Injuries in racing greyhounds

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ABOUT THE AUTHOR

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COVER IMAGE

Racing greyhounds struggling to stay upright whilst rounding a bend at Monmore Green race track in England, in 2010. Photographer: Graham Jones.

CONTENTS

1. Industry overview

Greyhound racing has taken place in the UK since the 1920s and the fundamental principles of the activity of greyhound racing, track layout in operational terms, remain largely the same. Although there has been a sustained decline in the sport's popularity in recent decades, it continues to draw crowds and supported a £1.3 billion off-course turnover for bookmakers in 2012-2013 (Deliotte 2014).

There are around around 15,000 active racing greyhounds in the UK today (EFRA 2016). They are raced anti-clockwise over the flat or hurdles around ovoid tracks, over distances of 210 – 1,105 m (Hercock 2010). A maximum of eight greyhounds can be entered into a race on GBGB licensed racecourses (GBGB 2018a). As of October 2018 there were 21 tracks licenced by the Greyhound Board of Great Britain (GBGB) – the industry regulatory body, as well as 5 independent tracks (Anon. n.d.).

The racing lifespan of a greyhound is short. Racing greyhounds start competing once they reach the age of 15 months, and they're usually raced weekly until made redundant due to poor racing performance, being past their prime at around five to six years of age, or after suffering a career-ending injury (Hercock 2010). The average racing greyhound is just two to three years of age.

2. Welfare Concerns

Welfare concerns centre relate to the 'wastage' of greyhounds in the industry, standards within kennelling, husbandry and transportation, and the injuries racing greyhounds sustain.

'Wastage'
Major welfare concerns relate to those dogs who are bred for racing, but never see the race track, and to those dogs that are retired from racing.

From 2018, the GBGB started to publish injury and retirement data online (GBGB 2018b). It reported that in 2017, 6,391 (86.32%) greyhounds were retained or rehomed, and 1,013 (13.68%) were killed or died a sudden death. However, there is no indication whether these figures included dogs that failed to make the grade at a trial, and they only related to GBGB licensed tracks.

Additionally, the House of Commons Environment, Food and Rural Affairs Committee (EFRA) (2016) recently voiced concern that "the fate of retired dogs unable to be rehomed at the end of their careers is unclear." They noted that in evidence supplied to EFRA, the Greyhound Forum[1] (2015) estimated that around 3,700 dogs are unaccounted for each year. This estimate was not dissimilar to that of APGAW (2007), which similarly considered numbers of greyhounds homed or rehomed and calculated that:

> … a minimum of 4,728 dogs are unaccounted for each year and we can assume that the majority of these dogs are destroyed. However, this figure does not account for dogs from independent racing or those which are bred for the British racing industry in Ireland. These figures must therefore be regarded as conjectural and are likely to be a significant underestimation of the true scale of the problem of unwanted dogs being destroyed.

Associated concerns are the breeding of greyhound bitches too young, too old, or too frequently (Hansen 2017), and the conditions in which breeding bitches may be kept.

[1] Representing eight greyhound and canine welfare organisations

Kennelling, husbandry and transportation

Significant welfare concerns have been associated with the kennelling and standards of care applied to racing greyhounds. These may relate to space provided in kennels, lighting levels, exercise opportunities, sanitation, and diets, dental and veterinary care, including regular vaccinations and other preventative healthcare treatments (e.g. parasiticides). A three month detailed investigation into the conditions of Greyhound training kennels in the UK published by the Dogs Trust (2015) revealed that breaches of even the minimal standards extant within the GBGB minimum standards Rule 212 and CIEH Guidance on Animal Boarding Establishments Act 1963, were common. These included kennels heavily soiled with excreta and urine that appeared not to have been cleaned for days, thick layers of dust and cobwebs, and absence of any visible signs of cleaning or cleaning materials. Some facilities were in a poor state of repair, with sharp metal and wooden edges posing injury risks to dogs, rot and water damage causing roofing collapse and additional hazards, inadequate lighting, no visible firefighting equipment, filthy food preparation areas, and additional problems. This author has observed very similar conditions in other video footage taken from a British greyhound racing kennel (Appendix). Photographs illustrating the problems are available online[2].

Concerns also exist about the relative lack of normal socialisation and habituation opportunities for dogs born into the greyhound industry. Socialisation is the learning process whereby an individual pup learns to accept the close proximity of other dogs as well as members of other species. Habituation is the process it becomes accustomed to non-threatening environmental stimuli and learns to ignore them (Hansen 2017). The 2016 Special Commission of Inquiry into the Greyhound Racing Industry in New South Wales (McHugh 2016) concluded that if a greyhound is not sufficiently socialised or habituated it may pass on negative traits such as fear and anxiety to any offspring, which can make it difficult for the greyhound to be rehomed. GBGB statistics reveal that 27 per cent of greyhounds that died or were killed in 2017 were designated unsuitable for rehoming (GBGB 2018b). Accordingly, greyhounds should not be individually housed, and should be exposed to a wide range of socialisation opportunities and normal stimuli from an early age (Hansen 2017).

Racing greyhounds are also regularly transported to racetracks. To help minimise stresses associated with transportation, it is important to ensure that greyhounds are able to stand up at full height and turn around at all times. However, the GBGB (2018a) Rules of Racing only requires that travel cages "… must have the following dimensions: 35.56cm/14in width, 101.6cm/40in length, 76.2cm/30in height" although the GBGB notes these are only minimum permissible sizes. These dimensions do not allow for a greyhound to stand and adopt a natural posture, which contravenes EU regulations.

3. Injuries

As Hansen (2017) observed, "Greyhound racing is inherently dangerous. Greyhounds race at high speeds in conditions which make injuries almost inevitable."

In its report into greyhound welfare, the House of Commons Environment, Food and Rural Affairs Committee (2016) reported that "after prolonged conversations" the industry provided the death and injury statistics in Table 1 for 2012 – 2014. It should be noted that use of the term 'euthanasia' (e.g. in the Retirement form for GBGB-registered greyhounds[3] - Fig. 1) is often misleading. By definition, euthanasia refers to killing that is not only humanely conducted, but also in the animal's best interests – typically due to very severe injury or illness when the prognosis for recovery is poor (AVMA 2013). Much killing of greyhounds is conducted for other reasons, e.g. lack of homes when racing careers end, and cannot be accurately termed 'euthanasia.'

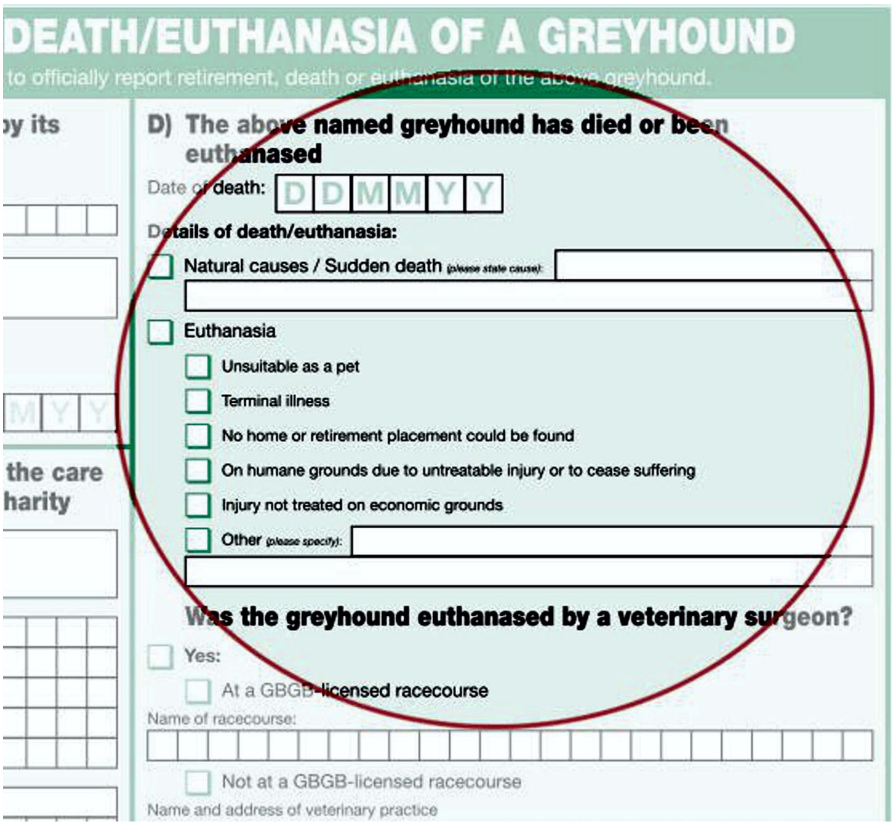
[2] http://greytexploitations.com/resources-reports/kennel-hand-speaks-out-as-the-greyhounds-voice/

[3] http://www.gbgb.org.uk/uploads/pdf/GBGB%20Retirement%20Form%20June%2014.pdf

Table 1: Injury and euthanasia data from GBGB tracks

Reported Numbers	2012		2013		2014	
	% of all raced dogs	Number of raced dogs	% of all raced dogs	Number of raced dogs	% of all raced dogs	Number of raced dogs
Euthanasia	0.12	441	0.13	461	0.13	393
Hock & Wrist injuries	0.19	687	0.19	643	0.21	693

Source: Racecourse Promoters Association



DEATH/EUTHANASIA OF A GREYHOUND

to officially report retirement, death or euthanasia of the above greyhound.

D) The above named greyhound has died or been euthanased

Date of death: D D M M Y Y

Details of death/euthanasia:

- Natural causes / Sudden death (please state cause):
- Euthanasia
  - Unsuitable as a pet
  - Terminal illness
  - No home or retirement placement could be found
  - On humane grounds due to untreatable injury or to cease suffering
  - Injury not treated on economic grounds
  - Other (please specify):

Was the greyhound euthanased by a veterinary surgeon?

- Yes:
  - At a GBGB-licensed racecourse

Name of racecourse:

- Not at a GBGB-licensed racecourse

Name and address of veterinary practice

Figure 1. Misuse of the term 'euthanasia' within the Retirement form for GBGB-registered greyhounds.

With respect to these data from 2012 – 2014, EFRA noted that: "The above data is not comprehensive as it is taken from 22 of 24 GBGB-licensed tracks, it does not cover all types of injuries, and it does not include injuries to dogs that manifest later away from the track."

EFRA also noted that these data provided by the Racecourse Promoters Association are significantly lower than "an analysis provided by the welfare organisation Greyt Exploitations, in association with the Sunday Times, of incidents at races over a 10 year period [which] reported that 40,151 dogs were injured and 18,410 did not race again." (Burgess 2015).

From 2017, the GBGB started to publish injury and retirement data online for GBGB licensed tracks. The numbers of injuries and track fatalities are included in Table 2.

Table 2. Injury and fatality data for 2017 on GBGB licensed tracks (GBGB 2018b).

	Total injuries	**Injuries as % of 419,385 total runs**
Hock injuries	843	0.20
Wrist injuries	707	0.17
Foot injuries	833	0.20
Hind long bone	48	0.01
Fore long bone	100	0.02
Fore limb muscle	540	0.13
Hind limb muscle	1,110	0.26
Other	656	0.16
Total injuries	**4,837**	**1.15**
Track fatalities	**257**	**0.06**

These rates do not appear to compare favourably with some international data. Sicard et al. (1999), for example, studied injuries sustained by racing greyhounds at five greyhound tracks in Wisconsin, US. In total, 1,887 orthopaedic injuries occurred during a two year period, within 43,260 official races. Eight greyhounds normally run in US races, giving a total of 346,080 greyhound starts – an orthopaedic injury rate of 0.55%. In contrast, the British injury rates reported by the GBGB (Table 2) were approximately double, at 1.15%. However, Sicard et al.'s study was limited to orthopaedic injuries, which may partially account for the discrepancy.

Causes of trackside deaths are indicated by a study of 87 greyhounds (61 male and 26 female) 'euthanased' at a GBGB registered track from June 2007 to August 2010 (Hercock 2010). The three top causes were severe injuries sustained during racing (80), health problems resulting from racing (3) and behavioural problems such as aggression (11) (Fig. 2). Some dogs suffered from more than one of these problems.

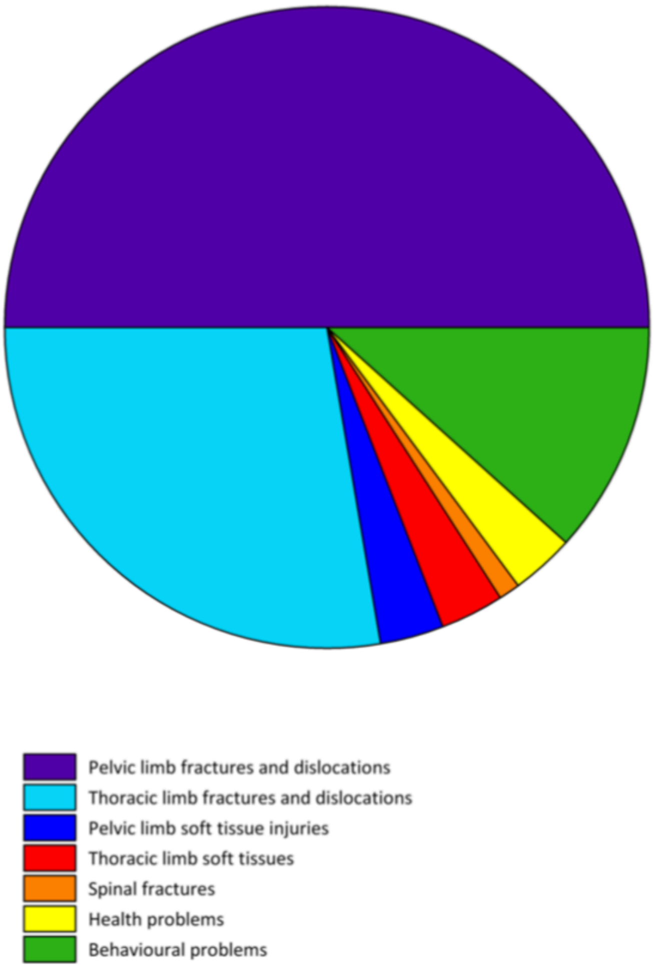


Figure 2. Reasons for 'euthanasia' of 87 Greyhounds at a GBGB registered track from June 2007 to August 2010 (Hercock 2010).

The primary remit of this report is the injuries sustained by racing greyhounds – particularly, fractures. Predisposing factors, common injury types, and recommendations for decreasing injury rates are examined in the following.

3.1. Injuries: predisposing factors

Factors such as speed, race distance and track design (particularly turn radius of curvature, and degree of camber (banking)) can all significantly affect increase risks of musculoskeletal injuries (Sicard et al. 1999). Additional predisposing factors may include region, weather, individual dog behaviour and physical characteristics, and local regulations.

Such predisposing factors may be classified into greyhound factors, and track/environmental factors.

3.1.1. Greyhound factors

The lean, athletic physique of greyhounds, in conjunction with a number of less obvious musculoskeletal and physiological adaptations, have made them ideally suited as sprinters (Williams et al. 2009) (Fig. 3). These characteristics have been enhanced through many decades of selective breeding. Accordingly, greyhounds are able to maintain average running speeds of around 65 km/h, versus 29 km/h for human athletes (Von Boehn 2011). They are the fastest breed of domestic dog, capable of reaching speeds of up to 18 m/s during racing (Hercock 2010).

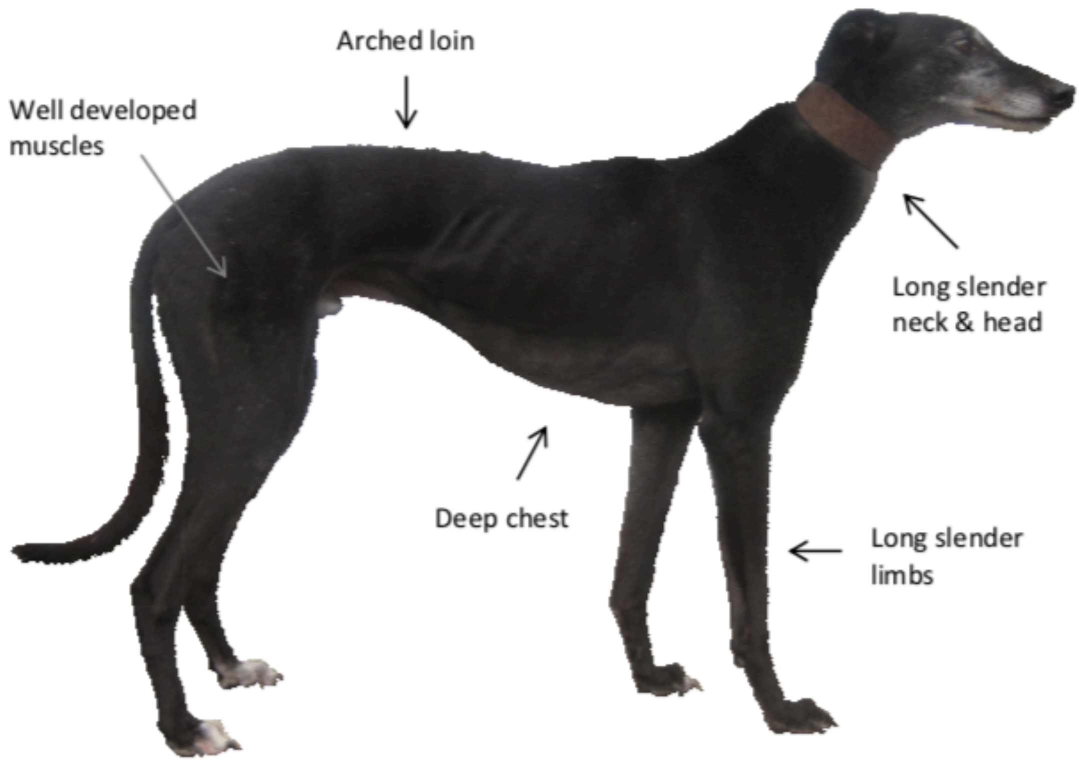


Figure 3. Some greyhound anatomical adaptations for speed (Burton, courtesy of Fay Penrose, in Hercock 2010).

However, such speeds result in very considerable forces on the greyhounds' limbs. The 'ground reaction force' is comprised of three components: the vertical component supports the body weight, whilst the horizontal (fore-aft) and mediolateral (sideways) components allow the animal to accelerate, decelerate, manoeuvre and balance (Biewener 2003 in Hercock 2010). Forces are affected by the weight and speed of the greyhound. As speed increases, ground contact time decreases, and forces generated against the ground increase still further (Hercock 2010).

Greyhounds have developed anatomical adaptations to these high forces, which include tendons in the distal limbs (ends of limbs) that are stronger and stiffer than in some other breeds. Their muscle-tendon units have a higher capacity for elastic energy storage, and an increased efficiency of energy recovery when compared to the Staffordshire Bull Terrier (Hercock 2010).

Whilst racing, greyhounds are subjected to high rates of acceleration, speed changes, and – when rounding bends – both centripetal and other ground reaction forces (Bloomberg et al. 1998, Usherwood and Wilson 2005). Forces are affected by greyhound velocity and mass, and track radius of curvature. Bitches normally weigh 23 – 30 kg, and dogs 27 – 37 kg (Hercock 2010). However effective body weight increases by approximately 71.0 per cent around bends, because body mass is subjected to both gravity and high centripetal acceleration. All four limbs experience an increase in peak force of approximately 64.5 per cent (Usherwood and Wilson 2005). Greyhounds transfer their weight to the left side of their limbs when they corner (Boemo 1998) (Report cover image). Hence their distal limb bones are loaded asymmetrically, with bones, and bony components, nearest to the inside of the track experiencing higher stresses (Fig. 4). As stated by Eager et al. (2017):

> 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 [Hickman 1975].

Figure 4. Greyhounds running anticlockwise transfer their weight to the left side of their limbs when they corner.

The asymmetric training and racing greyhounds undergo results in corresponding asymmetric anatomical adaptations, which were examined in detail by Hercock (2010). Rail-side (inside, i.e. left) leg bones experience the greatest average forces. The skeleton seeks to adapt to these increased forces by resorbing calcium from some regions and depositing it in others (remodelling). The left distal limb bones have significantly increased bone mineral density and markers of bone metabolism. They also have localised changes in bone composition (e.g. trabecular architecture – referring to 'spongy' or honeycombed bone). Bones on the right side are conversely depleted of calcium (Hercock 2010) – but are still subjected to severe stresses, especially during bends. Hercock (2010) conducted a detailed study of fractures in racing greyhounds. Summarising her examination of fractures of the right central tarsal bone, she stated that:

> … the fractured bones showed evidence of being hypomineralised (i.e. low mineral and high collagen content). These changes in the bone matrix and the asymmetries between the left (uninjured) and right (fractured) bones indicate an imbalance in the bone remodelling process has occurred leading to weakening of the bone and structural failure.

Rail-side bones (i.e. those within each limb that are closest to the inside of the track) also appear to undergo bony resorption as part of their remodelling. The likelihood of fracture can increase when bones are temporarily weakened during this process (Hercock 2010).

Additionally, racing greyhounds have left to right asymmetries in the tensile properties of their pelvic limb (hind limb) tendons, with rail-side tendons being stronger, stiffer and returning more energy than those in the contralateral limb (Hercock 2010).

Injury rates are also affected by greyhound age and weight. Young greyhounds (6 to 37 months) have a higher prevalence of metacarpal and metatarsal fractures (Bellenger et al. 1981, Ness 1993, Piras 2005), possibly due to lack of skeletal maturity and strength. Males are also more susceptible to these fractures than females (Gannon 1972, Ness 1993, Piras 2005), possibly due to their heavier weights (Hercock 2010).

3.1.2. Track and environmental factors

The injury risks to greyhounds racing at speeds are significantly affected by track design and composition, and can also be affected by weather and track maintenance.

Track design

Curved tracks are hazardous, because of the uneven forces they create on greyhounds whilst negotiating bends, as described above. This places asymmetrical forces on limbs, increasing the loading of certain limbs.

Additionally, curves also create areas of congestion. When greyhounds round curves, they have two options for dissipating excessive forces acting on their limbs: they may slow down, or seek a larger radius of curvature. Either may result in congestion (Fig. 5).

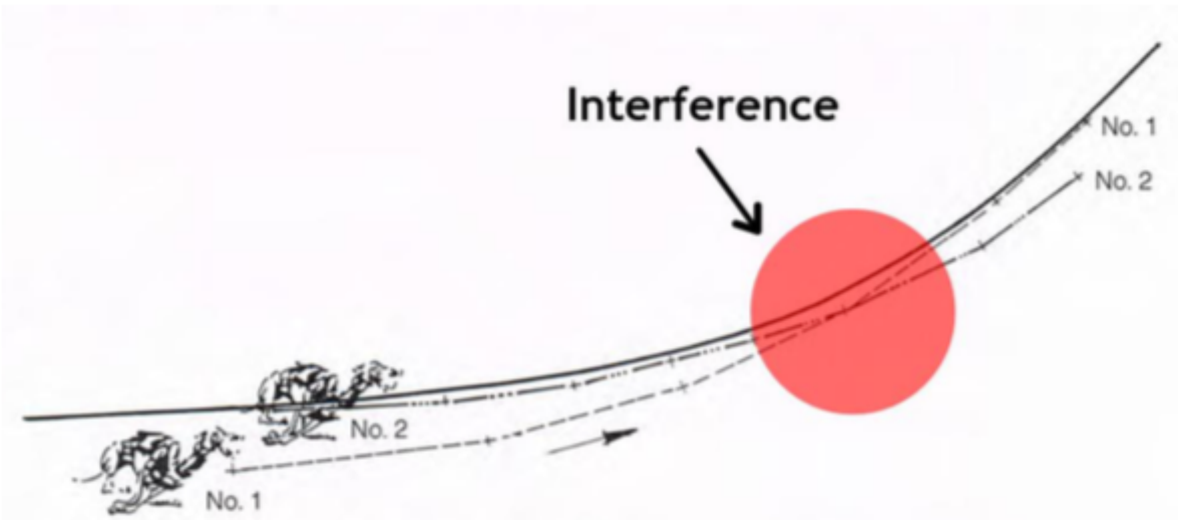


Figure 5: Zone of congestion during cornering (after Bloomberg et al 1998, in Eager et al 2017).

Congestion significantly increases risks of high speed collisions with other greyhounds, the rail or track surface. An inquiry undertaken by New Zealand's Racing Integrity Unit (RIU 2016) concluded that 68 per cent of injuries, and 75 per cent of fatalities, occurred from accidents at or approaching the first bend, when congestion is often at a maximum (Fig. 6).

Figure 6. Bends result in congestion, increasing risks of serious collisions.

Tracks of a larger radius, and steeper banking (camber) of curves, both reduce the degree to which greyhounds need to 'lean' inwards during cornering (Bloomberg et al 1998). This can decrease congestion risks, but results in faster speeds, with greater ground reaction forces. Unfortunately, many British tracks were designed many years ago when greyhounds were generally smaller and slower (APGAW 2007).

Track composition

In order for greyhounds to run with a smooth gait, the track surface should provide sufficient, uniform friction, without being so hard that injury risk is increased (Bloomberg et al 1998). In the US, track materials are a mixture of sand, silt, clay and water, which have varying particle sizes and mechanical properties (Gillette 2016). Their ratio determines impact absorption characteristics. For greyhound racing, the track surface should be resilient and have enough moisture content to dissipate impact forces (Bloomberg et al 1998). Ireland in Bloomberg et al. (1998) asserted that light-colored loam mixed with white sand is ideal. Gillette (2016) advises a 'sandy loam' or 'loamy sand' mix is optimal. Iddon et al. (2014) analysed injury data from a five year period at London's Rye House track, finding that a grass surface decreased injuries compared to a sand surface. Their analysis of data from a four year period at London's Walthamstow track also showed that fast track conditions significantly increased injuries. However, sand has almost completely replaced grass as a running surface on British greyhound tracks (APGAW 2007).

Moisture consistency influences compressive and shear strength. Moisture deficiency results in a hazardously hard track, and its excess decreases surface stability, with the result that sand may be thrown up into the eyes of following greyhounds (Bloomberg et al 1998). Toe injuries also increase (Gillette 2016). High ambient temperatures can evaporate track moisture and make the surface drier and harder. Prole et al. (1976), analysed two British tracks and concluded that in drier months, injuries were increased. They attributed this to the harder surface and associated faster running conditions (Prole 1976). Conversely, a drainage system is essential in controlling the scour and movement of surface material in the presence of heavy rainfall.

Track layers

The racing track is comprised of two layers (Fig. 7). The paw first penetrates the superficial absorptive layer, to briefly grip the deeper traction layer (Gillette 2016). The layer depths should remain even on both straight and bend sections (Figure 7.A) as depth variations are hazardous (Figure 7.B) (Gillette 2016).

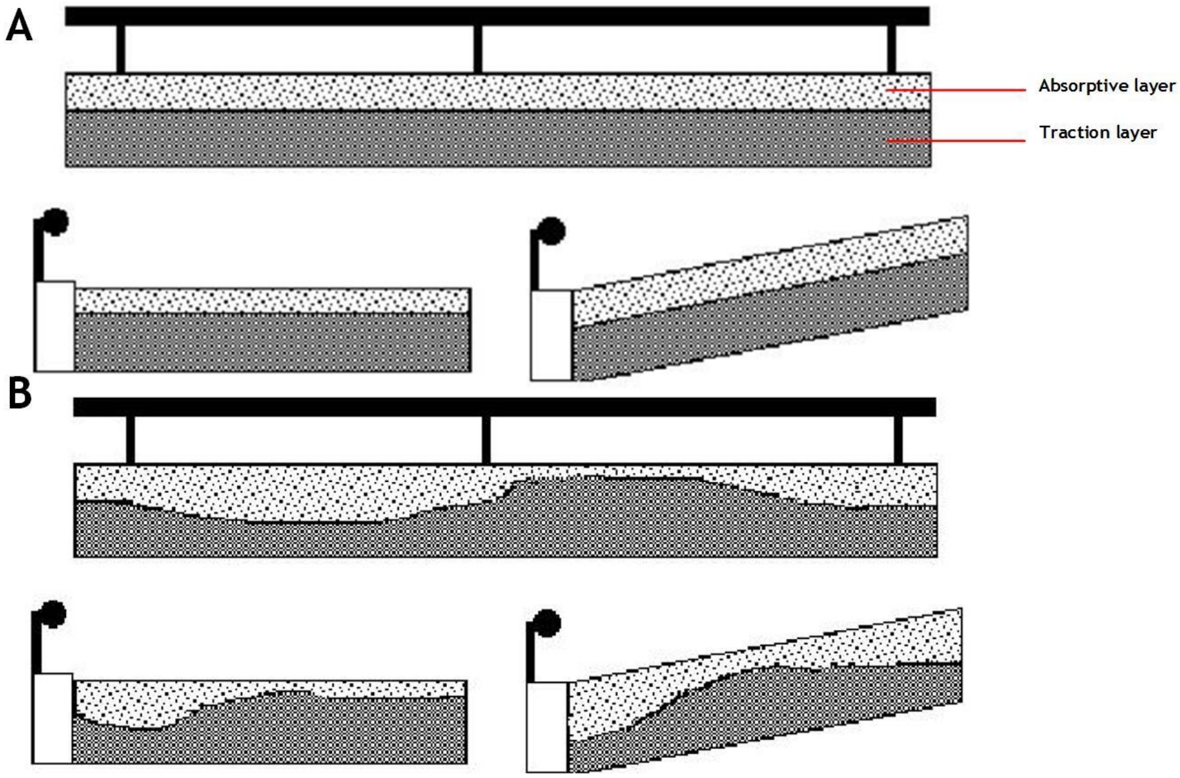


Figure 7: (A) The absorptive and traction layers of track surface. (B) An uneven absorptive and traction layers (Gillette 2016).

To analyse ratios of clay, silt, and sand, samples should be taken from different locations along the track. Two different depths are also recommended (Gillette 2016).

3.2. Injuries sustained

3.2.1. Fractures

Racing greyhounds are prone to fractures. Prole (1976) reported approximately 12.5% of injuries to the distal thoracic limbs (i.e. the front limbs), and 32.0 per cent of injuries to the distal pelvic limbs (the hind limbs), were fractures or dislocations. However, change of composition to sand tracks since then could impact injury rates.

Fractures and other injuries may result from trauma, as a direct and immediate consequence of high speed collisions with other greyhounds, the rail or track, particularly within congestion zones on bends. New Zealand's Racing Integrity Unit (2016) concluded that 45 per cent of fatalities result from dogs being checked while racing (Fig. 6). Of the remainder, most were injured as a result of faltering or simply going amiss during the running of a race for no apparent reason – although undetected injuries or health problems may contribute (Hansen 2017).

Figure 8. New Zealand's Racing Integrity Unit (2016) concluded that 45 per cent of fatalities result from dogs being checked while racing (meaning that the dog's stride has been broken).

Stress or fatigue fractures may also result without any external trauma, when locomotory forces at high speeds exceed biomechanical limits. They are much more common than direct, traumatic fractures (Hercock 2010). Such stress fractures are rarely seen in companion dogs or other working breeds (Davis 1967, Hickman 1975, Molyneux 2005, Prole 1976), but are very similar to those seen in human athletes and military recruits (Armstrong *et al.* 2004, Beck *et al.* 2000, Brukner *et al.* 1996, Kowal 1980, Matheson *et al.* 1987).

Risks increase when locomotory forces increase, e.g. when rounding bends, or when biomechanical limits are lowered, e.g. in young bones, or following bony remodelling as described previously. Most injuries that occur in racing are minor injuries that may not be recorded, and continued racing with such injuries can also cause major injuries to occur (APGAW 2017).

Fractures may affect different parts of bones. Long bones such as the tibia are comprised of a series of layers (lamella), which make up an outer cortex, surrounding a marrow chamber. Bony fractures may be grouped into lamellar or cortical shaft fractures; avulsion or chip fractures; simple fractures; and compression fractures (Tab. 3) (Gannon 1972).

Table 3: Types of fracture in racing greyhounds (Gannon 1972).

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

3.2.2. Muscle injuries

Muscle injuries ranging from sprains to tears are also common in racing greyhounds (Molyneux 2005). The muscles most prone to injury in the thoracic limbs are the triceps brachii muscle, which extends the elbow and flexes the shoulder, and in the pelvic limbs, the gracilis muscle, which adducts the limb (Davis 1973, Prole 1976). In British greyhounds the majority of gracilis injuries occur in the right limb (Prole 1976, Vaughan 1969).

3.2.3. Tendon and ligament injuries

These are also common, and vary from sprains to full disruptions (Molyneux 2005). These were summarised by Hercock (2010):

> In the thoracic limb, injuries to the digital flexor tendons account for 69% of all injuries to the metacarpus (Prole 1976). Additionally, the majority of carpal fractures, in particular fracture of the accessory carpal bone, are associated with avulsion of various tendons and/or ligaments (i.e. the tendon/ligament has pulled off a fragment of the bone) (Johnson 1987, Johnson *et al.* 1988, Johnson *et al.* 1989, Whitelock 2001). Other tendon injuries seen in the thoracic limbs of racing Greyhounds include avulsion or rupture of the biceps brachii and brachialis tendons of insertion (Schaaf *et al.* 2009), displacement of the biceps brachii tendon of origin (Goring *et al.* 1984, Boemo and Eaton-Wells 1995), sprain of the flexor carpi ulnaris tendon of insertion (Johnson 1987, Dee *et al.* 1990) and sprain and/or disorders of the attachment sites of the short radial collateral ligaments (Guilliard 1998, Guilliard and Mayo 2000a).

3.3. Common fractures

The tibia is the long bone of the lower hind leg. The metatarsal and metacarpal bones correspond to those of the human foot and hand, respectively, and the tarsal and carpal bones correspond to those of the human ankle and wrist. The canine metacarpals are shown in Figure 9.

Figure 9: Greyhound forelimb with metacarpal bones shown in the middle (purple) (Grill 2016).

Common fatigue fractures sustained by racing greyhounds are those of the central tarsal and adjacent tarsal bones (Devas 1961, Dee *et al.* 1976, Boudrieau *et al.* 1984), metacarpal and metatarsal bones (Gannon 1972, Dee and Dee 1985) and the acetabulum (the socket of the hip bone, into which the head of the femur fits) (Wendelburg *et al.* 1988). Prole (1976) reported that 11 per cent of all injuries involved the carpus, and 6 per cent the tarsus. Sicard *et al.* (1999) reported 13 per cent of injuries involved the carpus, and 25 per cent the tarsus.

Right tarsal and metatarsal fractures
The most common severe injury, often leading to the dog being euthanased, is a fracture of the right tarsus (Hercock 2010). This injury nearly always involves fracture of the central tarsal bone (CTB) and of one or more of adjacent tarsal bones (Gannon 1972, Hickman 1975, Boudrieau *et al.* 1984, Guilliard 2000, Hercock 2010). The anatomically important CTB articulates with all six of the remaining tarsal bones (Miller *et al.* 1964). Severe fracture of the CTB accounts for approximately 4 per cent of all racing injuries (Gannon 1972) and is a common career ending injury in racing greyhounds (Hercock 2010). Fractures of the metatarsals are also common.

These tarsal bone fractures are thought to be fatigue fractures resulting from repetitive loading during training and racing (Johnson *et al.* 2000, Tomlin *et al.* 2000). Propulsive forces during cornering whilst running anticlockwise result in the right hind limb being most affected. The relatively less mobile tarsal joint of the hind limb, when compared to the carpal joint of the front limb, is repetitively subjected to driving and thrusting action conducive to the production of lateral force. This results in simple fractures (Fig. 10) (Gannon 1972).

Figure 10. Metatarsal fractures (Specialists 2017).

Metacarpal fractures

Metacarpal fractures of the left foreleg are also common. The left front limb carries a greater proportion of weight during bends when running anti-clockwise (Gannon 1972). The pivoting action of the left forelimb, coupled with the relatively mobile carpal joint, produces shearing forces resulting in a range of fatigue and torsion fractures, that present as lamellar and compression fractures (Gannon 1972).

Tibial fractures

Tibial fractures are also common. These are most commonly avulsion or spiral stress fractures, due to a torsional moment caused by a rotational shear force (Fig. 11).

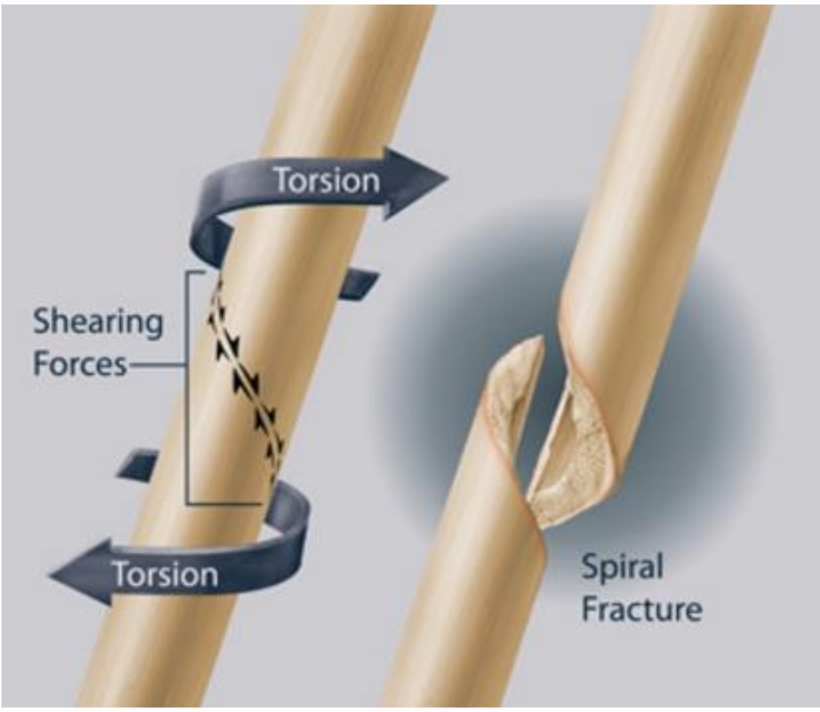


Figure 11: Mechanism of spiral/avulsion fracture (Szilagyi 2013).

Other common fractures

As reported by Hercock (2010), greyhounds are also prone to fracture of the right accessory carpal bone (Bateman 1960, Prole 1976, Dee and Dee 1985, Vaughan 1985, Johnson et al. 1988, Poulter 1991). This is usually associated with avulsion of one or more of the ligaments and/or tendons attached to this bone (Johnson 1987, Johnson *et al*. 1988, Johnson *et al*. 1989). This is believed to result from hyperextension of the carpus racing (Dee and Dee 1985). Guilliard and Mayo (2000b) determined that the forces acting on the carpus cause hyperextension of this joint by up to 270°.

4. Recommendations

Multiple factors relating to the design of greyhound racing tracks increase injury risks, but are amendable to modification. Interventions that would significantly lower injury rates include straightened tracks, shortened races, optimised track surfaces, lure extensions to position lures toward the middle of tracks, improvements to starting box design and positioning, delayed box opening, safety pads, and improvements to trackside veterinary facilities and services.

Straightened tracks

Oval tracks were designed in an era prior to high definition videography, to allow spectators equipped, at best, with binoculars, the best possible view of a racing pack. However, the bends within round or oval tracks, and the uniformly anticlockwise passage of greyhounds, create the greatest injury risks these animals are routinely subjected to. These result from areas of congestion within bends, as leading greyhounds slow or widen their radii of curvature. These create risks of high speed collisions and traumatic injuries to bones and soft tissues. Congestion, mostly within bends, results in approximately 80 per cent of catastrophic and major injuries (Eager et al 2017). And as described, stress fracture risks are increased by severe and uneven forces applied to distal limb bones, with characteristic, asymmetric injuries resulting.

These hazards can be greatly decreased or eliminated by the use of straight tracks. Modern technology is now able to provide live, high definition video to viewers, without geographical limitation. And in fact, alignment of moving cameras with the pack is actually likely to result in better visibility than traditional 'naked eye' or binocular viewing around oval tracks.

Shortened races
Races below 300 m in length have injury rates significantly lower than longer races (Hansen 2017). Accordingly, races should be limited to this distance. Beyond this distance, variations may not be statistically significant.

Optimised surfaces
The superficial absorptive and deeper traction layers of tracks should be of uniform depth, with both of an optimal composition, matched to weather conditions which may vary seasonally, e.g. by use of sprinkler and drainage systems. Tracks that are too hard result in higher speeds and greater injury risks. Tracks that are too soft are more likely to result in toe injuries, and sand being flung into eyes of following greyhounds (Gillette 2016).

Lure extensions
Positioning the lure towards the middle of the track may reduce congestion, and increase the useful field of vision for greyhounds. This can be achieved via an overhead track mounted carriageway, a heavy-duty rail mounted hoop arm system, or even, potentially, a drone-based lure system (Eager et al 2017).

Starting box design
Immediately prior to gate opening, greyhounds hear the distinct whirr of the lure and typically lower their heads in an attempt to observe its approach. This awkward pre-start crouching position is a contributing factor within a family of non-congestion related of injuries. Racing is from a standing start, and warmup protocols are extremely limited. Accordingly, box gates should be of sufficient height to minimise this (Eager et al 2017).

Delayed opening
Delaying opening to allow the lure to increase from 50 km/h to 70 km/h would result in greyhounds observing it some 40 per cent further along the rail. This would expand their useful visual fields (Eager et al 2017).

Starting box positioning
The position of starting boxes should be examined, and repositioned when judged to be too close to the first corner (Hansen 2017).

Safety pads
In New Zealand, fitted safety pads have been installed on the outside fencing on all racing tracks. Wanganui was also reported in 2014 as is the first NZ club to install a durable PVC safety rail on the inside of the track. Its purpose is to flexibility and absorb impact when greyhounds collide with the rail (Anon. 2014). Such safety measures should be mandatory.

Veterinary presence and inspections
Greyhounds with pre-existing injuries are more likely to sustain fractures. However, GBGB requirements (n.d.) state that a licenced track veterinarian may be provided with only 45-60 minutes to examine multiple relevant bodily systems of 90 greyhounds. As the requirements note, this limits the thoroughness of examination. This is not acceptable. Sufficient time should be allowed to permit a pre-race veterinary examination that is thorough, and includes a comprehensive examination of the musculoskeletal system. Additionally, trackside medical supplies and facilities should be sufficient to ensure prompt and medically appropriate attention to any injuries or other veterinary medical problems that may arise.

5. Conclusions

The speed at which greyhounds race, and multiple aspects of track design, jointly create serious injury risks. However, numerous aspects of racetracks and procedures could be modified to reduce injury risk, including:

- straightened tracks
- shortened races
- optimised track surfaces
- lure extensions to position lures toward the middle of tracks
- improvements to starting box design and positioning
- delayed box opening
- safety pads, and
- improvements to trackside veterinary facilities and services.

It is entirely unacceptable that many thousands of greyhounds continue to be seriously injured whilst racing, and that many of these are killed. Accordingly, such modifications to track design and procedures are immediately warranted to reduce injury risks. These modifications should be deployed at all tracks uniformly, so that standardisation of equipment and procedures provide consistent (rather than confusing) messages to greyhounds, wherever they race. This will result in reinforcement of injury reducing behaviour over time (Eager et al 2017).

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Appendix

Statement evidencing housing and husbandry concerns in a British greyhound kennel in 2008. The kennel name has been redacted.

17 Aug. 2008

To whom it may concern,

[redacted] **Kennels**

…

On 17 Aug. 2008 I viewed the DVD entitled 'Dogs: [redacted] Kennels: May 2008.'

I observed a considerable number (10-20) of kennels, some containing dogs that appeared to be greyhounds, while others were empty of dogs.

In general, the kennels were extremely small. None appeared to have outside runs or access. Very few, if any, had reasonable lighting, which was provided via overhead fluorescent lighting, or extremely small, high windows, some of which were shadowed by trees. Many kennels were in near-total darkness, which appeared likely to continue almost around the clock, because the lighting briefly provided for filming did not reveal any permanent light source for these kennels.

Dogs are highly social animals, with a range of physical and psychological abilities evolved for the purposes of exploring, foraging and interacting with one another and their natural environments, which can be wide-ranging. Greyhounds are particularly athletic dogs, with a particularly high capacity for exercise.

According to the narrator, the exercise provided was a brief daily trip to the 'exercise yard,' whilst the kennels were being cleaned. The yard was also small and barren. The ground was mostly bare dirt, which, in wet conditions, would have quickly become muddy, as described by the narrator. The large number of dogs using this small area would have resulted in a high level of faecal contamination, requiring daily cleaning of the yard to minimise disease transmission. There was no indication that cleaning occurred on any regular basis.

The lack of space, exercise and opportunities for socialisation, and the barren nature of both their kennels and the so-called 'exercise yard,' would have inevitably led to marked stress in these dogs. Over time such stress is likely to worsen, and is known to lead to psychopathologies such as behavioural stereotypies. Evidence of psychopathology was clearly visible, in the form of large holes chewed through wooden walls, which had been crudely covered with wire – through which contact between neighbouring dogs, with consequent risk of disease transmission, remained possible. The dogs revealed by torchlight appeared uniformly frantic for attention. Immunodepression, with resultant increased susceptibility to disease, is a common sequelae of such chronic stress.

The risk of disease outbreaks was exacerbated in this case by the very poor sanitation clearly visible within these kennels, and their poor physical condition. Debris was clearly visible on kennel floors and walls. There was no visible evidence that the narrator was incorrect in her assertion that certain areas – such as the area under dog 'beds,' are never cleaned. Dripping holes in kennel roofs were evident. Bedding appeared to be comprised of shredded newspaper, which was sometimes wet.

Very large piles (industrial quantities) of waste – presumably, bedding and other kennel waste – were visible. The narrator stated that these were destined for the local tip. In veterinary clinics such kennel waste is packaged as clinical waste and incinerated, to minimise disease transmission.

In short, the conditions in which these dogs were housed clearly violated their inherent requirements for space, natural light, exercise, environmental stimulation, social contact, and the opportunity to express natural behaviour. The kennels appeared extremely unsanitary, badly designed, and in a state of considerable disrepair. Housing dogs for any extended period of time in such conditions is blatantly cruel, ethically inexcusable, and violates the duty of care required under the UK Animal Welfare Act 2006.

Yours sincerely,

Andrew Knight
Veterinarian