the track for the 520 m distance are given in Figure 2.

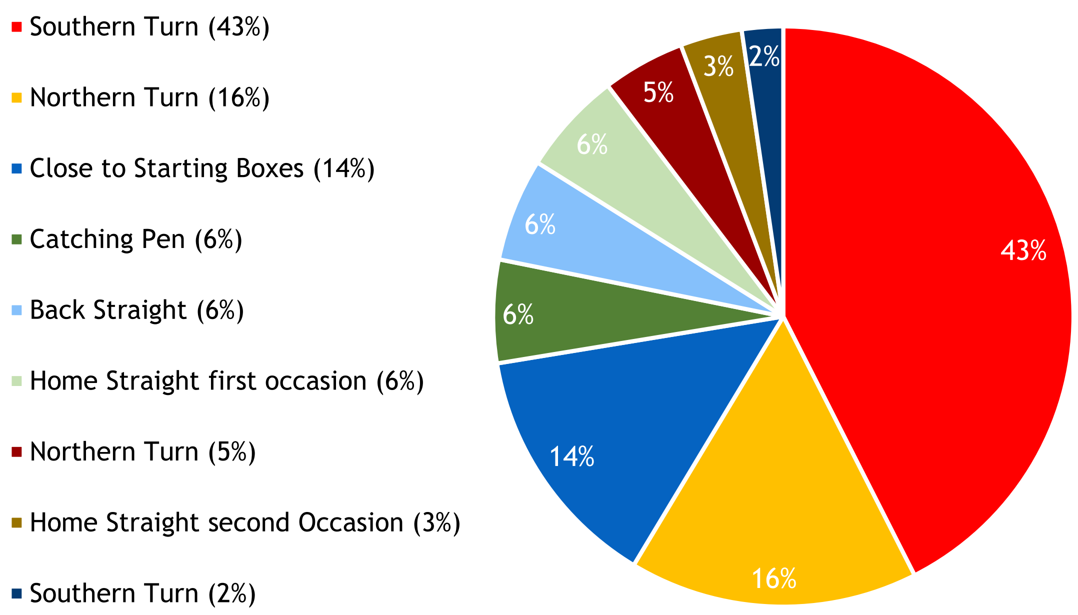


Figure 2: Percentage of injuries at different locations for the 520 m.

LOCATION OF INJURIES FOR THE 280 M AND 720 M DISTANCES

Locations of all level injuries for the 280 m and 720 m distances from 01 of Jan to 30 of Sep 2016 are presented in Figure 3.

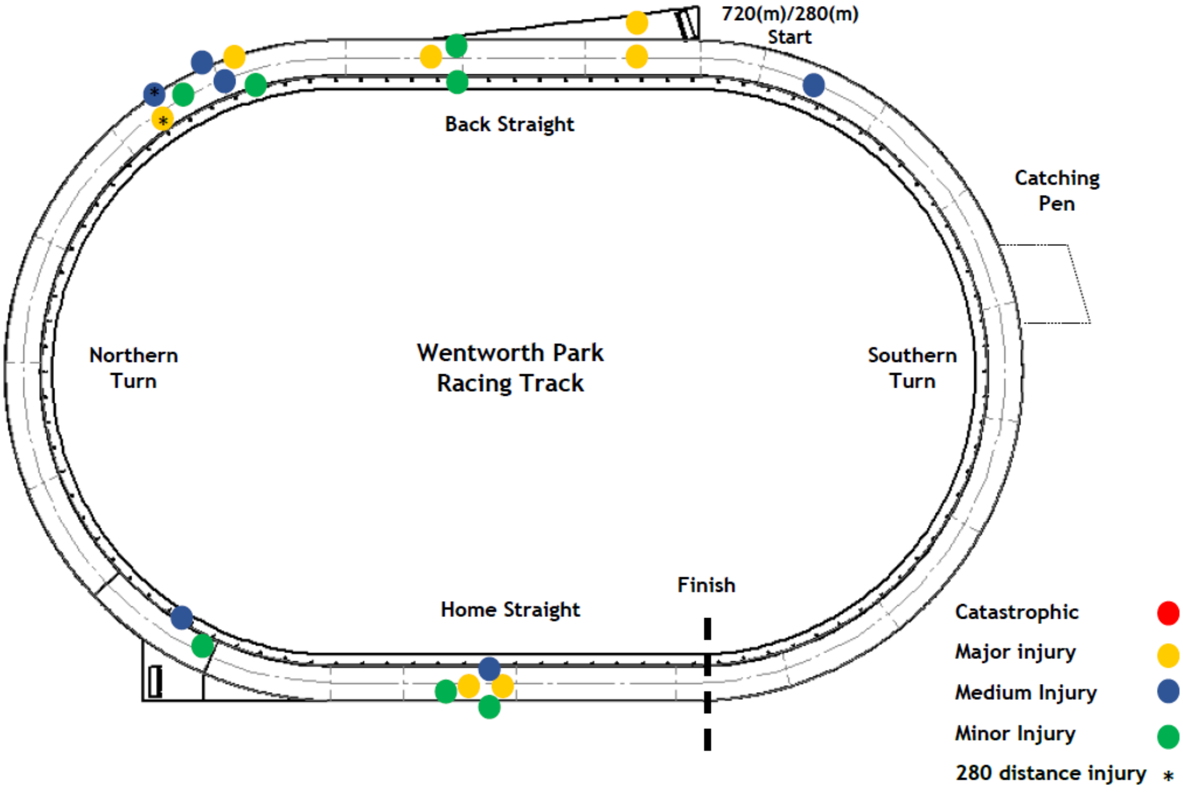


Figure 3: Locations of injuries for the 280 m and 720 m 01 Jan to 30 Sep 2016.

Where red dots denote Level 1 injury, yellow dotes denote Level 2 injury, blue dots denote Level 3 injury and green dots denote Level 4 injury. The star (*) sign shows locations of injuries for the 280 m distance.

To ascertain whether there is any significant difference between absolute numbers of injuries at different locations on the track for the 720 m distance, a statistical test (ANOVA test) was performed using MATLAB R16. The result did not show a significant difference between the locations of injuries at the 720 m distance.

The percentage of injuries at different locations on the track for the 720 m distance are given in Figure 4.

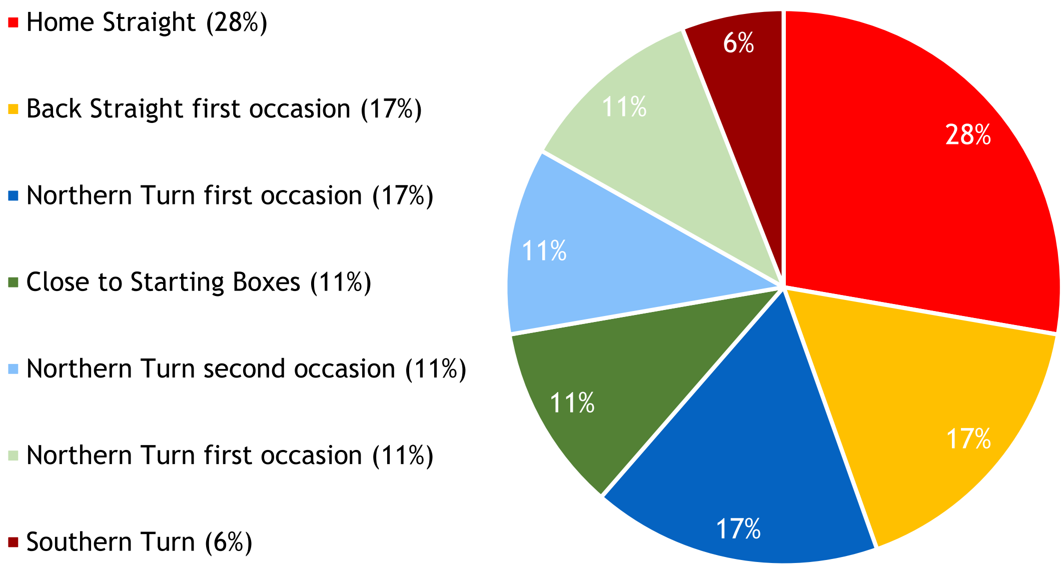


Figure 4: Percentage of injuries at different locations of the track for the 720 m.

CONCLUSION

The Level 1 injuries for the 520 m distance are significantly higher than those at the 280 m and 720 m distances. It is worth noting that the Level 1 injuries are the worst category of injury which led to the greyhound being euthanaised (i.e. complex/open/joint fractures, severe skull or spinal trauma).

There was no significant difference between Level 2, Level 3 and Level 4 injury rates at different race distances (i.e. chance of sustaining Level 2, Level 3 and Level 4 injury is the same for 280 m, 520 m and 720 m distances).

Almost half of the injuries occurred at the Southern Turn on the first occasion in the 520 m distance while no injury was seen at this turn in the 720 m distance.

Two differences between the 520 m and 720 m distances at the Southern Turn are the speed and distribution of the greyhounds around the inner rail. For the 520 m distance, the greyhounds have reached their maximum speed (this turn is shortly after the start where greyhounds have already completed the acceleration phase) and are clustered around the inner rail (this turn is shortly after the start and there is not enough time for greyhounds to be dispersed), whereas in the 720 m distance greyhounds are at a lower maximum speed (as this turn is the second turn after the start) and are dispersed.

As a general observation, the greyhounds which race at the 720 m distance are stronger but slower than those racing at the 520 m distance. More specifically, it was noted that the 720 m starters are slower around the Southern Turn.

The following was concluded:

1. There is no evidence that mirroring the 720 m box configuration at the 520 m will increase the injury rate; and
2. There is a high probability that mirroring the 720 m box configuration at the 520 m will decrease the injury rate.

APPENDIX E – GRNSW REQUEST FOR RESEACH PROPOSALS DATED 11 JAN 2016