THE UNIVERSITY OF LIVERPOOL

Aetiology and Epidemiology of Injuries in Dogs participating in Flyball

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CONTENTS

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Abstract

Investigation and research into the specific area of flyball dogs is lacking, and no official figures are known for the injuries sustained to participating animals. To gather more information on the epidemiology and aetiology of these injuries, a survey for flyball dog owners was conducted posing questions related to both injury and preventative measures used. Alongside this, high speed video was taken of dogs completing the box to analyse further what the body of the dog is subjected to whilst turning here. The video footage and survey results were compiled to determine the risk factors for injury, and relative effectiveness of prevention. Injuries were however found to be relatively low, with only a 0.0412% chance of the injuries looked at in the study per flyball run. The most common injuries were lameness in the forelimb and shoulder. The risk factors found to be significant were injury were those weighing 18-20kg, the type of box used, running on rubber matting, repetitive training comprising of full runs only, frequency of competing, not wearing leg protection and lack of warm up.

Introduction

Flyball is a team sport for dogs and handlers, and was first created in the early 1970s in California. Since then, it has increased in popularity and has governing organisations across the world, including the North American Flyball Association (NAFA) which was founded in 1984 and the British Flyball Association (BFA) in 1994. It is thought by many to be the *fastest growing dog sport* in the UK (BFA 2001).

In 2009, a total of 1917 dogs gained points by competing under the British Flyball Association in the United Kingdom (BFA 2009). However those running in starter tournaments are not included in that figure, and the BFA currently has 5924 dogs registered, comprising of competing, and retired, deceased and unraced dogs(BFA 2010) . Taking these figures into account, it could be estimated that the number of living dogs in the UK that are actively competing, intending to compete, or are retired is set at about 3500. When this is compared to the UK dog population of approximately 8million (PFMA 2010), it shows the incidence rate of dogs competing in flyball as 0.04%. Furthermore, when this is compared to the 30,000 racing greyhounds in the UK (10,000 registered per year, with a career of approximately three years (NGRC 2009)), flyball compares at 12% of this. Although when evaluated against such a huge industry the numbers seem comparably substantial, there is relatively little known about the incidence of flyball related injuries in the UK. A survey was carried out to try

to gauge the incidence of injuries in flyball dogs and to collate information on the preventative measures currently put in place by owners. The survey period was from December 2009 to March 2010 and resulted in 440 responses.

The flyball course remains the same throughout most of the world, and consists of two parallel lanes (Figure 1). The course is 102ft (31.1m) long, with four hurdles and a mechanically triggered box in which a tennis ball is loaded. The hurdles are set 10ft apart, with 15ft from the fourth hurdle to the box and 6ft from the start line to the first hurdle. Dogs are released from between 50ft and 5ft away from the start line and they stride over the four hurdles in sequence. The dogs apply pressure to the box on impact, which releases the ball for the dog to return over the hurdles again. The height of hurdles is dictated by the size of the smallest dog racing on the team. Four dogs run in sequence and the aim is to pass nose-to-nose on the startline, this is know as a “changeover”, “cross” or “pass”. In most countries electronic timing equipment is used to gauge a time for the team, with integrated sensor equipment to indicate if a changeover is too early.

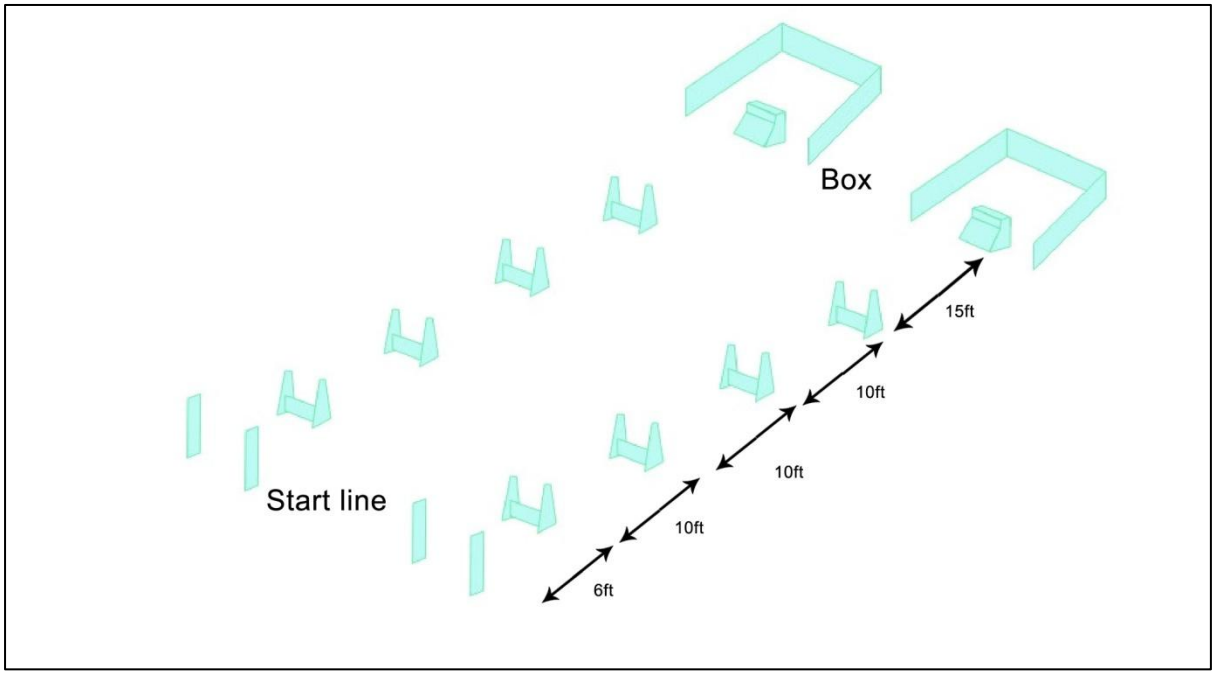

Figure 1 - The flyball course

Two teams of four dogs race in separate lanes to complete the flyball course, the winners being those that first have four dogs complete runs correctly with no early changeovers. The current fastest time in which four dogs have completed a run is 14.864s (Touch N Go A, USA), with the fastest official single dog time of 3.63s. In the UK team times are slightly slower with the British Record standing at 16.60s (Bassett Hotdogs), the average dog will run approximately 5.0s and the fastest around 3.8-3.9s. In a UK tournament, a dog will compete in up to six races in a day, consisting of a best of five legs format therefore theoretically upwards of 30 legs per tournament.

In 2009 there were 87 tournaments hosted in the UK, comprising of 170 days of competition across the country (BFA 2009). Dogs can only compete in open competitions once per tournament, and a rule is in place which states that no two shows can be held on the same date within 50 miles of one another. These tournaments are held throughout the year, typically with 30-60 teams of four to six

dogs racing per day. From April until October, competitions are run on grass, and through the remainder of the year on rubber matting or turf laid down on equestrian flooring. Alongside competing, the majority of dogs will take part in training with their team to prepare for tournaments and a few will also train at home.

Various training techniques are used throughout the world, with the majority of methods aimed at increasing speed without jeapordising the safety of the dog. Dangerous turns on the box, and potentially injuries, can result from lack of training in some cases, or from questionable training methods. A variety of props can be used in front of the box, to try to shape the dogs into the required motion. For example, a jump can be used directly in front to encourage the dog to get their back legs onto the box to push off, or some use a traffic cone to encourage entry at an angle. Poor box turns, along with the repetitive and fast nature of the sport proposes huge scope for injuries.

Although there have been no official studies completed on flyball injuries, parallels can be drawn from other areas. Several stages of the course, the training and types of dog have been analysed and likely injuries suggested, taking into account the manner of the sport. These theories can then be compared to the results of the questionnaire. Alongside this, there are a wide variety of products for sale aimed at sporting dog owners that could be seen to help prevent injury, as well as home made measures,correct training and conditioning. Following the analysis of potential injury, prophylaxis and preventative measures are also discussed. Similarly, these suggestions will be cross-referenced to the questionnaire results to analyse the apparent effectiveness of each.

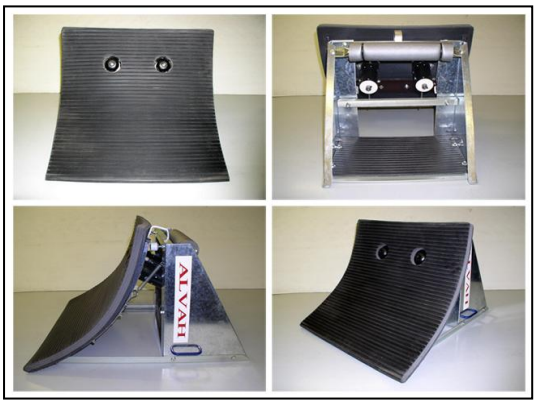

Figure 2 - Boomerang Box (Modern Dog Sports)

Figure 3 - Upright/CanAm Box (Modern Dog Sports)

The box

The flyball box is a mechanical device which works with a trigger mechanism to release a tennis ball when the dog applies pressure to the main panel. This usually involves the dogs forelimbs hitting the box, and catching the ball whilst they turn.

There are three main types of boxes used in the UK; the boomerang (Figure 2 - Boomerang Box (Modern Dog Sports)), the upright (Figure 3 - Upright/CanAm Box (Modern Dog Sports)) and the hybrid (Figure 4 - Hybrid Box (K.Burns)) . It is generally assumed amongst the flyball community that the boomerang is the most commonly used, though the questionnaire results will give a definitive answer. Teams consider each type to have advantages and disadvantages, although no formal studies have been conducted into the relative safety of each type.

The turnaround from the dog approaching the box, to leaving again is called the “box turn”, and if taught correctly vital hundredths of a second can be shaved off the dog’s time. There are many methods used to train this ranging from individually tailored techniques for

Figure 4 - Hybrid Box (K.Burns)

each dog, to no training at all and dogs hitting the box at high speeds; it is clear to see the scope for injury if due consideration is not given.

The actual motion of the turn that is performed may vary with the build and confidence of the dog, as well as depending on the initial training given. Although many would say that the "swimmers turn" was the ideal in terms of speed, it does not necessarily mean that every dog that turns like this will not get injured, nor does it mean that dogs *not* performing a swimmers turn will be more prone to injury.

In the UK, turning styles vary greatly from very efficient and fast turns, to those where the dog will hit the box straight on with no consideration of turning. The latter may come to a complete standstill on impact, or in some cases, end up slipping or landing on the box; this is sometimes termed a "slammers turn" and is decreasing in prevelance in UK racing dogs. There are no general technique patterns amongst these ineffective and dangerous turns, therefore suggestions of likely trends in injury would be difficult due to the vast scope for damage to occur in each individual dog.

In this case it is more useful to look at what is classed as a "good" turn, to look at where problems might occur from this section. By analysing the "swimmers turn" in detail, the potential injury risks can be highlighted. A summary of a good turn can be seen in Figure 5 - Jack Russell Terrier performing a turn.

Figure 5 - Jack Russell Terrier performing a turn

Each stage of the turn has been broken down to illustrate the scope for injury at each stage. The first stage of the "swimmers turn" is for the dog to take off and hit the box with their body at a slight angle, so as to be positioned correctly to retrieve the ball (Figure 6). A dog that completes the flyball run in 4.50s may be hitting the box travelling at approximately 7.61m/s (17.0mph), assuming that they take around 2.0s to get from the startline to just approaching the box.

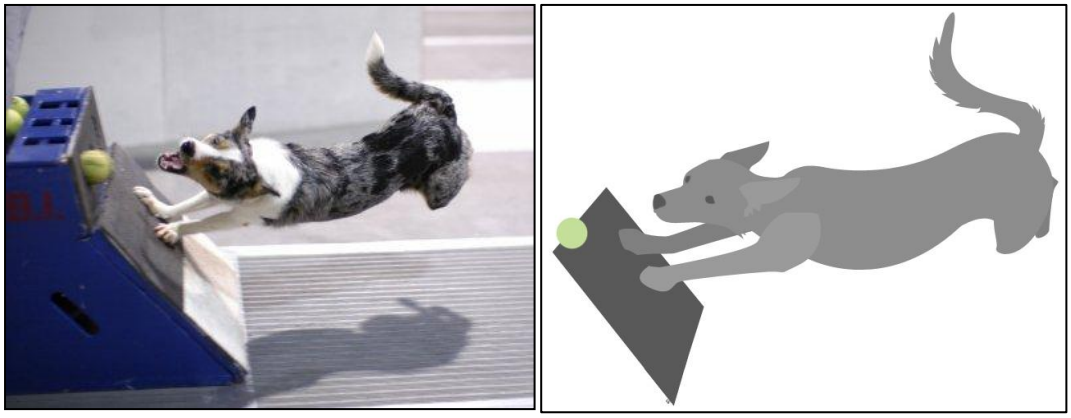

Figure 6

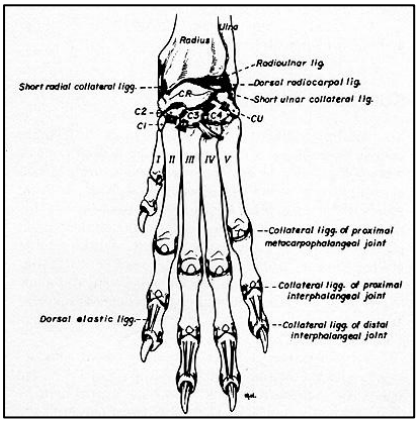

Figure 7 - http://cal.vet.upenn.edu/projects/saortho/chapter_25/25F2.jpg

At this point it is the carpus (Figure 7) that is coming under a huge amount of pressure, due to the high speed the dog was travelling at previous to contact with the box. Guilliard published work on carpal lameness in high activity dogs, where he noted that soft tissue injuries in the carpal region were common, especially in collie types (Guilliard 1997). This is particularly important as 52% of dogs that gained points in the UK in 2009 were Border Collies or Working Sheepdogs (BFA 2009), thus highlighting this as a potential injury for flyball dogs, particularly amongst these breeds. Miller classified these types of injury and resultant lameness into three categories: collateral ligament rupture, luxation of individual joints or bones, hyperextension injury and carpal sprains (Miller 1994). Guillard notes that the latter was the most common, and could be graded by severity, ranging from a first degree sprain with only a few fibres torn, to a third degree sprain with a fracture at the origin or insertion of the ligament. Although it was not mentioned, it would seem unlikely that there would be a severe injury of this type from one flyball run alone, however over a period of time a first degree sprain could progress to a more serious one with repetition.

The incidence of such problems could be linked to whether the dog's dewclaws are intact. Zink details how some owners that compete with their sighthounds in lure coursing observed that the incidence of foot injury and forelimb lameness was greater in those that had their dewclaws removed (Zink 1996). It was proposed that this could be due to the dewclaws and carpal pad touching the floor during canter or gallop (or in this case, on the box surface) and allowing the dog to take full advantage of being able to rotate the front leg about its axis; this could be seen to be very useful for dogs turning on the box. However, during preliminary investigation using video analysis for this study, the dewclaw was not seen to come in contact with the box surface. As the dewclaws and carpal pads may come in contact with the box *in some dogs* during the turn or approach, they may be subject to injury. Therefore it is proposed that in flyball dogs there may be a significant number of dew claw and carpal pad injuries.

Equally at this point, there could be injury to the shoulder or the remainder of the forelimb. The force of the dog hitting the box could potentially transfer up the limb to cause damage to both joint components and muscles. Therefore flyball dogs may be more likely to undergo injury to the shoulder than the none-participating counterpart, and how this shoulder /forelimb injury may be more likely in dogs hitting the box with the greatest force; the heavier dogs and the faster dogs. Looking at the actual injury rates in UK dogs could potentially highlight the validity of this proposal.

The second stage is for the dog to catch the ball from the box. Then the hind limbs are immediately swung around, weight is transferred from the forelimbs to the hind limbs and the dog pushes off the box (Figure 8). The motion of the turn here may cause problems in the back, neck and vertebrae and lead to degenerative diseases of this area, for example Spondylosis deformans (Merck 2008).

Figure 8 – The push off

This push-off helps to dog to propel itself towards the jumps. Some dogs will struggle to get both legs on the box to push off, which may result in one hind leg being on the floor. This could cause a slightly uneven distribution of weight in the dog; this might mean that the leg on the floor is under more pressure. As most dogs will always turn in the same direction, continuous excessive wear on one limb could result in injuries leading to lameness in the hind limb. Alternatively, this could also lead to uneven muscle build up and hence lameness in one limb being more likely than in the other, due to favouring one side.

One example of possible hind limb lameness would be the strain of the iliopsoas muscle. Iliopsoas is a combination of the psoas major and the iliacus muscles, which arise separately from lumbar vertebrae and join to insert on the lesser trochanter of the femur. The action of the muscle is to move the pelvic hind limb forward. Traumatic incidents can cause injury to this muscle, particularly at the border of the muscle and the tendon. Examples of such incidents include slipping into a splayed leg position, jumping out of a vehicle or “aggressive training” (Canapp 2007). If a dog was to slip into the box, with a leg remaining on the floor, then this type of injury may be possible.

Other injuries may occur on the box, for example the rubber coating on the box could result in friction burns on the paw pads with repeated wear. Furthermore, in very extreme cases there could be bone fractures and soft tissue damage resulting from a large collision with the box.

Hurdles

Constituting the majority of the flyball run, the hurdles are likely to pose a risk for injury in a variety of ways. There are several factors to take into account when considering them and injury, including; jump height and leg length.

Currently in the UK, to determine which height a dog jumps, a measurement is taken to the withers. The hurdle height is then 5inches below this, with a maximum height of 14” and a minimum of 7”. For example, a dog of 17” to the withers will jump 12” (BFA 2010) . If this dog was the smallest in the team, the other three dogs would be able to run over that height too, regardless of how much larger they are.

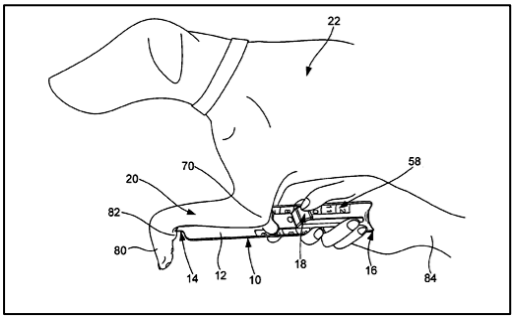

Figure 9

The United Flyball League International (U-FLI) is an organisation mainly functioning in North America. They use a relatively new method of measuring to account for the varying builds of dog. The patent for this device (Figure 9) is still pending and may be a future development in other countries. This technique involves measuring from the accessory carpal bone to the elbow, tying in with the theory that the greater the percentage of leg length to withers height, the better able a dog is adapted to jump (Zink 1996). The potential benefits of this system appear fairly extensive, as illustrated in Figure 11 and Figure 11; two dogs of a similar height to the withers can have a huge variance in leg length. As yet there has been no formal work carried out into looking at which of the two measuring options is preferable in the interest of canine safety.

Figure 10

Figure 11

Risk factors for injuries may be related to the height of the hurdles that the dog is jumping. It may be assumed that increasing the hurdle height will always increase the risk of injury. However this may not be the case, in many instances if a very fast dog completes the course over low (7”) jumps they

are able to build up a lot more speed before hitting the box. Therefore the dog has a greater acceleration, and through Newton's second law (force = mass x acceleration) the dog will hit the box with a greater force. This greater force may increase the risk of injury and also the risk of wear through repetition.

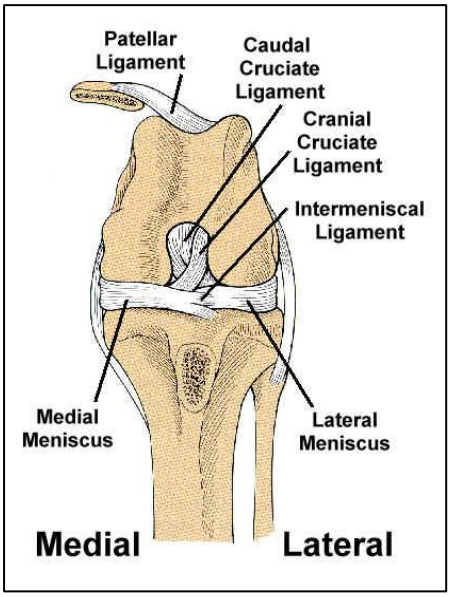

Figure 12 - From http://dogkneeinjury.com

Other injuries may occur with relation to this section, for example if the jumping style or stride length meant that dogs struggled to judge the distance between hurdles they might end up landing on or colliding with a jump. This may not only result in muscle tears, soft tissue damage and confidence problems, but injuries such as cruciate ligament rupture or repair can occur. These ligaments are in the knee joint, and comprise of a cranial and caudal component (Figure 12). A great deal of research has been completed into predisposing factors for this condition, and it is proposed that the cruciate ligament can wear down over time (Innes 2009). Therefore the actual rupture may occur during a normal activity, or when a slightly different range of motion is put upon the dog. This suggests that in some dogs the cruciate may become ruptured from an everyday activity, but also from a collision with a jump, or awkward turn retrieving or playing in the runback area. The continuing wear down over time has been linked to several factors; one study says that several large breeds are predisposed at a young age (Duval J.M. 1999). However another comparing three surveys taken on the condition shows how variable the epidemiology is with regard to this; the studies showed a shift each time between which was the most common sex and size of dog to undergo cruciate injury. Breeds which have been proposed to be more likely to undergo cruciate injury are the Labrador Retriever, Golden Retriever, Rottweiler, Mastiffs, Boxer, Newfoundland, West Highland White Terrier (Innes 2009).

Repetition

The repetitive nature of flyball alone may be a cause of injury. The addition of this activity to a dog's normal exercise could be seen to be overloading the cartilage and joint capsule with abnormal stress on a regular basis. This, along with uneven weight bearing for any reason and previous joint injuries, can be a predisposing factor to osteoarthritis in old age. Rychel states that although it is sometimes assumed that this condition is an eventuality of old age in dogs, this is not the case and that it can be attributed to such factors (Rychel 2010). For this reason it could be assumed that dogs which have competed in flyball may be more likely to develop osteoarthritis, the results of the questionnaire may be able to highlight whether this is the case. This uneven distribution of weight or repetitive stress on the animal could aggravate previous injuries or cause very minor injuries to become more severe.

Also falling under this category is the potential for injury due to the contact between the footpad and the floor. Although the majority of summer (April to October) tournaments are run on grass, throughout the winter a number of venues will use rubber matting. In most cases this matting is fine ribbed and has a layer of padding placed underneath. This could potentially cause friction burns to the pad of the foot both during running and jumping. It has been suggested that the feet of purebred dogs can be grouped into two categories; the cat foot and the hare foot. Dogs adapted for rocky terrain have "cat feet", described as having "thick treads" to help grip the uneven ground. Those dogs with "hare feet" tend to have elongated feet with thinner "treads" which is proposed to decrease the friction and assist with forward movement (Zink 1996). Whether this can be applied to flyball dogs may be highlighted in the questionnaire, where it would be evident that those with "cat feet" had less injuries of this sort due to the adaptation of the feet to lower the friction. However the wide variety of breeds in the sport could make this classification into just two categories difficult and other factors will need to be taken into account, including frequency of competing and speed of the dog.

Although no tournaments are run on sand tracks, as in the greyhound racing industry, there have been studies comparing that surface with grass. One set of survey results showed that on grass, 11% of injuries occurring were in the carpus (Prole 1996), whereas this type of injury occurred for 29% of injuries on the sand track(Agnew 1992) . This suggests that the various types of surface can affect the number and type of injuries caused, and hence it might be possible to do similar analysis to compare flyball surfaces.

Along with physical repetition there is also research in the world of human psychology about mental repetition and the theory of athletes becoming "stale" or "burning out." Voight details the three types of stress that athletes undergo; physical stress (muscles, cardiovascular), mental stress (thinking, focussing) and emotional stress (pressure, fear) (Voight 2003). Although these principles are only in humans and may only vaguely be of relevance in dogs, the concept of "overload" can still be applied. Voight refers to this is being when athletes are put under "intensive (level of intensity) and extensive (high volume) stress that taxes them to a point of incomplete recovery" and continues to detail some of the signs of such an effect as lack of focus, lack of work rate and loss of co-ordination. This may mean that if training sessions are too long, or too intense, then the productivity of those sessions is likely to decrease and perhaps even have a detrimental effect in the long run. Although not a physical injury, this could be responsible for a decrease in overall performance.

Age of training

Although a dog is not allowed to compete in open tournaments in the UK until 18months of age (BFA 2010), training may begin before this. It is generally believed in the flyball community that dogs should not receive any form of training on the flyball equipment until 6months of age, as a bare minimum. A large number of clubs will put in place age restrictions for beginners courses to have dogs of at least 10months old, for example, but this does not guarantee that no impact training will take place before this age. As no formal research has taken place into this, the questionnaire should be able to highlight the typical age at which dogs begin their training. However pinpointing exactly what type of training was started and the corresponding age would be difficult.

Care should be taken when training puppies due to the stages they undergo in bone development. Plates of hyaline cartilage, known as epiphyseal plates ("growth plates"), are at the epiphyses of each bone (Figure 13). These plates are responsible for longitudinal growth of bone, and will ossify (or "close") at different stages during development (Donald 2004). Typically the first to close are those in the pelvis, at around 5 to 6months, and the last is the tibia at the stifle, closing at around 10 to 14months. These are generally earlier in toy breeds, and later in larger breeds (Zink 2008). Therefore it is imperative that great care is taken for the young dog not to partake in high impact work until at least 10months of age.

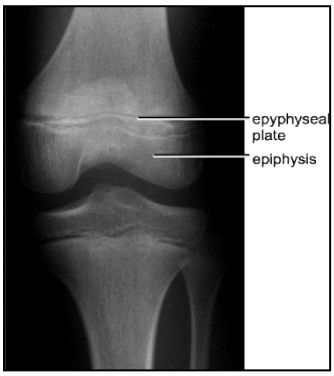

Figure 13 – From http://www.gla.ac.uk/

Excessive stress on the growth plates during development can result in injury. O'Brien et al conducted a study into thirty five dogs with growth plate disturbances, and explains how this type of injury can result in shortening of the limb, deviation of the paw, and deformities in the elbow and carpus. The majority of the injuries were in the forelimb, and the angular deformities described above were typically seen 5-7 weeks after injury. The specific injury most observed was the premature closure of the distal ulnar epiphyseal plate, which leads to the ulna being shorter in many cases (O'Brien 2008). This can mean that the radius continues to grow whilst the ulna has ceased to lengthen, giving the leg a twisted appearance.

From the above, it is clear that when training for flyball, careful consideration about the age of the dog should be taken, and appropriate training put in place. Injuries of this kind could be mild and hardly noticed, or fairly serious and cause a premature end to the dog's career. Although when compared to sports such as agility, there is relatively little commercial literature available on training a performance puppy, much of this can be cross-referenced. The risk of such problems later in life could be significantly decreased by working on groundwork before the closure of the epiphyseal plates, and then moving onto high impact work.

Weight and Structure

Injuries in flyball dogs may also be due to the conformation of the dog, as well as the training received. It may be the case that some dogs are better adapted to the task of flyball in physical terms. The constraints of the spacing of the flyball course, the bodily proportions and the weight of the dog itself may have an influence upon this.

In the 1940s, William Sheldon theorised that the human body could be split into three categories, or "somatotypes", based on the height to weight ratio of the individual. These three types are ectomorphic, mesomorphic and endomorphic (Slaughter 2005). It could be argued that this theory has limited relevance in this case, as Sheldon was a psychologist and not a physician with a large portion of his work focussed on personality more than anatomy. However, work has since proposed that the same principles can be applied to the conformation of dogs. In a 1997 publication "Conditioning the Canine Athlete", Dr.Christine Zink proposed the correlation between Sheldon's somatotypes and different breeds of dog (Table 1)(Zink 1997) .

Table 1 – Somatotypes and dog breeds.

Somatotype	Description	Breed examples
Ectomorphic	Tall, slender, long limbs	Saluki, Greyhound, Weimeraner
Mesomorphic	Medium size, strong bones, well muscled	Labrador Retriever, Beagle, Australian Cattle Dog
Endomorphic	Heavy set, or overweight	St.Bernard, Newfoundland

Zink also describes how ectomorphic breeds are well adapted for sprinting and jumping, and how mesomorphic breeds would be well adapted to a wide range of sports. Finally, those fitting into the endomorphic category carry more weight so have to work harder in tasks such as jumping. Although this typing may appear to fit, there will always be exceptions to rules such as the above. For example, although some of the larger ectomorphic breeds are adapted to jumping, the spacing of the jumps in flyball is such that they have to shorten their stride length and thus slow down.

Further to the somatotypes, the specific weight to height ratio of dogs may be used to assess jumping ability (Zink 1997). The lower the weight to height ratio, the easier it is for a dog to jump. For example an 18kg collie of 50.0cm to the shoulder would have a weight:height ratio of 0.36kg/cm, whereas compare this to a Australian Shepherd of the same height, but a weight of 25kg, giving a weight:height ratio of 0.50kg/cm. This may be backed up by the fact that 90% of the dogs in the Kennel Club Olympia Stakes final were border collies(KC 2009) . This is of course purely theoretical and border collies especially have a huge variety of both heights and weights, exemplified in Figure 14 is the build of one of the fastest UK dogs. There are also several factors with regard to jumping ability that are not taken into account with this theory, including overall conditioning, drive and training. All of these discounted, and looking purely at the conformation of the dog, with no other limiting factors, then a light frame with minimal weight is preferable for jumping agility. Although these animals may be adapted to jump well, it might not necessarily mean that the dog is less prone to injury.

It is not merely the height of the jump that is in question in flyball, but the spacing in between. The most efficient way for dogs to complete the course is to stride out over a hurdle without taking any steps before immediately taking off for the next one; similar to “bounce-jumping” in agility. The ease of this depends on the several factors, including the confidence of the dog and training, but namely the stride-length of the individual. The stride length can in many cases depend on the breed, size and conformation of the dog; an investigation into Lipizzaner horses found that the stride length in those animals was positively correlated to the height at the withers (Baban, Curik et al. 2009). Applying this to dogs it could be that past a certain limit, the stride length of that individual is actually significantly longer than the distance between the jumps. In the case of the greyhound, at full speed and extension it may have a stride length of around 5m (Ahmat 2008),

Figure 14 - Asher, 3.8-3.9s, WSD 19kg, 56cm to withers. Weight:height ratio of 0.34kg/cm

which is significantly longer than the 3m spacing of the flyball jumps. In theory this means that the dog would have to actively shorten its stride length so as not to land on the next hurdle, carrying this out on a regular basis and not being able to fully extent may have long term implications and lead to injury in the dog. This also implies that although some dogs may be built for speed whilst running on flat ground, when restrained by the proportions of the course then they are actually at a disadvantage.

General weight of the dog may also have an effect. This does not necessarily mean dogs which are overweight, but comparing heavier and lighter dogs. Those which are heavier will hit the box with more force, when compared to a lighter dog travelling at the same speed. When looking specifically at overweight dogs, the following have been highlighted as having increased likelihood in obese pets: cruciate ligament disease, osteoarthritis, intervertebral disc disease and hip dysplacia (German 2010).

Other Sports

Figure 15 - Dog completing the weave obstacle

A large number of flyball dogs will also compete or train in agility (Figure 15). It could be likely that injuries in these dogs are from either sport, or a combination of the two. Therefore it is useful to look briefly at the impact of other sports and associated injuries. Levy et al used a paper and web based retrospective survey of injuries in 1627 dogs, of which they found 33% were injured (Levy, Hall et al. 2009). They also highlighted several risk factors for dogs competing, coming to the conclusion that border collies are more at risk of injury and that most injuries occurred on the the A-frame, dogwalk and bar jump. Other conclusions were reached about the types of injury sustained, with soft-tissue injuries being most common, and shoulders and backs being hurt most frequently. Although the sports are similar in several respects, there are also key differences between agility and flyball, therefore although results of such studies are useful, they cannot be taken as absolute. Some of the major differences between the two include: agility jumps are higher (for a “large” dog the height is 22”, compared to 14” in flyball), there is a much larger variety of obstacles to train and complete, the course will be different each time and dogs will only tend to complete between three and five runs during a competition day. However it may also be argued that training in both disciplines is useful for the dog, as not only will it increase fitness but act as crosstraining. As dogs in flyball usually turn in one direction, exercises in agility which encourage the use of both sides of the body equally, for example the weaving poles, maybe help with more even muscle build up.

General risks for competing dogs

There will also be injury risks with regard to the lifestyle changes that flyball training might make more likely, or give more opportunity for them to arise. For example, if a dog is fed very close to racing then they may face the risk of gastric dilation volvulus (Wingfield 2002).

Dogs racing in summer months may face racing in the middle of the day in fairly high temperatures, this means there could be a risk of overheating and dehydration.

Current available methods for prevention of injury

Dogs which compete in flyball are canine athletes, and so to help prevent and reduce injury, there are a number of concepts marketed and suggested in literature. The general attitude towards this amongst owners varies, as does the awareness of the aforementioned information. Some owners will treat their dogs as the equivalent of Olympic athletes, putting together exercise and fitness programmes away from flyball, conditioning, looking at different feeding methods, warm ups, supplements and more. On the other extreme there may be owners that may not have considered the above, or do not have the option to, and in some cases the dogs only exercise may be at flyball training. This is no criticism of either method, as sometimes time, facilities and money are limited, and any variations in attitude are understandable. However it is important to understand the attitudes, and that the majority of people will be somewhere in the middle of the two. An appreciation of these approaches means that it can be taken into account by veterinary surgeons when treating and dealing with flyball dogs and their owners.

There are a variety of precautionary and pre-emptive measures available for owners to purchase to help to prevent the risk of injury, or increase comfort. In many cases, the relative effectiveness of these products has not undergone extensive study. Whether to utilise these products is the individual choice of the owner, there are no rules or regulations in the British Flyball Association regulating their use.

Figure 16 - Cohesive bandage (left) Elasticated boot (right)

Firstly, wrist supports are something that is talked about widely amongst flyball owners. A wide of products are available, but mainly they fall into three categories; cohesive bandage, pad protectors and elastic supportive boots (Figure 16). During preliminary tests with the high speed shooting video footage, cohesive bandage appears to show very little difference from having no protection at all, this means that perhaps it is of more use for protection of the dewclaws and carpal pad rather than support. An investigation into the effects of tactile supports and leg wraps with relation to jumping was

carried out, looking at the following kinematic variables: Point of take off (m), angle of take off (degrees), maximum height of the centre of gravity, point of landing (m), angle of landing (degrees) and velocity (m/s). No significant difference was found with any of the variables, except for velocity, where dogs were actually found to be slower with wraps on (Critchlow 2009).

Supplementation is also popular, from joint supplements to rehydration salts. Many products are available, from veterinary prescribed ones to human grade glucosamine tablet. There is little information available on using them pre-emptively, which is the case for many dogs, but there is extensive work on their use with regard to osteoarthritis.

There are many variables to consider with regard to supplements. For example, two may answer that they give a supplement but the accuracy of which they both follow the instructions and stick to the timing will differ. Alongside this, rehydration products may be given but at varying times and to different requirements. These issues can be questioned in the survey, but the usefulness of conclusions that can be drawn will vary.

Warm Up and Conditioning

Figure 17 - Wobble cushion

Not a supplementary product as such, but extra treatments that are used on top of normal flyball training and walks, conditioning helps to prepare and strengthen the body. One such method of this is through hydrotherapy, which is a none-weight bearing and stamina building exercise in general, or as part of a rehabilitation programme. Its benefits for the latter are said to include allowing the patient to resume exercise with a very low risk of reinjury whilst also reducing joint pain (McGowan 2007). In terms of conditioning for the healthy dog, it can increase muscle mass and strength as well as elasticity and increase the range of motion of joints; this might mean that injuries are less likely as the dog should be more able to cope with a joint being stretched beyond normal “pre-hydrotherapy” limits (McGowan 2007). Other methods of conditioning in dogs may include strengthening core body muscles, for example with exercise balls and wobble cushions (Figure 17); these should always be used after seeking professional instruction for correct use. There are many books, DVDs and seminars specifically aimed at the flyball and agility dog owners detailing conditioning and strengthening, particularly in the USA.

A warm up routine is generally considered to be very important in humans, and although animal-related investigations have taken place, there is little with direct relation to flyball dogs. The process of a warm up is usually conducted before exercise, and here it has been split into two components; general muscle warm up and stretch.

The purpose of warm up is thought to be to help smooth muscular contractions and increase the elasticity of muscles, therefore reducing the incidence of injury (Frick 2010). It has also been shown to increase the range of movement and overall flexibility (Thacker 2004), thus presumably increased performance. Zink details a study of 100metre Olympic athletes, where those that did not warm up were 7% slower than those that did; this could equate to knocking 0.35s off a 5.0s dog (Zink 1997).

Similarly, an investigation into the time taken for agility dogs to complete a set of jumps with an osteopathic warm up treatment was found to decrease, when compared to no treatment having been given (Munnings 2009). One explanation for the effect of warm up is the increased blood flow raising the overall temperature of the muscle and hence improving the extensibility of collagen both in the joint capsule and in the tendon (Frick 2010). This heating effect is also thought to improve spinal reflexes by the firing rate of the Golgi tendon organs being increased (Kirkendall 1999). Other sources also state that the warm up can improve overall oxygen kinetics of the muscle too (McGowan 2007). Therefore it may be assumed that dogs which have warmed up and less likely to undergo injury than those which have not undergone such a regime (Steiss 2002).

The information available on warm up for sporting dogs is extensive, but little information is available to indicate the quality of that which has been provided. For example, such sources of information include websites, DVDs, books and seminars ranging in suggestions from rubbing and body awareness techniques to stretching routines. Therefore it is important not only to assess the ability of the dog to perform such tasks, but also of the handler to ensure that they are implementing them correctly. Another point to consider is that time at flyball tournaments is often limited, meaning that if a handler has dogs in consecutive divisions then they may be forced to reduce the time which they spend warming up to ensure that they are in the ring on time. This is especially relevant when the results of one piece of research showed that to be of greatest benefit in preventing injury, the warm up routine should be 15minutes before the event (Woods 2007) .

Stretching is often considered part of the warm up, although it can be pre-exercise, post exercise or away from exercise altogether (Frick 2010). The topic has mixed views on whether such exercises should be performed before or after exercise, and how they should be carried out; some point towards both static and dynamic stretching as being useful pre-exercise (Frick 2010), whereas others state that static stretch before exercise not only risks damaging the muscle, but is of little advantage if the muscle already has a good range of motion. Frick described the two wide categories; dynamic stretching and static stretching. Dynamic involves increasing the speed and reach of an actual movement slowly, whereas static stretching sees the group of muscles pushed to their furthest point and then held in that position. The combination and timing of these types of stretching may also determine the effectiveness, for example Faigenbaum found that in teenage athletes, performing dynamic exercise before stretching was more effective than pre-event stretching alone (Faigenbaum, Kang et al. 2006). These “dynamic exercises” included what were described as “moderate-to-high-intensity dynamic movements” of 10yards; when translated to flyball this may include having the dog retrieve a ball from a very short distance or short sprints on lead. In humans, the majority of static stretching will be performed by the subject themselves and hence they can feel the “stretch limit”, whereas in dogs there is the possibility that the owner may cause damage by implementing such techniques (Frick 2010); this is another reason why dynamic stretching such as the aforementioned sprints and ball retrieving might be more beneficial, as the dog warms up whilst not exceeding limits.

In terms of dogs competing in flyball, several areas of potential injury are highlighted. The main areas are; lack of warm up, incorrect warm up techniques and over stretching. It is clear that there is a need for a more consistent message for dog owners about which techniques to use, and which will be of greatest use for those competing in different disciplines. Due to the limited research

conducted in the area of flyball, parallels have had to be drawn from other areas. To highlight the validity of these conclusions the results of the questionnaire can be utilised.

Materials and Methods

To gather information on the current epidemiology of injury in flyball dogs, a survey was created for the owners of dogs taking part in flyball. The survey comprised of 39 questions, allowing dogs of all ages and levels of experience to be inputted. This allowed data to then be narrowed down subsequently, but gave the opportunity to analyse many factors relating to injury (Table 2 - Information gathered in questionnaire). The survey largely targeted UK dogs, but also gave the option for dogs from other countries to take part.

Table 2 - Information gathered in questionnaire

Section	Information Gathered
General	Region Sex Age Breed Weight Height to withers
General Flyball	Whether the dog is the first flyball dog in house Experience (length of time training) Age starting training Jump height trained over most frequently Singles times (own height and with usual height dog) Competing status (current, too young, retired etc) Type of box Other activities (e.g. agility)
Tournaments (if applicable)	Running surface (summer and winter) Frequency of competing (summer and winter) Position in team (lead, mid-pack, anchor) Participation in singles and pairs events
Training	Composition of training sessions Home training Running surface
Warm up	Length of warm up (tournament, training, home, singles & pairs) Techniques used Use of “warm up” time in ring
Injury	Types of injury How long the dog suffered from the condition Did the dog come back to flyball following the injury When the dog sustained the injury (on a walk/in the house/flyball/agility) Recurrence of injury Treatment received Final diagnosis Other relevant information
Supplementation and therapy	Whether the dog has been assessed by a McTimoney Spinal Therapist Leg protection (training and tournaments) Joint supplements

	Hydrotherapy
Other	Further comments

Possible methods of distributing the survey included posting printed copies to team captains for distribution, handing out copies at tournaments or using a survey generated on a specialist website. Due to the lack of time at tournaments, and so as to get as wide of a picture of the UK as possible, the latter option was chosen. The survey was created using an online survey generator which also allows easier analysis of results.

Details of the survey were distributed online via email invitation and advertisement on flyball related websites, it was requested that it was passed on to other team members and was printed out on request for those without internet access. The survey was a simple layout, with the majority of questions being multiple choice or drop down boxes, except for the injuries section which allowed expansion on all points. The user was redirected to the University of Liverpool website on completion of the survey. The survey was launched in January 2010 and ran until February 2010.

As an ethical consideration participants remained anonymous, and no names of dogs or identifying features were specifically requested.

Alongside this in April 2010 high speed video equipment (Casio EX-F1) was used to take footage at between 300 and 600 frames per second. The main focus of this was at the box where 100 videos were taken and analysed from Division 1. Care was taken not to distract the dogs or to cause them to turn differently from usual, and the division consisted of teams running on all three types of box. These were then watched in detail to look for potential areas of injury and compare the upright, boomerang and hybrid box types. Still images of this footage are used in the results to illustrate what was found.

Results

A total of 440 completed surveys were collected during the survey period. 96% of these were UK dogs, and these were the ones which were analysed. Of these, 81% were currently competing, with the remainder either retired due to age (4%), retired due to injury (4%), too young (2%) or other reasons (9%) including personal circumstances or choosing not to compete.

The first section of results were analysed to give typical figures for give the arithmetic mean, median and mode of the weight, height to withers and singles times for the average UK dog (Table 3). This could then be used as a baseline when analysing the extremes of each of these categories to see the relative risk of injury. The ratio of male to female dogs completing the survey was 52.5:47.5.

Table 3 - Figures for average UK flyball dog

Measurement	Arithmetic Mean	Quartiles			Mode
		Median	Upper quartile	Lower Quartile	
Weight (kg)	18.1	19.0	22.0	16.0	19.0

Height to withers (cm)	46.3	48.3	53.3	38.1	50.0
Singles time (own height)(s)	4.96	4.85	5.45	4.55	4.55
Singles time (with usual height dog)(s)	4.89	4.85	5.25	4.35	4.55

Overall injuries

The question focussing on injuries gave a list of the injuries proposed to be likely to occur in flyball dogs. Participants were then prompted to provide further information on the length of the condition, whether the dog returned to flyball, when was the injury sustained, recurrence, treatment received and any other relevant information. It was also asked who had diagnosed the condition.

Due to dogs competing with varying degrees of intensity and length of time, it seems too generalised to look at percentage figures alone. For example, 7% of dogs had sustained some sort of injury to their dew claws. However, when compared to the degree of running and individual runs, it is a fairly low figure.

To analyse these results, it may be better to use epidemiological equations, in this case *Incidence Rate*. This gives a figure to illustrate the occurrence of a condition per animal years at risk. This has been adapted from animal years to flyball runs completed; therefore giving an incidence rate which illustrates *injuries per number of flyball run*s.

To calculate the total number of flyball for the dogs in the survey, the modal figures were analysed for each aspect. For an average dog, the total number of runs per year was very loosely proposed to be 810 (Table 4). The majority of dogs taking part in the survey had been training for between 2 and 3 years. Many factors must be taken into account here, dogs may only have trained for a year and not actually competed, some dogs may have competed for many years and others may have started competing within weeks of training. To gain a balance between these factors, the figure of 2 years experience was used. This gave that on average, dogs had completed 1620 runs each.

Table 4 - Average number of runs per year for UK flyball dogs

Location	Explanation	Number of runs
Tournaments (Summer)	Average of 2 competitions per month 5 teams to race against Approx. 3 legs per race (15 runs) Warm up runs (5 runs) Total 20, twice per month for 6months	240
Tournaments (Winter)	As above, however average of one competition per month Total 20, once per month for 6months	120
Training	Average once per week Most teams do full runs or half extra skills Approx. 15 runs per dog per session Probably likely to only train 30 weeks of the	450

	year, due to competition, weather, holidays etc. Total 15 runs, 30 times per year	
TOTAL		810

A total of 440 dogs took part in the survey, amounting to 712,800 runs completed by those animals. The injury figures were then completed by these to give an incidence rate per flyball run (Table 5).

Table 5 - Overall injury figures per flyball run

Type of Injury	Incidence Rate (%)
Arthritis	0.0045
Broken/fractured bone	0.0014
Hyperextension injury (carpus)	0.0006
Cruciate ligament rupture/tear	0.0021
Hip dysplacia	0.0015
Muscle injury (tear, sprain, strain)	0.0063
Other lameness (hindlimb)	0.0053
Other lameness (forelimb and shoulder)	0.0072
Other soft tissue damage	0.0022
Spondylosis	0.0014
Carpal pad injury	0.0018
Dew claw injury	0.0058
Damage to hard pads	0.0063
TOTAL (All injuries)	0.0421

These figures are all relatively very low, especially when considered that the estimate for the number of runs per dog is being fairly modest. It is also worth noting that a number of these injuries were commented on by the owners as not having occurred specifically at flyball. For example, a many of the cruciate injuries occurred whilst out walking. However, what is not clear is whether the dog competing in the sport was a predisposing factor to this occurring or whether it would have happened in the same way had it been a non-competing “pet” dog. Some of the above injuries which may sound serious on the offset, exemplified by the title “broken/fractured bone”, were not as severe as they sounded, many were broken toes and only a minority were larger bones such as the radius or ulna. The majority returned to flyball, and many of the injuries were sustained out walking or during collisions with other dogs away from flyball.

To analyse the injuries further, individual risk factors were looked at. Largely, these used the aforementioned figures for weight and speed or the “average” dog in comparison to the upper and lower extreme.

RISK FACTORS

Weight (Table 6)

The values for upper and lower quartiles were used as the extremes, including everything below this figure for the lower limit and everything above for the higher limit. The rate of arthritis appeared to increase with weight, with a dog weighing over 24kg being 1.5 times more likely to suffer from arthritis than dogs of 14kg and under.

Damage to the cruciate ligament by way of a tear or rupture was significantly higher in those dogs weighing 18-20kg than when compared to the other two categories. However other types of hindlimb lameness had very similar incidence rates across all three groups.

Forelimb lameness however was found to be higher in dogs weighing 18-20kg, those being 3.7 times more likely to have this problem than dogs under 14kg and 1.7 times more likely to have it than dogs weighing 24kg and over. Muscle injuries were also found to be higher in dogs in the average weight group.

Table 6 - Injury and weight

Injury Type	<14kg Incidence Rate (Per flyball run (%))	18-20.0kg Incidence Rate (Per flyball run (%))	>24kg Incidence Rate (Per flyball run (%))
Arthritis	0.0030	0.0037	0.0044
Cruciate ligament rupture/tear	<0.0001	0.0037	0.0007
Muscle injury	0.0040	0.0087	0.0066
Other lameness (hindlimb)	0.0030	0.0044	0.0037
Other lameness (forelimb)	0.0010	0.0037	0.0022

<u>Breed</u> (Table 7)

The four most popular dog breeds were compared; there was not a significant difference between the breeds in general. However Jack Russell Terriers did appear to have a lower rate of muscle injury, lameness and arthritis. The occurrence of muscle injury and lameness in crossbreeds was comparably higher than in the other three breeds looked at. The theory of different types of feet ("cat feet" and "hare feet") showed no conclusions due to the very small amounts of dogs with hare feet, and the inability to determine the type of feet of the crossbreeds, which make up 20% of the survey group.

Table 7 - Injury and breed

Injury Type	Border Collie/WSD Incidence Rate (Per flyball run (%))	Labrador Incidence Rate (Per flyball run (%))	Crossbreed Incidence Rate (Per flyball run (%))	Jack Russell Incidence Rate (Per flyball run (%))
Arthritis	0.0050	0.0070	0.0062	<0.0001
Muscle injury	0.0051	0.0077	0.0097	<0.0001
Other lameness (forelimb or hindlimb)	0.0082	<0.0001	0.0132	0.0054

<u>Age of training</u> (Table 8)

Injuries were analysed depending on when the dog started training for flyball. The three categories looked at were less than 6months, 1 year and 2 years of age. There appeared to be little difference between the figures for arthritis. However the incidence of spondylosis was much higher in those that started training at 2 years of age. The overall occurrence of lameness was around the same figure for all dogs, with those who started training later slightly higher.

Table 8 - Injury and age of training

Injury Type	<6months Incidence Rate (Per flyball run (%))	1year Incidence Rate (Per flyball run (%))	2years Incidence Rate (Per flyball run (%))
Arthritis	0.0046	0.0041	0.0036
Spondylosis	<0.0001	0.0004	0.0022
Other lameness (forelimb, shoulder and hindlimb)	0.0114	0.0133	0.0158

<u>Running surface</u> (Table 9)

The surface which the dogs trained on was taken into account in terms of injury rates. The majority of teams (81%) trained on grass, with the remainder training on rubber matting, sand or another surface. The two surfaces compared were rubber matting and grass, and the injuries looked at specifically were arthritis, loss of skin to hard pads, damage to the carpal pad and dew claw damage. Those who did the majority of their training throughout the year on rubber matting were 1.7 times more likely to damage their carpal pads, 2.6 times more likely to suffer from arthritis, 1.5 times more likely to damage their foot pads and 1.9 times more likely to damage their dew claws than those who train on grass.

Table 9 - Injury and running surface

Injury Type	Rubber Matting Incidence Rate (Per flyball run (%))	Grass Incidence Rate (Per flyball run (%))
Carpal pad damage	0.0024	0.0014
Arthritis	0.0095	0.0036
Loss of skin to hard pads	0.0095	0.0062
Dew claw damage	0.0095	0.0051

<u>Boxes</u> (Table 10)

The types of issue that could be associated with the box were first compared for each type of box. In terms of carpal hyperextension injury, the highest rate was on the hybrid box and the lowest on the boomerang box. Shoulder injuries were significantly higher in dogs using the boomerang box. Other lameness was found to be higher in the upright box, with dogs 1.1 times more likely to suffer lameness than those on the hybrid and 1.7 times more likely than those on the boomerang box.

Table 10 - Injury and type of box

Injury Type	Boomerang Incidence Rate (Per flyball run (%))	Hybrid Incidence Rate (Per flyball run (%))	Upright Incidence Rate (Per flyball run (%))
Carpal Overextension	0.0004	0.0015	0.0009
Shoulder injury	0.0046	0.0005	0.0028
Other lameness	0.0062	0.0093	0.0102

<u>High speed video results for boxes:</u>

Carpal hyperextension was seen on all types of box.

On all types of box it was observed that some dogs compress their face whilst retrieving the ball. This often had a knock on effect to the remainder of the body, resulting in the turn not being executed as the ideal.

The ground on the approach to the box was progressively churned up due to the repetitive nature of the sport. Lanes are usually moved if the tournament is over two days, but this resulted in several dogs slipping up onto the box. Although by direct observation, there did not appear to be a problem, when observing the footage the extent of this was clear. Below is illustrated the approach to turn on a boomerang box, the dog slips for a distance before the box (Figure 18 - Dog sliding into boomerang box) . The shape of this type of box facilitates the dog in continuing to slide up the box and making a proper swimmers turn logistically difficult. This was also observed on the upright and hybrid style boxes; however the overall shape of them meant that the dog would crash into the box rather than continue up it. It is not clearly which of these is the most dangerous, as although the dog on the boomerang does not hit the box in the same way, it may injure itself turning in an unusual way.

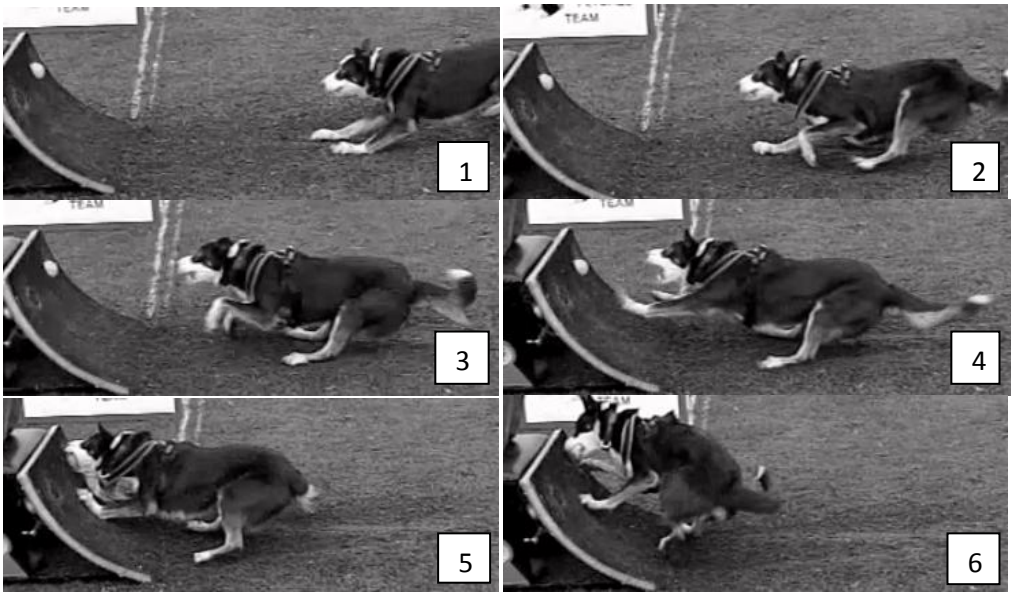

Figure 18 - Dog sliding into boomerang box

Finally to illustrate a point theorised in the introduction about iliopsoas injury. Canapp claimed that injuries of this type could arise from a dog going into a splayed leg position, and it was proposed that some dogs may turn in a way that means this is the outcome. The distance between the hind limbs is beyond normal limits and hence this type of injury may be likely (Figure 19).

Figure 19 - Possible risk of iliosoas strain in dog

Similarly, there are other areas where the dog is putting strain upon the body when leaving the box. This is illustrates the severe twisting which dogs can endure upon leaving the box and in order to get back in line with the jumps (Figure 20).

Figure 20 - Severe twisting upon leaving the box

<u>Other Sports</u> (Table 11)

Of the number that completed the questionnaire, 30% said that they take part in agility. The difference between the overall injury rate in those that partake in the sport and those that do not, is seen below. There was little difference between the two rates and hence it would seem that also taking part in agility is of no greater injury risk than just participating in flyball alone. However the detail of the question was not sufficient to indicate whether the dog competed and trained on a regular basis, or whether it trained on equipment in the garden as an enrichment activity.

Table 11- Injury and participation in agility

Activity in agility	Overall Incidence Rate of injury (Per flyball run(%))
Takes part in agility	0.0273
Does not take part in agility	0.0259

<u>Other Risk Factors</u> (Table 12)

Other risk factors also showed results in terms of injury. When looking at all injuries reported, the risk in those with a training format comprising of solely 100% runs had a higher injury rate than those who trained with a mixed format of 50% full runs and 50% extra skills; those with 100% full runs were 1.3 times more likely to be injured than those with a mixed format.

Those that competed four times per month throughout the summer were 1.3 times more likely to acquire any of the injuries discussed than those who compete once per month.

There was no significant difference between the injury rates compared to the singles times the dogs run. There was a slightly higher rate of dew claw damage, and loss of hard skin to the footpad in dogs running under 4.4s with their usual height dog.

Table 12 - Other injury risk factors

Risk Factor	Details	Overall Incidence Rate of injury (Per flyball run)	Injuries with higher than overall %
Training:	100% Full Runs	0.0334	Arthritis Dew Claw Damage Loss of skin to hard pads
	50% Skills/50% Runs	0.0251	Cruciate Rupture Other lameness (hindlimb) None Significant
Frequency of competing (Summer)	Once per month	0.0232	None Significant
	Four times per month	0.0300	None Significant
Singles time (with usual height dog)	<4.4s	0.0306	Dew Claw damage Loss of hard skin to feet**
	4.8-4.9s	0.0291	None Significant
	>5.2s	0.0289	None Significant

Preventative measures (Table 13)

The issue of leg protection was addressed. This gave the option of cohesive bandage, skid boots, pad protectors, elasticated leg supports and any other leg support. These were grouped to compare the difference between wearing any sort of leg protection, and not wearing any. The rate of carpal pad damage, dew claw damage and hyper-extension injury was much higher in those that did wear leg protection. However it should be noted that no time frame was indicated, and the dog may have started wearing the leg protection as a result of previous injury. The rate of arthritis was slightly higher, with the results suggesting that those who do not wear leg protection are 1.3 times more likely to suffer from arthritis. Those who did not wear leg protection also appeared to be 1.2 times more likely to suffer muscle damage. There was no significant difference between leg protection and the rate of other types of forelimb lameness.

Table 13 - Injury and preventative leg protection

Injury Type	With ANY leg protection Incidence Rate (Per flyball run (%))	Without leg protection Incidence Rate (Per flyball run (%))
Carpal pad damage	0.0045	0.0007
Arthritis	0.0041	0.0054
Hyperextension	0.0011	0.0004
Muscle damage	0.0064	0.0079
Other lameness (forelimb)	0.0030	0.0036
Dew claw damage	0.0075	0.0056

Warm up (Table 14)

Questions were asked about warm up, including techniques used. The most popular techniques used were recalls over jumps, walking 4min or less, free running 4min or less. Those dogs that were warmed up for less than a minute were 2.1 times more likely to undergo a muscle injury than those who received 5-9minutes warm up at tournaments. Similarly, these dogs were 5.3 times more likely to suffer from other forelimb lameness and 1.8 times more likely to suffer other hind limb lameness. Those who were warmed up for less than 1 minute were also 6.1 times more likely to have a problem with shoulder injury than those warmed up for 5-9minutes.

Table 14 - Injury and warm up

Injury	Tournaments	
	Warm up time of <1min Incidence Rate (Per flyball run (%))	Warm up time of 5-9 mins Incidence Rate (Per flyball run (%))
Muscle injury	0.0147	0.0069

Other lameness (forelimb)	0.0147	0.0028
Other lameness (hindlimb)	0.0118	0.0065
Shoulder injury	0.0147	0.0024

Discussion

The most significant findings in this case were that injuries in flyball dogs, although in existence, were at fairly low levels and a large amount were sustained whilst away from flyball. It was calculated that for an average dog, during each run there is theoretically a 0.0412% chance that an injury will occur. The results indicated that the most likely injuries were to the shoulder, and other forelimb lameness.

Risk factors were also identified for injuries, with the most notable being that:

- Dogs weighing 18-20kg were 3.7 times more likely to suffer from forelimb lameness than those under 14kg, and 1.7 times more likely than those who weigh over 24kg.
- Dogs weighing over 24kg were 1.5 times more likely to suffer from arthritis than those under 14kg.
- Crossbreeds were more susceptible to lameness when compared to Border Collies, Labradors and Jack Russell Terriers.
- Those dogs training the majority of the year on rubber matting were 1.7 times more likely to damage their carpal pads, 2.6 times more likely to suffer from arthritis, 1.5 times more likely to damage their foot pads and 1.9 times more likely to damage their dew claws than those who train on grass.
- Carpal hyperextension related injuries had the highest rate was on the hybrid box and the lowest on the boomerang box.
- Other lameness was found to be higher in the upright box, with dogs 1.1 times more likely to suffer lameness than those on the hybrid and 1.7 times more likely than those on the boomerang box
- Shoulder injuries appeared to be highest in dogs using the boomerang box when compared to the hybrid and upright style boxes.
- Training formats of 100% full runs were 1.3 times more likely to be injured than those with a 50% full runs, 50% extra skills layout.
- Those that competed four times per month throughout the summer were 1.3 times more likely to acquire any of the injuries discussed than those who compete once per month.
- Those who did not wear leg protection also appeared to be 1.2 times more likely to suffer muscle damage. There was no significant difference between leg protection and the rate of other types of forelimb lameness.

- The most significant results were in relation to warm up. Illustrating that those dogs who were warmed up for less than a minute were 2.1 times more likely to undergo a muscle injury than those who received 5-9minutes warm up at tournaments. Similarly, these dogs were 5.3 times more likely to suffer from other forelimb lameness and 1.8 times more likely to suffer other hind limb lameness. Those who were warmed up for less than 1 minute were also 6.1 times more likely to have a problem with shoulder injury than those warmed up for 5-9minutes.

These findings are significant as it may allow both owners to take action for example with relation to warm up, and provide clarity on advice for veterinary surgeons to give with relation to flyball dogs. Assumptions are sometimes made in the flyball community due to the lack of research in the area, and these results should help to make clear the risks and usefulness of preventative measures. The results also highlight the need for more clear information on warm ups in sporting dogs, and for the most effective methods when time is limited.

Other conclusions could have been made, for example the results showed that spondylosis was significantly higher in those that started competing in flyball at 2 years old when compared to those starting at 6months and 1 year. However, there were so few cases of spondylosis that this could have been a coincidence and should be looked into further before strong conclusions can be made on the matter.

Although few studies of this type have been conducted, it can be compared to that which was completed for agility (Levy, Hall et al. 2009).Although their study related mainly to specific obstacles, they did find that the most frequent injuries were of the back, and similar to this study, the shoulder region too. The conclusions made with regard to arthritis and weight also agree with work that has already been carried out (German 2010). The findings from this survey also back up the work already completed on warm up, and how it is thought to reduce and prevent injury. Comparing work of Prole and the work of Agnew showed a difference in composition of injury figures for different surfaces, although they referenced grass and sand (Agnew 1992; Prole 1996), this investigation also showed differences between grass and rubber.

There could be alternative explanations for these results. For instance the fact that arthritis is higher in the heavier dogs may not be related to flyball, this is also the case in non-participants. There could also be other confounding factors, for example those who compete in flyball may just generally be more active dogs and hence more predisposed to injury. On the other hand, the rate of injury could be much higher and those injuries just go undetected. In this study it was also highlighted the extent of which external sources were used to treat animals; 30% of dogs had been examined by a McTimoney Spinal Therapist. Many people expressed a concern at the lack of basic knowledge of flyball in the veterinary profession when prompted for further comments, and for this reason there may be the incentive to seek other individuals to ask for advice. It was also expressed that there seemed to be a reluctance to refer these cases to specialists, and perhaps if more was known about flyball then this would not be the case.

This study of course did have its limitations. A large number of the injuries were not sustained whilst competing or training in flyball, but instead out on walks or in the house. Whilst these may not directly be thought to be “flyball related”, they may have been predisposed to these due to the continuing wear and tear of taking part in the sport. It is very hard to distinguish between which

injuries are definitely flyball related, which may be flyball related and which definitely are not, from the survey results alone. There is also the problem of the time frame of the survey. For instance, the survey may have been filled out stating that the dog currently runs on a boomerang box, but it may have run on an upright for the majority of its career. Similarly, as already discussed, it may have been filled in that the dog wears leg protection and has suffered carpal pad damage; there is no indication whether it was wearing the protection at the time of injury, or whether this was a precautionary measure implimented post-trauma. Therefore, although the results are of importance with relation to warm up of dogs and training formats, they are not definitive due to the nature and restrictions of the survey.

If further research was possible, it would be useful for there to be more information regarding the relative safety and injury of each type of box. From the results here, it showed that no box was overwhelmingly more dangerous than any other, but each seemed to have a characteristic set of injuries. Additionally, it may be beneficial to look further into the benefits of leg protection with more of a grasp of the time frame involved. This would be important as if it was found to prevent or reduce the likelihood of injury, it would be beneficial to all dogs in the sport. A final finding which seemed significant was the relative impact of training on rubber matting in comparison to running on grass. The rates of certain injuries seemed significantly higher on rubber matting, and if this is the case, then methods of reducing this or alternatives could be looked into.

Conclusion

Flyball related injuries can be sustained throughout the flyball course, and also due to the repetitive nature of the sport. Injuries were however found to be relatively low, with only a 0.0412% chance of the injuries looked at in the study per flyball run. The most common injuries were lameness in the forelimb and shoulder. The risk factors found to be significant were injury were those weighing 18-20kg, the type of box used, running on rubber matting, repetitive training comprising of full runs only, frequency of competing, not wearing leg protection and lack of warm up.

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Individuals: K.Burns, K.Allcorn, L.Szostak, C.Clark, K.Ford
Box turn photos from http://www.freewebs.com/leadingedgeflyball/whatisflyball.htm (Glimpse)
Patent pending for measuring device: Application number: 11/787,507, Publication number: US 2007/0245583 A1, Filing date: 16 Apr 2007 (Eric Paul Tindall)