# Advancements and Progressions in Greyhound Racing:

# A Professional and Personal Trajectory.

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**Contents**

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**Abstract**

The context of these works is in relation to my work within the world of regulated greyhound racing within the United Kingdom, and represents a progression from my earliest interests in biomechanics and statistical analysis, through the development of this knowledge and the acquisition of new skills as the research progressed. It details my roles within disease control, research into exercise-associated sudden death, and the links with other research threads that stemmed from the first projects involved with the physics of wet sand tracks. I hope to show that my love of science, not just an acceptance but an enquiring methodology, has resulted in my progression through a variety of issues and as a result made a major contribution to the greyhound world. The links I make stem from my need to keep ideas separate, yet at the same time use the links so that I can jump from one line of investigation to another. The expansion of knowledge resulting from wet sand track investigations has enabled a much better understanding of the natural and applied processes involved in maintaining wet sand tracks, and also paved the way for a critical analysis of the interaction of greyhounds' feet with the running surface.

**Declaration**

This thesis is the sole work of the author. The views expressed in this research project are those of the author and do not necessarily reflect the views of the supervisory team, Middlesex University, or the examiners of this work.

**Abbreviations**

CHP – Canine haemorrhagic pneumonia

BGRB – British Greyhound Racing Board

DSMP – Disease Surveillance and Monitoring Program

GBGB – Greyhound Board of Great Britain

MRCVS – Member of the Royal College of Veterinary Surgeons

NGRC – National Greyhound Racing Club

SDS – Sudden Death Survey (renamed in August 2014 as the DSMP)

WST – wet sand track

**Terminology**

Within this document there are various terms and phrases used, for which a brief definition is supplied here.

**Bayesian analysis** – a broad area of statistical analysis whereby assumptions about an event's likelihood are modified by dynamic inputs, for example: "If it is raining today, it is more likely to be raining tomorrow." It deals with the probability of events occurring, and is used to update ideas about the future probability of the same event.

**Consequentialism** – an ethical theory that the consequences of a person's actions are the basis for judging whether the conduct was correct. In other words, the outcome of a morally correct act produces a good outcome, or the ends justify the means. The opposite of this is deontology.

**Deontology** – an ethical stance where the morality of an action is based on adherence to rules, sometimes referred to as a duty, or in this case, a duty of care. The opposite of this is consequentialism.

**Heath Robinson** – derived from the cartoons by Heath Robinson wherein unnecessarily complicated and unique machines were designed to achieve simple tasks, and where the machines were typically made from various oddments not originally designed for that task.

**Ockham's razor (Occam's razor)** – in competing ideas or hypotheses, the one with the fewest assumptions should be selected. In order to explain a new idea, the simplest route should be taken. This helps to dispose of long chains of complex ideas which have been composed to try to explain an idea, where the researcher is struggling to create a link.

**Utilitarianism** – an ethical stance in which the best moral action is one which maximizes utility, or the wellness of sentient beings. A form of consequentialism.

# ADVANCEMENTS AND PROGRESSIONS IN GREYHOUND RACING: A PROFESSIONAL AND PERSONAL TRAJECTORY.

**Introduction**

This work comes at a relatively late stage in my professional career, but at a time when I feel that I can reflect upon and assess the impact of my various projects both on greyhound racing and on my personal professional development. In my current professional position, I can look back at my professional output thus far and see that they are complete from an elementary point of view, and make a logical whole – one might say my works comprise a treatise on soil and biological mechanics with counterpoints in contagious and inherent disorders affecting racing greyhounds.

My works as a package of research across several disciplines have had a significant impact on the industry, yet at the same time they form the basis of future directions (for example, further work on greyhound injury patterns). The initial works into track physics laid the foundations for further work since any later research would have been misguided without a sound knowledge of track physics. My context statement will reflect upon and follow my progress from my earliest interests with veterinary science, through the development of my greyhound researches to the present moment, which although not climactic, is at a time when

most of the core research has been completed. From this core, future projects can be formulated which will serve to refine some concepts and hopefully strengthen my original findings. I hope that my reflections will serve to convey the way in which I approached the various tasks allotted to me, and demonstrate the dogged lines of thought I embarked upon to reach my goals. It is simple enough to say "goals", but in reality these goals were sometimes hidden and sometimes explained beforehand. For example, my track physics work asked questions of why and what happens, but other works were clarifications or statements relating to regulations (e.g. disease control or genetic problems). It should be noted that my work was not a one-man struggle against adversity, rather that the work was commissioned by the GBGB in order to gain evidence for any policies, regulations and practices that were under consideration at that time. Some of the research calls were outside my area of expertize, so the reader should understand that there were (and still are) several research threads being explored by other researchers for the GBGB. My interest lies in injury and disease patterns, and in track physics - hence my contextual statement reflects upon my responses and actions in taking on these particular commissions, and how the work suited my motivation and desire to contribute to greyhound welfare and the evidence-base of knowledge around the sport. Once my evidence was presented to the GBGB, it was then a matter for the various committees to consider both my evidence and evidence from other researcher's projects and to act accordingly. In some cases I was enacting my own advice (e.g. the 15 minute rule), whereas in other cases I saw the results of my work have a nationwide effect, for example the disease control policies resulting from my investigations into the rare syndrome of the sudden death of a greyhound at a residential kennels. In yet other cases, my evidence was contrary to accepted practice, and as such more effort was needed by the GBGB to integrate my findings with normal practices, for example

hydration in race kennels. With regard to my work on track physics, this showed how scientific evidence can both defend local policies and also present new ideas for track maintenance (e.g. the use of antifreeze solutions).

It is worth describing at this point how my thought processes work. I have a visual map of the various trains of thought, and each idea is linked to the next like a gear train. A line of experimentation or thought may stimulate the next idea, and it is normally when I am performing some physical task that the new ideas come to me – for example whilst out dog-walking, or when pulling a block around a sand track. I do not set out to come up with a new experiement, but often the next idea will be linked with the current task. As an example, when I was first emploted as a track vet I noticed patterns in the various injuries and events, so I started to collect data, which meant learning about data storage and relational databases, which meant that I then had to learn statistics to make sense of the patterns, which lead to a need to understand how wet sand tracks behaved. So each stage had a question which I then resolved so that I could progress to the next stage of the thought train. The train does not stop – each idea or project continues to operate. This is shown graphically in *Figure 1*.

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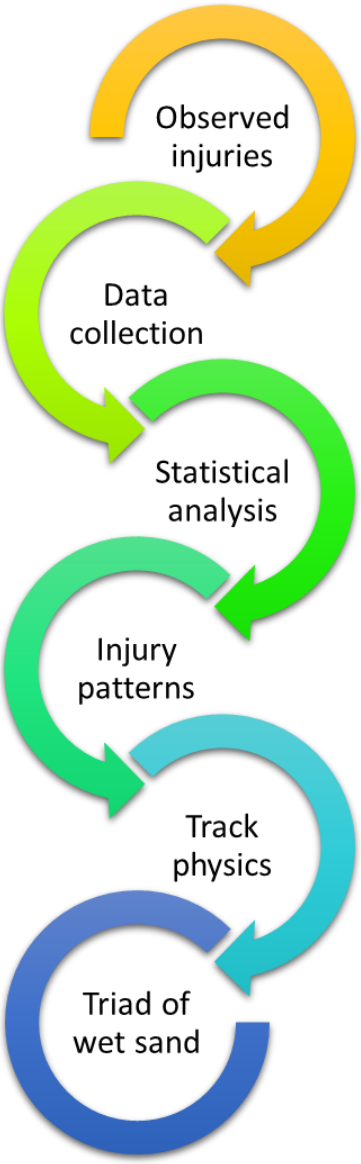


*Figure 1: In this example, it is seen that observations lead to data collection, then to a need to analysis to elucidate the patterns, which can only be fully explained by knowing more about wet sand tracks, which has led to the "triad of wet sand". This flow of ideas is explored more in the text.*

The overall relevance of my work falls into three categories: working at the national level, working within a professional context and setting reference points for the governing body. As will be seen within my narrative, there are links between track management, veterinary science and the desire to see change. I have followed various lines of investigation which I have kept linked in my mind and have thus been able to create novel realizations. The main link comes to the idea of why a veterinary surgeon would want to study geology: it turned out that a knowledge of the physical properties of granular materials and their interaction with water was a key piece of my learning, as in order to understand the interactions of the greyhound with the track, I first needed to understand how the track behaved. In particular, I needed to investigate how wet sand changed its behaviour under differing conditions, and from this I was able to formulate a standard model of wet sand behaviour. I was keen to explore this behaviour since I had many questions about the greyhound-track interaction which could only be understood, in my view, my having a personal and detailed knowledge of the microscopic and macroscopic behaviour of wet sand. If the behaviour could not be predicted, then the investigation of injury patterns would have had many problems since unknown behaviour is regarded as a statistical error, and this error would spoil any predictive models I wanted to develop when trying to find the patterns behind the various racing injuries. Reducing this error by increasing my knowledge was important since injury rates are typically very low, which itself creates statistical error. Thus I was aware that injury patterns could hide within other errors, and by reducing other errors I could hopefully uncover these patterns. Therefore my logic followed on that I had to have knowledge of wet sand because this knowledge would reduce the error component in future injury pattern models. The fact that it took several years to fully understand wet sand shows that my reasoning was correct, and looking back I can see that not having this

understanding would have made nonsense of an equivalent time researching injury patterns – my time as a veterinary geologist, to coin a phrase, has been well-spent. I can now further my investigations of injury patterns to the benefit to the racing greyhound, being as it will be based on a solid knowledge of track physics.

My approach to my research was set by my desire to follow injury patterns back to their root cause, but the stumbling blocks were the limited scientific knowledge of sand tracks (only a couple of papers have been written on the subject, both by the STRI[1], viz: Cook and Baker (1998a, 1998b)), and although less than compared with horse racing, several papers on greyhound injuries (Cook, 1998; Hercock et al., 2011; Lipscomb et al., 2001; Sicard et al., 1999). There was a good knowledge base for exercise physiology (Cox et al., 1976; Pieschl et al., 1992), and detailed research into biomechanics of running greyhounds (Williams et al., 2009b; Williams et al., 2008a; Williams et al., 2008b). So the focus of previous research was on greyhound biomechanics and exercise physiology, less on injuries, and minimal on track physics. Thus it was clear that I needed to gather information within the poorly researched area of track physics before any links between biomechanics and track quality could be made. As such my first approach to the BGRB was on the subject of track physics, resulting in my first research paper (Payne, 2007b), which itself then lead on to further projects as will be detailed below. As I uncovered the properties of wet sand tracks I was able to make recommendations for the correct management of tracks, and these recommendations did broadly agree with what was already being done, so the BGRB (and then the GBGB) treated my work as validation of their current track maintenance techniques. My research also assisted in the formation of a

[1] Sports Turf Research Institute, http://www.stri.co.uk/

common track preparation protocol, which my later work would then modify once it was realized the significant impact that the sand type had on the overall performance of the track.

At the time of my first project, there was ample funding for various areas of research, hence the investment into the alternative track surfaces which I was involved with (Payne, 2007a, 2008), and there were also proposals from UK Universities into investigating injury patterns. These investments came at a time when funding for greyhound racing was very healthy as there were 28 stadia around the UK (most of these are in England), and the flow of money from betting was helping to support the funding. As times have moved on, there are now 25 stadia, and less funding, even though there is about £2.5 billion wagered on races each year. Part of the issue for less funding comes from the increase in on-line betting, for which no bookmakers' levy is charged. The bookmakers' levy is used to assist research funding, so the GBGB has a ring-fenced research budget to ensure that research can continue.

An essential part of my research is my motivation: this stems from my desire to find out how greyhounds interact with the running surface and how this interaction can lead to injury. This is a prime mover for me as it encompasses track physics, data collection and analysis, together with developing models and results that will hopefully benefit greyhound welfare. As described above, I saw that to have a proper knowledge of injury patterns once must first understand the two sides of the equation: the biomechanics of the racing greyhound and the soil mechanics of the wet sand. Greyhound biomechanics is well understood (see Williams et al. (2009a); Williams et al. (2008a); Williams et al. (2008b) and Williams et al. (2009b) for

comprehensive descriptions), but track physics far less so because human running surfaces are synthetic nowadays, and geology tends to focus on the construction and energy exploration industries. Thus there is a knowledge gap in the use of wet sand as a running surface.

Being able to understand all the parts of the sand-to-greyhound interactions is very important to me as it allows the chain of events fit together to a coherent whole in my mind. This theme of a holistic knowledge base is repeated within my research, and starts with the need to understand wet sand. The research into track physics has also had a wider impact, in that the ideas have been incorporated into standard track preparation guidelines which have been issued to all GBGB-licenced stadia. I find this pleasing since the work I have done is already being used to help maintain race tracks, and from this there is feedback from how this maintenance is affecting the tracks. This acts as a source of refining information from which further changes can be made to fine tune wet sand track management. This Bayesian[2] approach attracts my mind as I can follow the changes in a logical manner I can understand.

This same pattern of the linking of research aims with management practices was also evident in my research work with the hydration of racing greyhounds. Here there was the clear need for properly hydrated greyhounds, but in conflict with the ruling that once kennelled at a race track, the greyhounds could not have access to water for fear of doping irregularities. Fortunately there was ample research to back the veterinary argument, so the only part I had to

[2] A form of analysis where links are made based on probabilities e.g. if it is raining today it is more likely to be raining tomorrow.

complete was to show that water loss did occur during the kennelling, and from that the ruling was changed to allow access to water whilst kennelled at the stadia.

These concepts of the meeting of veterinary science with greyhound-specific research will be expanded further in my narrative. I have divided my professional journey into professional progression and into the several research threads: track physics, disease control, and exercised-induced fatalities, which I intend to critically discuss in terms of the process of discovery, how they interlink, and how they project into the future.

# CHAPTER ONE – MY CAREER

## Early Professional Career

My first experiences of veterinary medicine were gained when I volunteered to work at two local veterinary practices during my A-level studies. I supplemented my enthusiasm by both technical reading and light reading on the subjects of anatomy, biology, and biochemistry, not to mention veterinary medicine. I especially remember reading "Veterinary Notes for Horse Owners" by Capt. M. Horace Hayes (first published in 1877), Black's Veterinary Dictionary and the autobiographies written by Alf White (writing as James Herriot). It was the combination of science and art of veterinary medicine that really made me want to become a veterinary surgeon working in mixed practice. The actual appeal was the use of science in being able to affect a living being – or rephrased: how something that has evolved over eons can be explained and predicted either wholly or in part by science which itself was a few thousand years old. In the same way that mathematics can describe the motions in the universe, so veterinary science can describe the physiological and disease processes that occur in nature. This was fascinating to me – the study of science could be used to describe such actions as locomotion, blood flow, the movement of ions across membranes, progressing from the macro to the micro. I could visualize the chemical processes within cells and see the changes that occurred during exercise for example. Then we have the reverse: the actions of the animal have an effect on its own cells. We see exercise stimulating the development of muscle strength, improving recovery, causing reactions in the bone to increase mineral and organic strength. It is the interplay of the macroscopic events on the microscopic world that makes me wonder how superbly it all fits together. Being a veterinary surgeon means to me a scientist who studies animals and is able to affect change in those animals by understanding this interplay. Consequently, when I came

across the various problems described in this reflection, I was moved to not just resolve the result, but to follow the entire process back to its microscopic roots. As an example, a greyhound running on sand is not just locomotion, it is the interaction of wetted mineral grains with the elastic structures of the greyhounds' tissues, all the while resolving this microscopic interaction with the macroscopic effects. Hence I saw the need not to understand biomechanics, but to understand mineralogy, anatomy, physiology, mathematics, physics and chemistry. Each has its own compartment in my mind, but I link them to create the whole picture – I can see the macro and micro at the same time, thus I have a strong need to have all this knowledge available, otherwise I would fail to make these links. Herein is the answer to why I as a veterinary surgeon need to be a physicist, chemist and mineralogist – each on its own is insufficient for me, and also causes me to think what it would be like not to have this desire. Surely to understand any part one must have a complete knowledge? Although my reflections here have enabled me to communicate my thinkings, it is not a new process to me. From a young age this holistic desire has been at the root of everything I have done, so becoming a veterinary surgeon was actually part of my progression as a thinker, not just a career. Indeed, my current post of Assistant Professor of Veterinary Anatomy at the University of Nottingham's School of Veterinary Medicine and Science is part of this whole progression and mind-set.

When I qualified in 1989 from the University of Cambridge School of Clinical Veterinary Medicine, I joined a mixed practice in Leicestershire. I decided to be involved in an active mixed practice as I thought this was the best way to obtain a good all round experience, and from there to focus on areas which particularly interested me. I found that surgery and treating ailments from first principles stimulated me most, to the extent that I began collecting

old textbooks on anatomy and pathology, plus some texts on the treatment of animal diseases. (In order to see my train of thought, I need to state that before the Royal Charter of 1844 veterinary surgeons as professionals did not exist, rather the animal medics were called farriers and learned their trades by apprenticeship). The textbooks associated with this era were remarkable in their clinical observations and use of descriptive English, and their eye for ailments without recourse to laboratory tests and instruments such as we have today made for very interesting reading. I reasoned that the professionals of the time where not simpletons – they were as cognisant as you or I, but they lacked the scientific knowledge being as it was limited by the technologies of the time. Thus they developed excellent observation skills, in the same way that a blind cave-dwelling animal has evolved more acute tactile senses – the pressures of needing to know more about their surroundings lead them to develop other ways of making sense of the world. This reliance on subjective information and experience was actually a form of Bayesian analysis in that the pertinent observations were recorded and the clinical response to therapy assessed. This created a cycle whereby repeated examinations of the disease's progress under treatment caused modifications of the therapy in order to generate a favourable outcome. My belief was (and still is) that being able to accurately observe clinical signs, and ascribe a significance to these signs in order to formulate a treatment plan was a crucial process in my veterinary professional development. I believed that the old ways must have worked to some degree otherwise they would not have persisted. I knew to be careful of this argument, since there are many instances of entrenched thought not giving way to new science, and my aim has always been to use the evidence generated by good science to alter good practice. This is why I like research since I can follow my own quest for knowledge which can then be used to either justify the old ways, or to push for change when the evidence

indicates change is needed. Later in this reflection I will explain how this approach has come together in the management of sand tracks: I show why the old ways work as they do by providing evidence, yet at the same time show that other management methods are needed to supplement the old ways. My acceptance that both old and new can exist together stems from the concept that without evidence processes progress by Bayesian modification, but that new science can indicate where quantum shifts in the processes are needed to avoid the sometimes slow progress that trial and error can produce.

Referring back to my career as a practicing veterinary surgeon, I am not implying that I did not use diagnostic tests, rather that I ensured I properly identified the clinical signs, rather than relying on the tests to give an answer. To me laboratory tests can circumvent a good observational approach, and as such leave the professional cheated of the experience of diagnosis. This diagnostic experience is a key point for me since the act of following the problem enables a greater understanding of the cause of the problem, and this is a recurring theme in my research in that although I use others' research as a starting point, I still review the entire process so that I understand the entirety of the problem.

I still have a huge interest in clinical observation, even though I am no longer involved in clinical practice, by having a small but very valuable library of historic text books on the subject of "Farriery", as veterinary surgery was known before the twentieth century. One of my favourites is "The Modern Farrier", published in 1844, which has excellent clinical observations even if many of the therapies are frowned upon nowadays. I have even successfully used some

of the old remedies in stubborn cases where current therapies have failed to provide a resolution. I feel that one of my major strengths is that I am able to assess, review and revise old ideas and then apply my own slant on them. Obviously not all will agree with my approach, but I found that it worked very well for me, and paid dividends when I was able to diagnose an illness without recourse to further tests when financial considerations were brought into the mix. There are instances where medicine has progressed so far that the old knowledge is forgotten, like the fading of the wake of a ship, whereas I like to liken of the acquisition of knowledge to that of drawing a line on a sheet of paper – the pencil progresses but the line remains. I have tried to bring this philosophy into all my thoughts and actions – for example in my current employment as a teacher of veterinary anatomy I use a series of books from different eras. For example, the oldest book I use is a tome first printed in 1910 (Sisson and Grossman's "The Anatomy of the Domestic Animals", pub. Saunders 1975) and the newest an electronic book produced in 2014 (de Lahunta, Glass and Kent, "Veterinary Neuroanatomy and Clinical Neurology, pub. Saunders 2014). Using this range gives me the excellent hand-drawn images from the older books combined with the most up-to-date research in neuroanatomy, and in so doing allows me to see the wholeness of anatomy. This holistic overview of knowledge is very important to me as without it there are too many empty boxes in my brain which reduces my flexibility of thought – an explanation of what I mean here is dealt with later.

So, returning to the thread, where I have had cases where I did not have access to technical facilities I have drawn on my clinical experience and knowledge to enable me to make a diagnosis based on my own analytical processes. To me, being told the answer is anathema – I need to follow the process. As a simple example we are all familiar with the mathematical

problems phrased like "if it takes three days to fill a bath with a spoon, how long will it take to empty it with a ladle twice the size". These problems are constructed in such a way that there is a shortcut through the problem. I cannot do this – I have to resolve the problem into its actual formula so that I can solve it for any size of spoon or ladle, much to the annoyance of my family, since it takes me much longer to do this than to use the shortcut. But at the end I have a formula to solve all similar problems, whereas that detestable shortcut only works for the given puzzle's situation. This relates directly to my career-long ethos of gathering as much data as possible on varied subjects and which provided the groundwork for my later education in statistical analysis and mathematical modelling – creating formulae not shortcuts.

**Involvement with Greyhound Racing**

In order to provide some context of the background against which I worked, it is useful to briefly describe here the structure of the regulation of the greyhound racing industry. The racing greyhound industry has had a governing body since 1921, the NGRC[3], and they existed alongside the BGRB. The two bodies had different remits: the NGRC regulated, whilst the BGRB was more concerned with the commercial side of greyhound racing. In January 2010 the two bodies were merged into the GBGB. The GBGB has several committees each with different remits, and I have been most closely involved with the Veterinary Subcommittee (a branch of the Welfare Committee) and the Track Subcommittee. I have worked on projects commissioned by all three bodies, but now that there is only one overall body, the results of the works can be made available to all sections of the GBGB.

[3] For abbreviations, please see page 5.

From my time as newly qualified veterinary surgeon in 1989 until about 2004, I was what may be loosely described as a general practice veterinary surgeon, with a definite preference for large animal (i.e. horse and farm) work. This preference was simple enough to rationalize: I liked driving, and the travel between successive clients gave me time to reflect on the case and to think about the next one. Also there was a little of the "old farrier" in me which enjoyed the idea of following in the tracks of my predecessors in their clinical rounds. In the mid-2000s an old back injury received as a child started to make itself known, and in about 2004 this reached a crisis whereby I was unable to move for several days. On medical advice I gave up large animal work, and moved back to the Midlands (I was in Pembrokeshire at the time) to be nearer to my relatives. Although this was a low point in my career, I did not cease veterinary studies, and continued to read my textbooks and internet resources. In terms of my own feelings, I was of a mind that accepted the situation but without being distressed or troubled, although oddly enough I became mentally unable to drive a car for several weeks. This mental dropout reset itself since after being a passenger for this period, I suddenly realized I could once more drive. I think that lack of distress came down to my Asperger's Syndrome whereby events happen but without an emotional link. As such I just disassembled the situation into its parts and then assessed each part. So I had "work", "learning", "research", "computers" and such like as different compartments within my brain (but no "emotion" box!). From these I make links that I visualize as strings of light – the thickness of each string represents the strength of the link. Long links represent trains of thought connecting apparently unrelated ideas, which you may liken to watching an arrow coursing from bow to target, but leaving a trail of light. Short links are rigid chains, and represent closely linked ideas. So I have a mental

image of my work as boxes or containers linked by strands. I can move in and out to see the whole or see the contents of the boxes – and within each box new ideas can sit. In order to generate coherent thought there cannot be too many empty boxes (meaning no knowledge or the implicit acceptance of facts) otherwise my thinking is blocked by knowing there are things I do not know. I can sometimes accept an unknown to enable to partially complete and then "park" a train of thought, but I will have to return to the unknown and explore that before continuing with the original line of thought. This method of dealing with small unknowns mimics the reason why I explored track physics before continuing with injury pattern analysis – the fact that I can park both small and large trains of thought is no great hindrance, since the ideas are still kept within boxes and thus remain manageable whatever their real-world size. This is one of the reasons I like computing, as both file management and relational databases exactly mimic the arrangement of ideas within my mind, and similarly these systems do not function properly with empty entries.

It was while I was convalescing that I was essentially able to have a sabbatical of about 18 months, which served to clear my mind and body. It is in my nature to set experiences in compartments, yet retain the ability to make links to those experiences I needed, and ignore those which interfered with logical thought. Thus I can still draw on the clinical experiences of my large animal work, but without the emotional bind of being concerned that I am no longer able to be a large animal veterinary surgeon – this to me is mental overburden and not conducive to clear thought. At the time I did not have a plan for progression – after all being a veterinary surgeon was part of me, and I was sure I would be able to continue my career in some vein.

When I felt able, and as part of my exploration into what to do next, I tried my hand at small animal practice, but quickly found that standing immobile for extended periods at the operating table only aggravated my back pain. This small foray was really a case of testing the water, and to see whether small animal work was something I would enjoy without any large animal work. Whilst searching for positions to give me a re-entry into veterinary medicine, I discovered a job as a track veterinary surgeon at Coventry Greyhound Stadium. This proved to be the outlet I was looking for, as the greyhounds were physically small enough for me to lift and work with, yet the mentality of the trainers and owners was of the large animal ethos i.e. that the greyhounds were working animals there to do a job. So there was the combination of the bond one sees with family pets with the pragmatic views of the farmer. This suited my own mentality since I could relate to both these views, and I could communicate in my usual compact and efficient manner, i.e. I could explain a problem without the frills needed in small animal practice. Although I do have a bedside manner, it is not verbose but rather to the point, choosing my words to make for direct but not blunt communications.

The greyhound work was essentially of the triage style, where immediate first aid was supplied where necessary, but leaving me with many hours of observation and cogitation. I quickly realized that much of my large animal knowledge was applicable to the greyhounds, specifically the biomechanics and characteristics of the injury patterns. This suddenly opened a new avenue for me – the investigation of injury patterns via the analysis of collected data. This in turn wakened my latent interest in statistical analysis. The facility with which I could gather

data on the greyhounds' performance and my like of ordering information to make sense of it seemed to come together with such logical ease that I wondered why it had not been done before. My research developed quickly and began by learning more about statistical analysis and data storage and management. The data storage aspect was particularly interesting since it required great discipline to generate unambiguous datasets, and was a new area to me. As I have already discussed, a new area represents a knowledge vacuum that needs to be fulfilled. I began with simple databases, and then expanded them into relational databases. It was the development of these relational databases that caused some unease within the committees I was to sit on, as such a detailed database of performance and injury had not been held before, and the suspicion was that the data was going to be used for no good. On this I was stubborn when challenged as to why I was keeping the data. I defended the need for data collection and analysis as this was the route to evidence based practice. It was the entrenched belief that the sole purpose of data collection was to denigrate greyhound racing that was the reason behind why data collection had not been carried out in a systemic fashion previously. As I expand later, the uses I put my data to where eventually seen as very beneficial and indeed supportive of the welfare efforts made by the greyhound racing industry to improve the welfare of racing greyhounds.

**Progression onto Professional Committees**

My interest in the details behind track preparation, injury mechanics and exercise physiology was noticed by the Stipendiary Stewards. These stewards are officials of the regulatory body (at the time the NGRC, now the GBGB) and monitor the tracks' compliance

with the regulations (the Rules of Racing[4]). Probably as a result of many informal discussions with the stewards, I was invited to sit on the NGRC's Veterinary Welfare and Scientific Committee in 2007. In this position I was made aware of current issues, and was also able to voice my opinions and assist with the generation of new regulations and guidances. Similarly, other people within the industry became aware of my interest in evidence-based decision making, and my keenness to expand the basic knowledge available to make such decisions. It was these early links that started me on my path of research into racing greyhounds.

The stimulus to my brain was the novelty of the work, and the fact that it did not appear to be an area where much research work had been completed – as noted above I dislike knowledge holes as they spoil my way of linking areas of thought. I particularly wanted to work on the problem of injury patterns and how they change – that is to say that there is a marked patterning of racing injuries (this is common to many sports, not just greyhound racing). Since I am intrigued by patterns and cyclicity, injury patterns were magnetic and became a core research theme, embodying biomechanics, anatomy, physics and geology/mineralogy. It was at this point that I found that there had been little or no research on the running surface (wet sand), and to me this was both strange and a hindrance. Strange because I thought it had already been done, and a hindrance since the lack of research created a block to my progression. I could not possibly explore injury patterns without a full understanding of the behaviour of wet sand tracks. As such my research had to build the knowledge base on the behaviour of wet sand tracks, and leave the injury pattern research until later. This did not stop me collecting performance and injury data, and I continued to expand my skills in managing large data sets

[4] Updated rules are available at http://www.gbgb.org.uk/rules-of-racing.aspx

and the coding necessary to extract the data. My enthusiasm and commitment must have had an effect because I was invited by the BGRB to present a proposal for a project to explore wet sand track physics. This proposal was accepted, and I was granted access to the licenced stadia around the country in order to run the project.

One of my first projects was on the basic interactions of sand and water, which although well-understood from a geological point of view, was less appreciated when used as a running surface. To my mind, this basic level of understanding was essential if I was to progress my research. It may well be asked why a veterinary surgeon would want to conduct basic research into the interaction of sand and water. Indeed this question was posed to me during my first project, and without explaining the detail of my thoughts as I have done in this reflection, I explained that a fuller knowledge of the basic science was important in being able to understand track maintenance, and with this, injury prevention and improvements in greyhound welfare. As I have explained above, the root of this desire has always been within my professional ethos, in that I always wanted to know why a thing was true or why such-and-such worked in a particular way. It is never enough to know by rote, but to investigate and analyse leads to a greater knowledge and deeper understanding of the process in question. Even veterinary medicine strikes me in the same way: it is not sufficient to have an animal with an illness – the cause and reasons must be known in order to not just answer but to understand the needs of the ill animal. This stems from the fact that I have always enjoyed taking machines and engines apart and reassembling so that I could analyses their constituent parts and see the relevance to the overall function of the machine. To me there are exact parallels with animal anatomy and biomechanics, so I reasoned why could I not evaluate and analyse the animal's anatomy, relate

it to function and biomechanics and use this as a basis to understand abnormalities and repair processes. Being a veterinary surgeon places me in that ideal place where I can operate, repair and suture in order to re-create the original form i.e. being a surgeon enables me to repair anatomy in the same way that a mechanic repairs machines.

Thus leaping to the now, my desire to fully investigate underpinned all the projects I undertook with the GBGB and its forerunners. So my answer to the question "why" is "to understand", which encompasses the process of gathering evidence, analysing and reflecting, going forward to a deeper understanding and coming back to generating evidence-based practices and rules that all help to improve not only my only own knowledge, but racing greyhounds' welfare.

**Progression with Biomechanics**

My first interests with biomechanics originated during my veterinary studies, since from an early age I had always been interested in both natural and engineering sciences. The appeal is in the fact that many locomotory machines are functional copies of animals – even the use of the wheel is an engineering way of reproducing the oscillations of an animal's limbs but without the acceleration and deceleration forces induced by the duty cycle imposed by animal locomotion. Indeed engineers struggle to make direct copies of animal locomotion because the materials and power sources are only just becoming available that can reproduce animal locomotion. We are returning here to the concept of human desire to progress being limited by technology, in the same way that early clinicians used observation to replace technological deficiencies.

Anatomy seemed to me to be a logical merger of these two areas of nature and engineering: the natural architecture of an animal coupled with the physics of movement. The way in which the anatomy is perfectly adapted to the requirements of the animal intrigues me – the necessary adaptations have taken millennia to produce but we can still see the similarities between many different animals. For example the basic design of the forelimb has remained constant since animals first progressed onto land and yet despite the subsequent variations on that theme they still operate within the constraints of the laws of physics, and are still recognizable as forelimbs. I am certainly not the first person to have noticed this (for modern examples see Williams et al. (2008b) and Williams et al. (2008a) ). Indeed one only need look at the progress of automata to see the way in which nature gives scientists the ideas for a basic design. There is no point inventing a new design when nature has already perfected several over the millions of years of evolution. In any event, the scientific mimicry of nature has and still does fascinate me, and in my lectures to veterinary students I use simple models to explain complex anatomical and biomechanical concepts. During my veterinary studies I was able to examine in detail the relationship between nature and physics – after all, all nature is governed by the laws of physics, a point I make to my students on a regular basis. Animal movement is bound by physics in the same way that machines and planets are, but with the added attraction that animals' movements are the product of living and adapting tissues. Having this appreciation of biomechanics has allowed me to see the relationship between all animal movements, including racing greyhounds and their interaction with the race circuit. It is not a simple case of a static analysis, but a dynamic analysis of foot fall, weight bearing, thrust and take-off, only some of which can be appreciated with the naked eye. Where the new knowledge lies is in

videographic analysis of locomotion, greyhounds included, and this can be extended by the use of telemetry to measure limb velocities and forces (i.e. acceleration).

My initial research proposals were along these lines: the analysis of limb forces and wet-sand interactions, however it became rapidly clear that the basic knowledge was missing. When I first joined the world of greyhound racing in 2005, I did rather expect that as my experience grew I would be able to tap into a vast repository of knowledge which I assumed existed in a formal format. The reality was that there was indeed a lot of knowledge, but that this was made up of collections of anecdotal and personal experiences, each jealously guarded as the "right way". As I realized this, I sought to find a way in which the experiences could be validated and an evidence base developed in order to allow a more logical approach to the many areas of greyhound racing. This lack of order and evidence created a deal of professional and personal frustration in that I could not see how progress could be made without some solid based of proven knowledge. It is in my make up that I need to see order and logic, and performing tasks because they had always been done that way did not marry with my personal and professional ethos, which needs order and logic. For me, I needed to see this information in an organized state in order to determine patterns and knowledge gaps – only in this way would I be able to see my way through the exercise. Going back to my way of visualizing concepts as boxes joined by lines of light, these gaps distort my thinking. I have to avoid the gaps to keep the lines of thought straight – I need to create a box to put the gap into, then once the gap is enclosed I can start to think about how to resolve the lack of knowledge. Having the gap contained means the thought lines are straight, so I can continue to function, and also sets a compartment in which further investigations should be conducted.

The first step on the way to resolving the knowledge gap was to create a database of information, and then determine which pieces of information formed patterns and which were just single instances. In order to do this I needed to learn about database construction and management, and along with this the ways in which the database can be interrogated to extract relevant subsets of data. Following from this I also needed to develop my statistical knowledge, as I was aware that the data I planned to gather could be sensitive, and thus I wished to be able to analyse my own data.

**Progress with Statistics**

Statistical analysis has been very important in my work, since many of the projects have generated large amounts of data which needed to be analysed in order to produce meaningful results. From the time of my A-level studies I have been interested in statistics and how numerical analyses can help to formally explain subjects from the mundane to the nebulous. After my A-levels, my statistical training progressed but little. It was only after I started to gather data on greyhound performance and injury that I rekindled my studies and through personal study, and managed to gain a good overall understanding of the uses of statistical analysis. I could see the link between data and clinical significance. For example from the data I collected, the body weight distribution of the greyhound population is clearly divided by gender, with males being 5.1 Kg heavier than females, on average. At the other end of the analytical spectrum is given by my work on the racing performance of female greyhounds, where I developed 30 separate models using an extensive dataset to work out how much the

performance of greyhounds varied during oestrus through dioestrus and into anoestrus (Payne, 2012b).

This type of analysis would not have been possible a few years ago, and my fascination with statistical analysis and modelling meant I could use these new methods and software tools to analyse the data in order to benefit my work by being able to add their support my conclusions. Also the development of multilevel statistical software and the available processing power on modern desktop computers means that the analysis is now within the grasp of many researchers and has opened up several areas of research that were previously delayed by having to use older methods and tabular calculations. In this instance the older methods were limiting on the quality of the analyses that could be produced, but they do still have their place. My favoured approach is to use multilevel models from the outset (after the usual process of checking the data for normality, and removing outliers and mis-entered data). Even with such powerful tools, I still try to visualize patterns within the data using the 'mark one eyeball'. This adherence to basic tools, then progressing with more and more detailed analysis is key to all statistical analysis, as it prevents false assumptions being carried through to later calculations. Again we have the analogy with clinical observation being the mainstay of diagnosis by keeping in mind the whole problem, and not dispensing with these older methods just because new ones are available. This balance of old and new and being able to decide which to use and whether to only use one method, or to supplement the old with the new is one aspect of all these disciplines which will always make me stop and think. My statistical knowledge has advanced during my professional career as each stage of my research has demanded more varied analyses, so this progression can be regarded as an ongoing development which I have called upon many times,

and each time my depth and breadth of statistical knowledge has increased but only on a need-to-know basis. Although my tenet is to explore new realms to their fullest, the world of mathematics is so large that I have had to limit my learning to what I really need for the current analyses. This has meant that I have asked for statistical help for some of my work, but I have treated this as a learning experience by doing the analyses myself once I have received guidance. I could not hand the data to someone and receive the results, as I would not understand the results, and thus my understanding of the whole exercise would suffer. In order to progress I do need to do all my own work. This reluctance to take the easy route has a downside in that I can take longer to produce a result but at least I will have gained hands-on knowledge to be able to perform similar future analyses without being limited by my lack of knowledge. Statistical analysis would not be possible without data, so I will continue my reflection by discussing data management and data extraction.

**Databases, Queries and Analysis**

I have always had an interest in information technology, and learnt my skills on a Research Machines 380Z [5]. As technology advanced, so I bought various second-hand computers and learnt about the internal workings and construction – showing again my need to understand how a device works, not just to be able to use it. Up until about 2007 I used computers mainly for accounting and web browsing, but when I started to gather data on greyhounds, I became aware that I needed to be able to record this information in a way which could be compact, organized and searchable. My first datasets were carried on a standard spreadsheet (which is just a two-dimensional database), but as the datasets grew and particularly

[5] See https://en.wikipedia.org/wiki/Research_Machines_380Z

when I started to add in raceform data, I found that spreadsheets were easily overwhelmed and not suitable for the tasks I had in mind. At the time my youngest daughter was at primary school, and I made friends with another one of the fathers, who was also very interested in databases.

The results of these afternoon discussions led me to investigate relational databases. This style of data storage was just what I was looking for – a three-dimensional data storage array, where I could place my limited spreadsheets and link them together as tables of data. It only took a few key words (viz: "SQL" and "relational database") for me to investigate the realms of relational databases and how to extract data from them. I experienced this as one might view a cathedral when entering for the first time – the outside belies the contents. I at once saw the advantages of storing my data in a 3-D array, and absorbed the background set theory and explored the various software options available. I wasted little time in transferring my data to a relational database. This enabled me to both enter, manage and retrieve the data and gave me the control I needed to be confident in the security of the data (also important to the GBGB) and to make sure I was retrieving the exact datasets that I needed for my analyses.

The underpinning feature of relational databases is the use of unique keys to identify records, with the same key being used in other tables. Thus linked records can be extracted knowing just one key. The other feature is the ability to filter out the data using special code (called Structured Query Language or SQL [prn: *see-kwel or just ess-kue-ell*]) to query very large datasets quickly. Once I had learnt the basics of relational databases and how to write SQL

code, my data storage expanded thus enabling me to perform more analyses. This data expansion then created another software problem – that of size. At that time I was using a Microsoft[6] Access database which had certain limits which I was getting near, and with the size came the problem of stability. Worried that I might corrupt my data without my knowledge (I backed the database up every day, as I have done ever since), I investigated further software and discovered that the enterprise class of data storage was the Microsoft SQL Server series of packages, one of which was free and could cope with two gigabytes of data. This would easily cope with the datasets, so I in installed SQL Server 2008 (I am now running the 2014 version[7] which handles 10 gigabytes). Although SQL Server is designed to run from a server, which several computers can access, I run it on one computer, with SQL Server as the backend database and Access 2010 as the user-friendly frontend. This setup has worked well and has protected my data, as well as being very fast – the SQL queries are written in Access but run on the SQL Server.

So all this software is all well and good, but what was the aim in installing it on my computer systems? Firstly the visual appearance of the data within the software package mimicked my own mindmap, so that was interesting since I could see my mind on the screen. Secondly, in retrospect one could say that I could have just given the data to a third party and explained what I wanted, and how I wanted to access the data. But here there were two hurdles: one was my need to understand fully the data storage and how the data access was achieved, and the other was that of trust. Much of the data I hold is sensitive in that it contains the racing

[6] https://products.office.com/en-gb/access
[7] www.microsoft.com/en-gb/server-cloud/products/sql-server-editions/sql-server-express.aspx

events of thousands of greyhounds, with links to all their lines of raceform. Such a dataset is open to abuse, and is certainly not one for the public domain, although the results of data analysis in the various papers I produced served to strengthen various ideas and hypotheses, and thus the results but not the raw data are seen publically. This concept of hiding raw data is not unique, and is a precaution against misuse of the data, so this is really the main reason why my datasets are kept secure. Even within the dataset various blocks to misuse exist, since all names and locations are coded, as well as the dataset being split into several tables. The table links are the key to unravelling the data, and without the linking information the links between tables cannot be made, and thus each table of data be analysed by itself without compromising other data tables, yet if more information is needed, the links can be used to provide this extra information. Having this information close and under my control gave me the confidence to expand the datasets and the internal links without the worry of data loss or corruption.

Of relevance at this point is a meeting I attended with the BGRB and the Horse Racing Association on the subject of injury data storage and analysis. At this time I had just migrated my data to Access 2007 and had a fairly extensive dataset of injuries and raceform. During the meeting we discussed data and databases, and I mentioned that I had my database with me on my laptop. I demonstrated the way in which the database worked, and how it could be queried (retrieve information based on a set of criteria). At this time the concept of data acquisition and storage was viewed with much suspicion, since the fear was that such a database would be disseminated and be accessible by anyone. Since I understood the way in which the data was stored, I knew that it was secure, and could see the benefits to the greyhounds. For example, for a particular injury I could query the database and extract the patterns for this type of injury, and

from that ascertain various risk factors. Having identified those risks, it would be possible to go back to the trainers and the stadia and suggest modifications of training and track preparation. This to me was a logical process – from data storage to analysis to risks to corrective action, and bereft of any political machinations. Politics is not my forte and it vexed me to think that such benefits could be blocked by politics. Direct debate was clearly not going to be effective since the entrenched idea was that all data would be used to denigrate the work of the governing body. My resolution was to only use the data in my own work and papers, and by this route demonstrate the marked usefulness of performance and injury data in furthering greyhound welfare. Many of papers use the data I hold, the clearest examples being the two papers on the effect of the oestrous cycle in racing greyhounds (Payne, 2013a, b).

From the standpoint of the current day, I can look back and see that as my database has grown then the trust in my data handling has increased to the stage where I use the data in reports and papers as a base line for the topic in question. I think that this is because I control the entire data flow from storage to analysis, and that I am not perturbed by using the results to explain new concepts, even where there might be conflict with accepted practice. It is now almost an expectation that the data I hold will be referred to as part of the evidence based approach which is so important in developing sound advice and guidance on diseases for the GBGB. The current state of the database is now such that I can embark on the analysis of event patterns during races in order to determine risk factors for such aspects as track width, radius, track consistency and the way in which individual raceform affects the likelihood of an event occurring. For example racing frequency can affect injury likelihood, and this is very much an individual dog problem. The ability to handle this data has driven me to expand my knowledge

of statistical analysis, and studied statistics from the basic levels all the way to multilevel analysis. Now that I am employed by the University of Nottingham, I have continued this line of education by attending their regular statistical clubs, and it has been commented that I attend because I actually enjoy statistical analysis! This also has the advantage that other researchers are coming to recognize my interest in statistical analysis, which is providing research opportunities for various threads in my research, for example exercise-associated sudden death in racing greyhounds.

**Roadmap**

It is at this point that my narrative will follow the various projects I have been involved with, using the reports as time markers of my accumulation of knowledge, experience and the enactment of good practices as the results of systematic analysis and reflection upon these. Although the projects are interleaved, my narrative will be best served by reflecting on my progress within each project, set out according to the date at which I started each project, with cross-references where necessary. It is useful here to have a map of my various works so that the various threads can be followed (*Figure 2*).


*Figure 2: Key: ACF = Acute Cardiac Failure; AGDV = Acute Gastric Dilation and Volvulus; CHP = Canine Haemorrhagic Pneumonia; EIAH = Exercise Induced Abdominal Haemorrhage; SOP = Standard Operating Procedure; Str.zoo' = Streptococcus equi zooepidemicus; TIGH = Transport of Injured Greyhounds.*

*Within this map there are links between sections, for example: Racing and CHP, Disease SOP and CHP, Compaction and Injuries. These links are explored in the text.*

# CHAPTER TWO – TRACK PHYSICS

## Introduction

My work on wet sand track physics spanned several years (2007 to 2014), and produced some findings early on which were later revisited and confirmed. The progress of the various papers (Track Physics I to VIII) showed how my initial ideas were very broad and detailed, but each of which gave rise to targetted lines of research whose conclusions answered the remit of the projects and also improved the overall understanding of the nature of wet sand, culminating in the triad of factors influencing track quality. This start, expansion and then consolidation formed a pleasing progress within my mind, and served to envelope the whole area of track physics in a mental basket framework and enabled me to understand the entirety of track physics within its own compartment.

## Track Physics

It is the study of the physics of wet sand tracks that first involved me directly with research, and the off-shoots of these studies which has led to more knowledge and further opportunities. My initial interest in the properties of wet sand led me to enquire as to the current state of knowledge (as it was then in 2006). I was surprised to find that most knowledge was observational and little was being transferred between tracks. As it eventually turned out, local knowledge is very important in preparing a track, since without the science and evidence much of the preparation suitable for a particular track was obtained by trial and error, working from a basic premise. The science behind why this approach worked was gradually uncovered in my work from 2012 to 2014 (Payne, 2013c, 2014a, b). The basic outcome was that the performance of wet sand as a running surface depends on three factors: (1) sand type (2) water content and (3) the amount of compaction (packing). This was, I thought, a pivotal moment since up to this

point I had not been able to formulate an over-arching concept of wet sand track behaviour. The simplicity of the concept fitted very nicely with the general scientific principle of Ockham's razor[8], whereby using known formulations is preferable to unknown ones, and also that the formulations are testable. The repeatability of my results was something that I came to judge as a consistent finding, and the fact that the results gave the same answers when approached by differing routes was also a substantive indication of the truth of what I had discovered. This had the effect of further stimulating my research, and gave me the motivation to continue the various threads to their ends. Also these threads seemed unrelated, I was able to see their relevance to the whole set of works, for example the performance of wet sand is a variation in states when compared with frozen sand – it is still water and sand, but it is the interaction that is different. These concepts are discussed below and within the relevant papers, and show how the works contributed to the understanding of the behaviour of wet sand tracks.

My first works uncovered the extent to which water content and compaction affected the quality of the running surface, but it was only in the later projects that the true significance of sand type became apparent. It is the contribution of sand type that has led to the different management practices seen at different stadia, since each stadium's ground staff have become familiar with their track. The fact that each track's sand type is different (due to sourcing from different quarries in differing ratios) means that the management of each track does have to be different in order to generate the same quality running surface. Hence we have the complete science behind the art of track preparation, and why each set of ground staff are adamant that

[8] A principle whereby the hypothesis with the simplest components should be selected as being the most likely to be correct. Sometimes written as "Occam's razor".

their way is the 'right' way to prepare a track. Change the sand type and the management has to change with it. The discovery of the triad of wet sand track management amounted to the culmination of my work, and this has just recently (March 2015) been validated by the Sports Turf Research Institute[9] as part of the GBGB's program to ensure that all the research work performed on their behalf is scientifically solid i.e. is evidence-based using reliable data and rigorous interpretation.

Stepping back in time a little to my first ideas about track physics, my desire to expand the knowledge of wet sand became known to the members the then Track Committee of the British Greyhound Racing Board (BGRB). At this time funding for research within the greyhound racing industry was readily available, and as such a meeting was set up for me to present my proposal. The meeting went well, and my proposal was accepted. The outcome of this first tranche of research (Payne, 2007b) covered several aspects of wet sand track physics, each of which was to generate separate lines of specific research for my later works. This paper formed the core knowledge of the behaviour of wet sand tracks, and suggested various methods for track maintenance and design. During the actual research work commissioned by the regulators, I visited several licenced tracks and was favourably received at them all, showing that the quest for knowledge was accepted by many in the industry. The main query I received was why should a veterinary surgeon be interested in track physics and why was I able to spare the time to actually conduct the research. My answer was, and still is, that prevention is better than cure, or translated into my research, that knowledge of the behaviour of wet sand tracks was key to understanding the interaction between the greyhound's foot and the running surface.

[9] STRI website: http://www.stri.co.uk/

Being a veterinary surgeon did not prevent me from taking an interest in such matters, and indeed I believe that my training and experience enabled me to produce more directed research, since my experiences and interests give me a special, if not unique, insight into the relationships between anatomy, physiology, biomechanics and injury mechanics. I did not find it unusual to want to know more about geology – the thought that veterinary surgeons should only treat animals went against my desire to have knowledge of all aspects of the work in which I was involved. Indeed I considered it strange not to want to know more about areas outside one's formal training, especially where these peripheral areas were in fact part of the holistic understanding I was trying to achieve. I wanted to be in a position where I could follow my own ideas without having to stop and ask for a knowledge in-fill from others – this would destroy my train of thought and lead to a certain dissatisfaction with my work. By having the knowledge to follow my ideas, I would be able to have a complete understanding of my works by being able to link my mentally boxed ideas. As I have said before – knowledge gaps disturb my thinking, so I have to have a complete knowledge to be able to think.

This idea of merging of different disciplines, loosely described in the vernacular as "where the silicon meets the skin", actually underpins the drive of my track physics research. In order to understand what I was seeking with this work, it should be stated that there is a common misbelief that running animals have their own laws of physics. There are no special or new laws of physics at work in locomotion – the universal laws apply equally well. The problem is that we have to produce mathematical models to quantify the foot-sand interaction, and it is this that gives the myth that biomechanics has its own laws. In order for the foot-sand interaction to be fully understood, a richer knowledge of the physics of wet sand tracks was

needed. For example, it is the deceleration of the foot within the surface layers of the sand that determines the force applied (via F = ma). Thus a harder surface requires more force to deform it, and this higher force creates more deceleration, so the impact energy has to be dissipated more quickly. It is the energy and force peaks that are injurious should they exceed the capacity of the biological tissues to either transmit or absorb the energy. Linked with this is a knowledge of anatomy, and thus the rationale behind my interest can be explained from wet sand track physics to the forces taken by anatomical structures. Similar research has been carried out on behalf of the horse racing industry (Chateau et al., 2010; Peterson et al., 2012), with the development of various tools to measure the properties (the going) of the grass race surface. The difference here is that horses race on grass, whose roots both bind and hold water within the granular substance (i.e. the soil). The challenges faced by the turf specialists are different because of this, but the aim is the same: to better understand the properties of the running surface and thus be able to develop groundwork techniques to maintain the most ideal state.

As my initial research identified and uncovered more areas of knowledge (Payne, 2007b), so further research was performed. The method I employed was that of small progressions, with each stage gathering a certain amount of knowledge. After each step I could then reappraise my approach and confirm that the research thread I was following was both relevant and evidence-based. That said, my first project (Payne, 2007b) was rather too large in terms of the amount of research and new ideas which I explored and discussed. With hindsight this first paper could have been broken down into smaller sections, each dealing with a single aspect of wet sand behaviour, and ending with a management paper which could have reviewed the track management routines and thus compared current practice with my suggested methods.

Sand track management works on the principle of "local knowledge works best", which came about due to local management decisions coupled with the experience of the track maintenance staff. As my later research was to discover, this localization of knowledge had a scientific basis due to variations in sand type. This was not appreciated as important until my research demonstrated the effect of different sand types on the surface quality, and that this was linked with compaction and water content (Payne, 2014a). Put simply, for any given water content and compaction, the overall hardness was linked with the sand type, and it was this effect that was understood by the track staff, if not scientifically then at least practically.

Due to the acknowledgement of my work on the first project, I was invited in 2012 onto the Track Sub Committee of the newly-formed Greyhound Board of Great Britain (GBGB) as a scientific/veterinary advisor to support the veterinary surgeon already on the committee. The next stage in my research was to investigate water content and the problem of frozen tracks, and being on the committee, I was able to describe the route the project would take. The problem was basically that there was a limited understanding of how to prevent a wet sand track from freezing, and what to do when it did freeze. Thus a review of the extensive research available on antifreeze compounds used in other working environments (e.g. roads and airport runways) was my first step on this project. Because of the broad spread of the first project, this second project was equally broad, as it not only included antifreeze compounds, but also an investigation of the best watering techniques. Using my experiences with the first large paper, I decided to break this project down into smaller sections, thus allowing me to concentrate on one aspect of the research (e.g. antifreeze) and also allowing a steady delivery of reports to the GBGB, rather than them having to wait until I had completed all the projects. This lead to a series of papers: the

water content of wet sand tracks (Payne, 2007c), track quality measurement (Payne, 2009b), watering techniques (Payne, 2009c) and the control of the evaporation of water (Payne, 2011b), together with the frost protection of tracks and dealing with freezing sand (Payne, 2009a, 2010a).

The papers on water control stemmed from the need for further research into how wet sand behaves, and how track quality could be measured. The measurement of track quality was an interesting problem, since the basic premise of what constitutes a good track was perhaps surprisingly not known despite the many years of greyhound racing. The research into foot-sand interaction had not been performed at that time, so what was deemed to be a good track was not based on evidence, but on observation and localized common sense opinion. Thus to be asked to design a set of measurement tools presented an intriguing problem – should the tools measure to the accepted standard, or should they measure what was really needed by the greyhound? I approached the problem by considering what equipment would be used by the track maintenance staff. There would be little point in designing complex equipment, nor would measurement delays be well accepted, as both these factors would result in non-compliance. Therefore the aim was to develop a suite of equipment which staff could use to measure the consistency of a running surface (Payne, 2009b). The challenge was to design equipment within a set of criteria which I devised, these being:

- Easy to use.
- No power source needed.
- The results are displayed on the device (i.e. no look-up tables needed).

- Robust and durable.

These criteria were based on my observations of the manner of practice of the track staff, and the conditions under which much of their equipment was stored. That is not to say that the equipment was badly handled by the track staff, rather that the equipment had to survive a rough life of bumps and knocks, storage in possibly damp conditions, and yet still had to work each time it was used.

The pieces of equipment are described in the paper, but in essence the items are plastic, with corrosion-resistant fixings. I came up with several designs, the simplest of which was a rod with an outer sleeve, the idea being that the rod was pushed into the sand and in so doing cause the outer collar to ride up the rod (Payne, 2009b). The deeper the rod was pushed, the further up the rod was the collar. Thus by reading off on a scale how far the collar had moved, the operator could assess the hardness of the track. The problem with this device was that although simple, operator error was large, since the amount to push the rod into the track was based on a standard force, and that was very difficult to quantify. This device was actually part way to becoming a Clegg hammer[10], but measured penetration from a standard force as opposed to deceleration. In reality the GBGB opted to use overall estimates of track hardness since they were concerned that track staff may not have been able to use and interpret the information given by the devices. This aspect of delivering science is the most challenging, since the inventor (in its generic meaning) cannot measure every area of interest every day. The aims listed above were achieved by all my invented devices as described in the paper (Payne, 2009b), so I was disappointed that

[10] A Clegg hammer is a device which measures the G-force acting on a mass when it is dropped from a predetermined height onto a surface. The harder the surface, the higher the G-force measured as the object decelerates to a stop. The force is recorded in units of one G, or Gravitons.

the devices were never used beyond my trials. At the time of writing this reflection, the GBGB has expressed a renewed interest in these tools, so in fact my work here will not be wasted, and actually allows for the original paper to be circulated without delay. This is a nice case of research ahead of requirement which can now be reinforced by my later works.

One device of note was a multi-wheeled device which left a number of grooves on the sand surface, and the operator counted the grooves (one to four) to determine the hardness. What I liked about this device was that the record was left on the medium being measured, so one could then walk around the track and quite easily see where the track was soft or hard by observing how and where the number of grooves changed. This device took a deal of development and went through several iterations, with the main problem being clogging of the wheels with wet sand. I solved this by devising a series of scrapers which kept the wheels clean. This process of test and development was interesting as I decided to work by modifying the equipment rather than redesigning a new form, as in this way I became familiar with the device and was also able to see the modifications. Another advantage was that I could test how easy the device was to dismantle and re-assemble, as it would be quite likely that the device would need to have parts replaced at intervals. Within this idea I used readily available items from hardware stores so that repairs did not need a new item to be manufactured – rather the track staff could use parts off the shelf from the stores with minimal preparation. Although the device looked a little Heath Robinson[11], the point was that it was robust, easy to use and easy to repair. These are important attributes when wishing to encourage staff to use novel pieces of measuring equipment.

[11] A device which looks like it has been made from odds and ends, often to a unique design.

**Antifreeze Compounds**

A major issue with wet sand tracks is that they freeze in cold weather thus making them unusable, with an obvious impact on the profit of a track. With tracks which freeze in some areas, rather than all over, this event could be missed by the ground staff and the greyhounds allowed to run. This would result in injuries to the claws, thus generating welfare issues and meaning that the racing strength was reduced for future events, which increased the demand on the uninjured greyhounds. There were two issues therefore: (1) welfare and (2) financial. Such a combination is a great stimulus to research, and the GBGB commissioned me to run a series of projects to investigate how wet sand froze, could it be thawed, and could the freezing be prevented in the first place. The experiments took place in several stages over two years, working from the small scale to the real world.

The work on antifreeze compounds presented an interesting challenge since I had to firstly set up some base line experiments to explore freezing sand and the effect of antifreeze, then to expand these in size to generate models for real tracks (Payne, 2009a, 2010a). This was performed in three stages: laboratory-style experiments, medium-scale outdoor experiments, and on-site experiments. This progression in scale meant that I could deduce and then control the confounding variables and thus derive the process of wet sand freezing with more confidence than just simply measuring a real track and hoping it would freeze. The results were unique, and repeatable. One major finding was the limit on freezing protection afforded by simple salts. Solutions will freeze at different points according to the concentrate of solute, but

wet sand has a lower temperature limit below which it will always freeze regardless of the amount of solute.

When I aired this fact, many grounds men did in fact agree that sometimes tracks would freeze despite how much salt was applied. Thus the experimental findings were validated by general observations. What was puzzling was the fact that this effect had not been described before, and I wondered why this might be the case. The use of antifreeze on roads depends on adding rock salt (essentially grit plus sodium chloride) to achieve melting of the ice and snow, so any trials in this area by interested parties would not have included wet sand performance. In a similar way, athletic tracks are not based on wet sand, so frost protection was not needed. Thus the behaviour of wet sand under freezing conditions was not investigated, and my findings did appear to be unique. It is important that they were reproducible, and in subsequent trials this important effect was repeated. The outcome of this is not just as straight-forward as measuring the track temperature and being able to decide whether frost protection would be effective. The other effect was that the previous practice of dumping more salt on the tracks to prevent icing resulted in tracks with very high salt contents but no greater antifreeze protection. Concentrated salts are detrimental to biological tissues, thus the greyhounds' feet were being exposed to this environment. The new knowledge that there was a limit on antifreeze protection meant that salt concentrations could be kept as low as possible, and once the limiting temperature had been reached, no further salting would be effective. Thus the welfare benefits of this finding were important in that the greyhounds would not be exposed to high salt concentrations and that racing could be stopped when antifreeze protection was no longer effective.

**Alternative Surfaces**

Due to the vagaries of wet sand tracks, the BGRB and then the GBGB commissioned studies into alternative surfaces. Two contenders were an oil-based sand mix called *Starmat*®, and a modified horse racing surface, *Viscoride*®, which was composed of sand, soft waxes and fine elastic fibres. The *Viscoride*® had been modified slightly by the manufacturer and was known as *Viscoride-K9*®. I was asked by the BGRB (and then the GBGB) to make an assessment of these two surfaces (Payne, 2007a, 2008) due to my previous experience with track measurements. The techniques that I had used to date were based on shear strength measurements in wet sand, so I was the posed with the problem of measuring different surfaces with the same equipment, or of developing a different measurement technique, whose results may not be directly comparable to the previous datasets. For most granular materials, shear strength and normal strength are linked by the coefficient of friction, but where the binding medium was not water but wax or oil, the properties of the binding medium also needed to be taken into account. I reasoned that the measuring the oiled sand would be straight forward and I could use the drag-block method (Payne, 2007b) and thus be able to compare shear strengths. Thus the measurements on *Starmat*® were comparable to those of wet sand tracks. *Viscoride-K9*® presented a significant challenge since the nature of the binder did not allow the studs of the drag block to penetrate. For this surface I had to measure compressive strength, but then the issue was to decide how far into the medium could the probe be pushed. A normal greyhound footprint at speed penetrates approximately 20-30 mm (author's unpublished data) depending on the surface hardness, so I set the depths at 20, 30 and 40 mm, using a probe of about the same area as a greyhound's digital pad (approximately 2.3 $cm^2$). The team I was working with on this

project had laid a *Viscoride-K9*® track, and so my measuring trials were performed on a real track.

In its use as a horse racing surface, *Viscoride*® was maintained in an expanded or "fluffed up" state by special machinery. It was obvious to us that this state was not appropriate for greyhound feet since the loose depth was several centimetres, and so we opted to lay the track flat but develop a method for lifting the top 2-3 cm slightly to give a deceleration layer. This proved to be the greatest obstacle as the sticky nature of the wax binder was easily compacted but not so easily lifted or aerated. Another problem was the fact that the *Viscoride-K9*® stuck to the vehicle wheels and rollers, so track damage was a real problem to be overcome. The roller adhesion was solved very neatly by angling the roller such that it skidded when being pulled, and this skidding action wiped the roller free of the wax and fibres. The propensity for marked compaction was never really solved, and was such that we deemed it unsuitable as a running surface for greyhounds, and the project was closed. The knowledge and insight gained from this exercise was very valuable, as it showed that wet sand tracks were much more easily managed and did not require new machinery. The knowledge that track equipment could be redesigned was taken forward to another project, with which I was not involved, whereby the designs for the current machinery were reassessed to check that they did in fact perform as expected. The result of this was two new items of equipment. One is worth mentioning here since it operates within the context of my expertize. This machine was dubbed the "slitter" since it carried a series of blades rotating at high speed on a drum, the technique being to allow the blades to dig ("slice") into the track and break the hard pan. Previous equipment used the mole plough principle, or where based on the rotating drum format but with

short wide blades. The issue of compaction will be dealt with in detail, since compaction is one part of the triad of effectors on track hardness.

**Studies in Compaction**

Another issue which was causing problems was the age old problem of track compaction. Compaction has two undesirable effects: (1) poor drainage of surface water and (2) increased shocks through the greyhounds' limbs, linked with increased injury rates. There is thus a link between track hardness and injuries, although the precise risk has yet to be quantified, and is one of my future projects to try and attribute quantitative risk factors to different injuries. This is what originally stimulated my interest in track physics, since as a new track veterinary surgeon I came across repeated injury types, and I knew that such injury patterns are part of a certain injury mechanism, whereby physical stresses cause clinical injuries at constant sites. These are termed indirect injuries, and are typical of applied loads exceeding the biological strength of the musculoskeletal system, and as such indicate a consistent mode of failure. With direct injuries, one sees no patterns, and thus controlling the exciting cause is nearly impossible. Examples of direct injuries include falls, road traffic accidents where the injury is seen at the point of impact. The obvious injury patterns were clear signals to me that there was a consistent injury mechanism, which thus opened the way to being to determine this mechanism, since one could analyse the running conditions, gender, weight, race time etc. in order to elucidate common factors.

Once the common risk factors are found, it is then a matter of attempting to control these risk factors in order to reduce injury rates. A problem with this approach is that it is difficult to obtain exact information on the trainers' training regimes since these are closely guarded secrets, and yet may have a bearing on the greyhounds' abilities to cope with the stresses of racing. Thus one may erroneously attribute a risk factor to some feature of track design when in fact the issue lies with, for example, the calcium content of the greyhound's diet. In my case once I had begun to gather the data, I then realized that the track quality was not recorded, thus there was no way to relate injury data to track quality. It was at this point that I decided that in order to do my job properly as a veterinary surgeon, I would need to become a wet sand track physicist. This idea has been explained above as an example of my need to fully understand a topic before progressing to a related topic. Analogous to this is the idea that one vaccinates animals to prevent disease – I wanted to develop track physics as a way of preventing greyhounds from becoming injured, so to me the process was a natural part of my progression and replacing "vaccine" with "track physics" was not the mental side-leap that some people thought it might be.

Soil compaction is very well understood in the field of geotechnics (Collins, 2005; Duncan and Wright, 2005; Gerard, 1965; Kamei and Sakajo, 1995; Massarch, 1998; Orense et al., 2004; Sezer et al., 2011), so this knowledge needed to be extended into wet sand tracks. The compaction of wet sand tracks is one of the core themes of my work, and is closely related to the water content and sand type, making up the triad of track factors which affect track hardness. The problem to solve was not merely an understanding of compaction, but to try and avoid highly compacted surfaces or at least make the compaction even. This idea of even

compaction stems from the fact that animals (and humans) run over a surface with a certain expectation of its performance (hard, soft, loose, springy, etc.). If the surface changes physically but remains visually constant, then the animal will run in the same way over the different surface, but the problem lies in the fact that running over different surfaces requires different running styles (imagine yourself running over pebbles versus sand – the running styles are different). The impact of this is that if the limbs are not prepared for the particular surface then injuries are more likely. This combination of running styles and stride-to-stride adjustments of limb stiffness is very important to realize, since this helps an understanding of why visually even tracks can still produce injuries, yet uneven tracks can have fewer injuries. What is happening is that the animal is looking at the surface ahead, and making predictions as to how that surface will behave, based on what the surface is actually like under their feet. So if the surface is even but behaves differently at different sites, the animal will not adjust its running style to accommodate the different surface. This pre-programming looks six seconds ahead, so it is based on time not distance. A good example of this as an explanation is when you ascend or descend stairs and forget which step you are on: most houses are built with 13-step staircases, and we quickly learn that fact. If you forgot which step you are on, or only partially ascend and then descend, then you have to concentrate on the stairs to make sure you do not miss the last step or try to go a step that is not there. Animal locomotion is no different, and the use of visual clues to predict the quality of the running surface based on current strides is a common strategy for fast locomotion.

A common fault on sand tracks is the presence of a vehicular route across the track to allow access to the in-field area. Vehicles compress the track at these crossing points, so when

the track is prepared there is no visual difference between the crossing point (hard) and the rest of the track (not hard). It is common to see injuries at this point due to lack of compensation in running style. Oddly enough, you would see fewer injuries if the crossing point was an obvious visual feature since the greyhounds would alter their gait over the crossing to reduce limb stresses. If the track is prepared by using tines to break up the surface before being smoothed (plated) then injuries could be reduced. The newer types of machinery and management practices based on my and others' (STRI) research has helped to make ground staff aware of this issue and to prepare tracks properly to avoid the hard crossing points.

Several of the projects dealt with compaction (Payne, 2007b, 2013c, 2014a) since this recurring theme forms the core of track maintenance: how much water to apply and how much compaction is needed, as well as a knowledge of the sand type. The completion of this series of papers allowed me to come to the overall conclusion that there is a triad of factors affecting overall track hardness: sand type, compaction and water content. Each of these interacts with the other two. It is the realization that sand type was a significant part of track maintenance gives credence to the long-known fact that the track manager at each stadium knew his own track very well, and could prepare it in a consistent manner, and yet those techniques did not work on other tracks. The difference is in the fact that each stadium has its own sand mix, and thus the effect of water and compaction will be different. It is this that gives credence to the reluctance of some track managers to take on board new ideas and techniques – it is not just curmudgeonly resistance but a belief that their method works well. The evidence now shows that this should in fact be the case, since even though there are a limited number of good quality silica sand

quarries in the UK, the exact proportions for each track will be different according to the actual amounts mixed from each source, and how well the new sand is mixed with the existing surface.

The discovery that sand type plays a role in track hardness was known before, but the added knowledge is in the degree of the effect. And this degree of effect is in itself related to the standard practice of watering tracks almost to the point of saturation – within the range of hardness near saturation, small effects become significant. As such the newer recommendations for track maintenance will include an analysis of the current sand composition (Payne, 2014a, b). Of interest here is an un-commissioned paper I wrote suggesting that tracks are over-watered, and that some consideration should be given to applying less water (Payne, 2013d). This idea had been seeded in my work in 2007, but it was only after the intervening projects had been completed that I was more confident in my hypothesis. I was particularly pleased with the outcomes, especially the triad of wet sand management, since I had worked for many years to uncover the complex interactions of sand, water and pressure, and being able to end with this almost perfect triad of factors seems a fitting conclusion to my sand track work. The depth of knowledge gained during this research journey will stand in good stead for any future questions, since there were many areas which I explored. The last area of comparing sand types will be discussed next.

**Comparing Sands**

This work was one of the latest to be completed, and drew heavily on the results and conclusions of previous projects. It was already well known that the sands from different

quarries had their own characteristic grain size distributions, and that these differences also affected the flow of water through the sand. It was already common practice to alter the mix of sands at tracks in order to achieve the desired water flows (i.e. drainage patterns), but the extra investigations I performed related the sand type and the water content to its compressive strength. This produced some interesting results since it was now apparent that not only did differing sands have different water flow properties, they also had different compressive strengths (Payne, 2014a). Although this knowledge was not knew to the world of geology, it was a new finding for the knowledge of wet sand track behaviour.

Bringing all this information together will now allow a better understanding of the interactions between sand type, water content and compaction, and also brings more validity to the pretext that local knowledge of the behaviour of wet sand tracks is very important in preparation and also in dealing with adverse weather. As with many disciplines which have grown out of tacit or experiential knowledge, the science has caught up with observation, and as such we are now in a better position to both predict the behaviour of wet sand tracks and to change the maintenance practices to best prepare the track for different weather conditions. What is interesting here is that many track managers have always maintained that they know their tracks well, and some are reluctant to introduce new methods, since they see track preparation as an art form. The results from my track physics projects showed that there is a triad of factors which affect track consistency: sand type, water content and compaction. Each track has its own sand mix, its own machinery and its own local climate – thus each track does indeed require different management practices to produce the desired running surface, and it would be true to say that local knowledge is very important in determining the best

management. It is a nice case of standard practice having the backup of evidence-based research, but where the research supports the standard practice. There is sometimes the idea that standard practice is the "best we have until we learn more", and that evidence-based practice and management will always result in a change. In the case of wet sand track management, science supports the standard methods.

Within this last series of papers, I also measured the water content of wet sand tracks in different weather conditions, as the vague syndrome of "summer time lameness" has yet to be fully explored. One cause of summer time lameness was thought to be drying and hardening of the tracks in hot weather. The results of my work indicated that there is very high rate of evaporation of water from the tracks in hot weather, and this can indeed shift the hardness of tracks which are prepared in wetted states, since drying a wetted track will make it harder (Payne, 2014b). The stage is now set for me to return to my original task of investigating injury patterns, using the track physics research as a solid base for progression.

# CHAPTER THREE – DSMP

## Introduction

My narrative now moves to the greyhounds themselves and although I have split the reflections into sections, my work with greyhound diseases was happening in parallel with my work on track physics. This did not create any contradictions or distractions since I set each arm of my research into separate mental boxes, and then created links as and when I needed to. Additionally the disparate nature of the research meant that it was not a great issue to keep them separate, nor was it a challenge to hold the ideas in my mind and work on both at the same time. As time progressed the sudden death research produced some very interesting and stimulating results and as it is an ongoing project, data is still being collected which further refines the understanding of the diseases and syndromes.

## Sudden Deaths at Stadia

At the time when I first became a member of the NGRC's veterinary committee in about 2007, a project was set up by the Senior Veterinary Steward to investigate the causes of death of greyhounds at race tracks. The incidence was known to be very low, but there was no formal data gathering in order to determine the root cause of these deaths. The project was formalized as the Sudden Death Survey, and in this format the arrangement was to transport deceased greyhounds from the stadia to a single laboratory for a post mortem examination (PME). At this time, the survey only dealt with cases which were located in the South-East of the country in order to reduce the courier fees. When the NGRC was absorbed into the GBGB in January 2009, I took over the running of the survey, and saw the opportunity to both expand the project and to make it more efficient. With the GBGB's blessing the project continued, but was expanded to include all UK licenced greyhound stadia, with the country divided into three

sections, each with its own laboratory and courier service. Thus each courier only delivered to one laboratory.

With this protocol, the project continued unchanged into 2014, when it was modified to shift the focus onto kennel disease outbreaks. The reasons for this were several and from different quarters. On the one hand, budgetary restrictions demanded that the project be made more efficient whilst epidemiological data suggested that sufficient was known about the nature of sudden deaths after racing that there was little more to be gained. As such I developed a new protocol which was issued in August 2014, and from then on PMEs would only be authorized for strange cases, being substituted by a requirement for a blood sample to be sent to a single laboratory. I agreed a special group of tests with the laboratory, such that no laboratory forms were required, since I wished to both increase compliance and reduce the workload of the track veterinary surgeon. Having worked as a track veterinarian I was aware of the stressful periods, one of which was the sudden death of a greyhound during racing. Thus by developing a "no form needed" system I was aiming to reduce the veterinarian's workload at a stressful time. The link between the case and the reports was maintained by me using an anonymising system of unique identity numbers. The concept of unique identity numbers is not new, and the way in which I used them allowed a case to be followed within the large dataset I was gathering.

As to the outcomes of the Sudden Death Survey (renamed the Disease Surveillance and Monitoring Program, DSMP, after August 2014), it showed that the deaths were falling into two main groups: heart failure and a new syndrome of bleeding. It was my own analysis of the data

that lead me to this conclusion, since there was no prior knowledge of the bleeding syndrome, and the pattern of the data told me that there were two problems. One view could have been that heart failure was the leading cause of death, and that the bleeding was part of this, but it was clear to me that the simpler explanation (Ockham's razor again) was that two processes were at work. With this premise it was much simpler to follow the cases backwards in time and see that certain factors were indeed present in one group but not the other. The new bleeding syndrome is interesting for many points, which are described below.

Before the SDS started to produce results, many veterinary surgeons, myself included, assumed that the main cause of death post-race would be acute cardiac failure. It came as a surprise to see that in fact the cause for about 50-55 % of cases was haemorrhage from the sublumbar muscles, specifically the iliopsoas muscles and the associated blood supply (Bentall et al., 2009). I coined the term Exercise Induced Abdominal Haemorrhage (EIAH). Looking back at previous records, this syndrome did not appear to have reported before, even when I went back as far as 1975. I convened a working group of pathologists from the participating laboratories in order to discuss various ideas as to risk, pathophysiology and subclinical incidence. Due to the very low incidence (1-2 per month), it was difficult to detect proper patterns, but the consensus was that racing was the main trigger since the syndrome was not seen at any other time. As such we focussed on the biomechanics of the racing greyhound and determined by logical progression that since the iliopsoas muscle was a hip flexor, damage was being caused during hip extension. The damage alone was not likely to cause a fatal haemorrhage, so other factors were thought to be involved, and the top two candidates were hypertension and von Willebrand disease (vWD), both of which occur in greyhounds with a

higher prevalence than other breeds. The syndrome of muscle bleeding linked with vWD has been described in humans (Keikhael and Shirazi, 2011), which I discovered as I was researching the literature once I had developed my hypothesis. Thus the proposed scenario was of hip hyperextension during fast running, coupled with other risk factors. A similar syndrome has been described previously in sporting dogs (Canaap, 2007; Laksito et al., 2011), but not greyhounds prior to my research involvement. Thus there was previous evidence in both dogs and humans of portions of the EIAH syndrome, but not the complete syndrome as was seen with racing greyhounds. Additionally there was vague evidence that EIAH was more common in the colder months, and this fitted with the known premise that cold muscles do not stretch as well as warm ones, so one recommendation we could make was to make sure that greyhounds were kept warm prior to racing, and that the pre-race routine included trotting but not stretching exercises.

I and two colleagues (who are veterinary physiotherapists) wrote a paper for submission to the GBGB as guidance for best practice. In this way we were able to link the pathology with biomechanics, known risk factors and best practice in order to improve the welfare of the racing greyhound. As more data became available, it was found that some cases had evidence of previous haemorrhages into the iliopsoas muscle. This new piece of evidence prompted a new advice, in that trainers and veterinary surgeons should be aware of greyhounds with vague “hip area” pain and consider the possibility that these dogs had had a non-fatal bleed in their sublumbar muscles. Alongside this, analysis of race data also revealed that about half of the cases of EIAH had suffered from muscle cramp (whereas only a small percentage of all racing greyhounds suffer from cramp), and it was already known that cramp was more common in

colder weather. The same analysis revealed that most cases of EIAH were male greyhounds. There was now good evidence that EIAH was the end stage of a subclinical problem of muscle cramps, muscle tears and possibly a lack of fitness, coupled with the risk factors of von Willebrand Disease (vWD) and hypertension, and some unidentified risk linked with being male. Thus the rare condition of EIAH had gradually revealed its secrets and enabled evidence-based guidance to be given to trainers and veterinary surgeons.

The papers covering this subject discuss the epidemiology, pathology and possible causes (Payne, 2009e, 2010b, 2011c) and a joint paper was also written by the team leaders (Bentall et al., 2009). The general analysis of this condition is ongoing, and has been supplemented by the changes to the survey to now include blood sampling. The initial results of this have enabled a link to be made between sudden death at the end of the race and electrolyte disturbances. In particular was the finding of a dramatic hyperkalaemia post-race both in greyhounds which died and those which had been blood sampled to try and determine a cause for muscle cramping. This aspect of my research is quite challenging since there are physiological, budgetary and logistical constraints in that blood sampling post-mortem has to be performed very soon after death otherwise genuine changes will be masked by post-mortem changes in the blood. Ideally a post-mortem should follow, but budgetary changes have meant that some supposition is required as to the cause of death. This is not as difficult as it might seem, since previous patterns are so clear-cut that predicting the cause of death is fairly easy from the presenting signs. The logistical constraints stem from the need for the attending veterinary surgeon to take two blood samples for two different laboratories.

This seemingly simple exercise has needed several edits to the guidance sheets to make it clear what is needed (Payne, 2015). This shows that for simple information to be given one must heed what the recipient might be doing – in the case of these samples consideration had to be given to the fact that race nights are busy, and the additional stress of a sudden death affects the pre-planning inasmuch that the veterinarian would not set out the sample kits in preparation (the death rate is about 1 per 10,000 dog runs). Thus when a death did occur the sampling process had to be conducted smoothly and without error, hence the need for clear instructions set out in a very simplistic manner. Without my previous experience as a track veterinarian it would have been difficult to write the document since I would not have the inside view on the difficulties presented on race nights. I have been in the situation were clearly designed forms make the difference between understanding the process and completing the task, and not understanding and performing the task poorly or not at all. It is clear that when designing a form in the office, one must be versant of the real world constraints and thus be able to produce a protocol and paperwork that work well together and gather the necessary information and samples efficiently. Sometimes this can only be done by feedback or iteration, but this is wasteful of valuable opportunities, so it is much better if one uses one's own or others' prior knowledge to get the design right (or nearly so) at the first attempt. This insider knowledge was also put to good use when I designed the Transport of Injured Greyhound Certificates and the related policy (Payne and Allen, 2007) (see elsewhere in this document), and where the first iteration needed only one minor edit.

**Canine Haemorrhagic Pneumonia**

Research into his disease has produced some very interesting findings, and my work has supplemented these results. Since the sudden death survey investigates all deaths of licensed greyhounds, canine haemorrhagic pneumonia (CHP) has come in for special attention due to the fact that it is rapidly fatal, and that the pattern of the disease spread (epidemiology) appears to be unique for racing greyhound kennels in the UK. These two facts focussed my attention, and stimulated not only the basic research but the writing of a specific disease management protocol to try and control the disease (Payne, 2011a). The investigative process is detailed below.

Canine Haemorrhagic Pneumonia (CHP) is a severe pneumonia resulting in death within 6-8 hours of first signs, with the most common presentation being the finding of a dead greyhound at the morning rounds. The trainer reports the death to me via the established protocol of the Sudden Death Survey (now named the Disease Surveillance and Monitoring Program, DSMP), and I arrange the collection and transport of the body to the nearest laboratory approved by the scheme. There are three laboratories which take the bodies, and they report their findings back to me, after which I coordinate the management of the kennels to reduce disease transmission, and to alert the GBGB Stipendiary Stewards[12]. At the first cases in 2007, there was much alarm at the sudden deaths of five healthy greyhounds at one kennels, and the NGRC engaged the help of the Animal Health Trust in diagnosing the cause of the deaths. The causal organism was found (*Streptococcus equi zooepidemicus* or *Str. zooepidemicus* for convenience in this thesis) and thus enabled a management plan to be devised. The fact that this

[12] GBGB Stipendiary Stewards are roving inspectors who travel around a designated region of the UK overseeing the running of trainers' kennels, and their compliance with the GBGB Rules of Racing.

was the first set of cases meant that the controls were fairly draconian, since the only knowledge of how the disease spread in greyhounds came from studies in the USA where fatalities rates of 90-100% were recorded (Byun et al., 2009; Hayward et al., 2010), together with very rapid spread. Some outbreaks had led to the deaths of thousands of shelter dogs, and there was the worry that a similar situation would occur in the UK outbreaks. Thus the initial controls enforced the closure of the trainer's kennels for 21 days, together with the treatment of all in-contacts with antibiotics. Due to the financial losses associated with the closure, the NGRC would compensate the trainer. One concern was that the threat of closure would suppress the reporting of cases, and thus mean that the disease would be able to spread more quickly. As it turned out, there were further cases in the following weeks, but the in-contacts were very difficult to trace owing to the large number of inter-kennel movements of greyhounds which occur.

My involvement was to establish contact with the in-contact trainers, and as a result of this I developed a standard questionnaire which I gradually modified as I gained experience in the type of data which was needed to be able to understand the spread of *Str. zooepidemicus* better. As time passed, it was apparent that cases of CHP usually occurred in isolation, and it was uncommon to see a second case at the same premises, and that there were no cases more than two days after the first (index) case. As such the quarantine period was dropped to 14 days, and then to seven days with successive reports, with no increase in the incidence (number of new cases). At the same time, quarantine was limited to the kennel blocks containing the ill greyhounds, leaving the unaffected blocks to continue racing, thus reducing the financial pressure, and hopefully increasing the compliance for reporting. With this increased knowledge

and confidence, several guidance papers were written for trainers (Payne et al., 2012, 2014), together with publications in the Veterinary Record (Gower and Payne, 2010, 2012) with the aim of increasing the awareness of CHP, an uncommon disease in general small animal practice, but one where early recognition of CHP can be a life-saver. I am still involved with the research, with the long term aim of developing an efficient vaccine for dogs. The causal organism is proving of continued interest in both equine and canine respiratory disease outbreaks (Priestnall and Erles, 2011; Priestnall et al., 2010; Sundberg et al., 1981), and as such this research is set to continue with inputs from myself in the form of random sampling of greyhounds at race tracks.

With the stable coordination of the DSMP, in 2011 the GBGB tasked me with writing a standard operating procedure for the management of disease outbreaks at kennels. I wrote this document via several iterations, with the final version being approved by colleagues at the Animal Health Trust. This document is still in use, and has not needed further modifications (Payne, 2011a).

With the DSMP in its seventh year, a retrospective analysis is now being performed by me, and early results show that CHP cases wax and wane on a long cycle over three to four years. If this is shown to be correct by observations from 2015-2018, then the cyclic variation in *Str. zooepidemicus* will be a significant finding, since the aim would then be to determine whether the disease cycled naturally, or as a result of the controls put in place by the GBGB based on my research.

**Racing Physiology and Water**

One of my long term aims was to allow water into greyhound kennels at the stadia. In fact a colleague once asked me what I wanted to achieve with my positions on the various GBGB committees, and my first answer was to put water into race kennels. The work I was performing on sudden deaths at stadia had also raised the possibility that high blood pressure was a cause, itself the end of a physiological chain that included the hydration state of the greyhound. I already had an active interest in racing physiology, and the idea formed in my mind that racing greyhound physiology had its own unique differences, and that investigations into the hydration states of greyhounds would add to the data I was collecting from post-race blood samples.

Changes to the Protection of Animals Act 1911[13] had brought the act up to date in the form of the Animal Welfare Act 2006[14], and there was a concern that not providing water in the kennels amounted to a breach of the new act. This simple idea of providing water in racing kennels before the greyhounds were due to run should be easy to action, but in fact there were many questions that needed to be resolved. The original rules certainly allowed for pre-race water to be provided to greyhounds, but then that greyhound would no longer be able to participate in the race at that meeting since the act of opening the kennel to offer water was regarded as a breach of security. This lead to two papers, based on literature research and a pilot study, which explored the water and electrolyte balance of mammals, and in particular racing

[13] The Protection of Animals Act 1911at http://www.legislation.gov.uk/ukpga/Geo5/1-2/27
[14] The Animal Welfare Act 2006 at http://www.legislation.gov.uk/ukpga/2006/45/contents

greyhounds (Payne, 2011d, e). One of the challenges was to ensure that any supplied water could not be deliberately tampered with (e.g. by the addition of drugs which may slow performance). This was resolved fairly simply by supplying mains water from a stand pipe, and by disinfecting the bowls after each use.

I was commissioned to design and run a pilot study to investigate the water balance of greyhounds in stadia kennels. The study involved recording the specific gravity of the greyhounds' urine as they arrived at the stadium, and just before they raced (Payne, 2011d), and I found that the urine did become more concentrated, as was expected, plus the clinical signs of dehydration were increased. This study did not show any more than was expected, but it did serve to prove that water balance was an issue that needed to be dealt with. I was asked to conduct a related study whereby the racing performance of greyhounds was measured against whether or not they received water whilst kennelled at the stadia. I reasoned that the issue did not lie with whether hydration affected performance, but that water was being withheld and that in itself was the main issue since that could have constituted a breach of the Animal Welfare Act. As such I declined to run the study, citing this argument and the fact that plenty of research had already been done on mammalian physiology to fully understand the effects of hydration on exercise (Butudom et al., 2003; Butudom et al., 2004; Coenen, 2005; Harris, 2009; Schwellnus et al., 1997; Schwellnus et al., 2004). The next step was for the trialling of water in stadia kennels, really to test whether the greyhounds drank the water or just spilled it. The initial trials were successful, and in August 2014 new advice was issued which permitted access to clean water at all times during a greyhound's stay at a stadium kennels. (A note here: free access to

water at the trainers' residential kennels has been mandatory for some time, and is part of the requirements for a kennel licence.)

In a linked piece of literature research, I wrote two articles on racing physiology related to greyhounds which focused on electrolyte balance (Payne, 2011e). The prevailing view was that greyhounds needed electrolytes after exercise in the same way that horses do, but in my opinion that view was flawed for two reasons: (1) greyhounds are sprint athletes and (2) greyhounds, like all dogs, do not sweat. The detail to my argument went as follows. Data from blood samples collected for other reasons showed that electrolyte balance was indeed grossly disturbed by racing but that these changes were quickly rectified during the recovery period (up to 30-40 minutes), and since all the electrolyte concentrations were raised post-race, there was little reason to supplement orally post-race. The recovery from exercise involves losing heat and re-establishing a normal acid-base balance. These two aims can be achieved by respiratory compensation (hyperpnoea and tachypnoea, i.e. panting), but does involve water loss by evaporation which would compound the electrolyte swing. Essentially all the greyhounds needed post-race was clean water to replace exercise and recovery losses. Based on the weight of the evidence, a new Rule of Racing was introduced (note any rule changed by the GBGB involved discussions within different groups and usually took months) which banned electrolyte preparations from the paddocks, and permitted only unrestricted access to clean water. Since then there have been no repercussions in terms of reports of ill health or poor performance. Indeed one interesting long-term effect seems to be a reduction in the number of sudden deaths at stadia (part of the EIAH syndrome), so I have wondered whether I have inadvertently found the link with EIAH – that of improper hydration. The pathophysiology would link this with

haemoconcentration (thicker blood), and thus adverse effects on blood pressure during exercise in a species known to be hypertensive. It would be very satisfying to be able to prove this, at it would be an excellent example of two areas of research (hydration and sudden death) coming together to solve queries in both areas. This linking of ideas often comes suddenly, even when the results have been built up slowly. Often it is in moments of reflection that one is able to identify these links, and then trace the thoughts back along the various inward roads to see where other links may be made. Once these links have been made, further avenues of thought and then application can be deduced, themselves leading on or linking up with other areas of research. Having such a wide research base has given me wide knowledge in apparently unrelated areas which I can then link up in what may not be an obvious manner, but are at once logical when brought together.

# CHAPTER FOUR – OTHER PROJECTS

## Reproduction

The research into the effects of the reproductive cycle on greyhound performance (especially the effect of the oestrous cycle on females) was a specific task set by the GBGB. There was no prior research in this area – the nearest was the effect of the menstrual cycle in women athletes. The GBGB wanted a set of peer-reviewed papers to be published, so the challenge to me was two-fold: the data analysis and the peer-review process. This resulted in two papers (Payne, 2013a, b) and represented a quantum leap in my writing styles. Many of my GBGB papers were written in a quasi-scientific style since my target audience was mostly non-scientists. With these papers I needed to write in a concise scientific style, and I found some difficulty in writing to the papers' titles – a challenge equivalent to writing reflectively! It was not a knowledge gap – it was a writing gap – how to address just the aim of the research without background relevance. One only has to compare these two papers with the paper I wrote for the GBGB (Payne, 2012b) to see the difference in styles. I was pleased with the outcome of the two papers since they were published and as such set in the scientific literature as evidence of my work with greyhounds. I can count this as a milestone in my career since the work remains as a unique set of investigations into the interaction of reproductive cycles and athletic performance in any animal. I will recount the process below.

Both male and female greyhounds race, and usually there are both genders in any one race. The female greyhounds are kept entire, since it may that at the end of their racing careers they will be used as brood bitches if their race performance was good. Most bitches cycle twice

yearly, whilst many greyhound bitches only cycle annually, but in either case there is a mandatory time off after they are declared in season, since it is believed that sexual urges may affect the race performance of both genders. Alternatively the trainers could elect to use medications to suppress the season. The time off was previously set at 70 days, and was reduced as a trial to 21 days. Trainers chose either to stay with the longer time off, or bring the bitch back into racing after 21 days. This trial period of 21 days was never confirmed as ideal, but became embodied in the Rules of Racing.

In order to decide which length was best, I was commissioned by the GBGB to determine whether any performance changes did occur, and when. The results (Payne, 2012b, 2013a) showed that performance did decrease and then recover after 21 days, with the worst performance being at about 45 days post-season, so the evidence suggested that 70 days off was a more appropriate period. Linked in with this was another paper to investigate whether spaying (Payne, 2013b) created a performance change. The results here indicated no change in performance. Combining these two results then enabled an informed decision to be made about how best to manage racing greyhound bitches, in particular the lower grade bitches since they were less likely to be bred from, yet would still either need oestrus suppression medication or time off, thus costing the owner money for their upkeep but with no return.

Spaying of lower grade bitches was advised as a reasonable recourse since there would no longer be any need to either suppress the oestrus or to allow the bitch to rest for either 21 or 70 days. Additionally, spayed bitches are much more easily rehomed, and therefore the demand

on retirement kennel spaces would be less. The dilemma faced by trainers and owners is that once spayed, a bitch's reproductive potential is forever lost, and there is always the hope that one's pride and joy may develop into an excellent performer and thus be more attractive as a brood bitch. So the longer racing career needs to be considered against the loss of breeding potential, and this, I believe, is the main reason for the slow uptake of spaying as an alternative to oestrus suppression. As an example of impact, the two papers I wrote were unique in that no previous work of this type had been performed before, even in the horse racing world. This uniqueness stemmed from the proper recording of the oestrus dates, a large amount of linked raceform, and my database which allowed collation of this data. The changes anticipated by this research have been slow to develop, probably as a result of opinions at different levels: the owners may feel that spaying removes any chance of producing successful puppies, whilst the trainers may not accept that a spayed bitch will run as well as an entire one, despite evidence to the contrary. There has been world-wide interest in my research, judging by over 700 downloads of the papers. In the grand scale this may not be much, but in the relatively niche world of greyhound breeding and racing, this may represent a significant interest. The GBGB has a spaying incentive program, but even with this there has been a slow uptake. The research remains unique, and no further research has been performed. I have an amount of linked data to continue the research, which will compare bitches spayed and hormonally suppressed in order to complete the triad of papers.

**Injury Mechanics**

Having completed my track physics research, my thinking and research can return to the original reason for becoming involved in greyhound research in the first place. I now have the base of knowledge and experience with wet sand tracks to be able to both assess injuries and to concentrate on elucidating injury patterns. This is the current phase of my research, and involves the collection of both injury data and race form data. The aim of this research is to break down the data by each injury type and then generate risk factors for that injury, and will add to the small number of papers already published (Cook, 1998; Guilliard, 2010; Ridgeway, 2006; Sicard et al., 1999). Although the analyses have not yet been performed in detail, some early broad analyses show that injuries do have a pattern, and it is hoped that these patterns will enable the discovery of ways in which the injuries may be prevented or reduced, with obvious improvements in greyhound welfare. The impact of injuries is much wider than the effect on the injured greyhound since with the necessary time off for recovery from injury, the workload is shifted to the other greyhounds within that kennel, thus risking further injuries. I performed a series of analyses based on the concept of an ideal time between races, which was stimulated by this idea of increased workload on uninjured greyhounds in the same kennel. This produced an interesting pattern, in that greyhounds which were run too often had a higher injury rate as one might expect, but also that running too little also had a higher injury rate. The sweet spot was at about 110 metres/day, which since most greyhound races are about 450 metres long, meant one race every four days or so. Looking at how often greyhounds were run by experienced trainers, I saw that they recommended three races per fortnight: very close to the one race every four days that I had calculated. So my analysis gave strength to the accepted knowledge. The fact that the better trainers had moved to this point of three races per fortnight is an examples of Bayesian

progression, where a point is picked, the results assessed, and a new point picked. Thus by iteration the ideal point would be reached, which in this case was 110 metres/day. A similar exercise was also conducted for a talk I was asked to give on pre-race examinations, which I will discuss below.

For many years, there has been standard way of examining greyhounds pre-race where time is limited. The hypothesis was that experienced veterinary surgeons had developed a best practice examination to maximize their chance of detecting an injury whilst keeping the examination short. Essentially they were looking for common injuries, on the basis that common things occur commonly. I performed some analyses on my data, looking at the frequency of different injuries and found that the examination routine was indeed matched to the common injury sites – an excellent example of Bayesian analysis at work. Another interesting analysis was that of the time off required for an injury before the greyhound returned to racing. To my surprise the analysis produced a direct relationship between time off and the likelihood of returning to racing, meaning that for each injury plotted on the regression line, one could read off the expected chance of returning to racing and how long the recovery period could be expected to be. To my knowledge this analysis has not been done before, so I am keen to produce a paper on this aspect since it will have a high impact on welfare if the analyses are repeatable and robust.

It is fascinating that these various patterns have developed, almost analogous to natural selection, where the various individuals involved with greyhound racing have gradually settled

at the most efficient point for generating the best effect with the lowest cost, where the prime goal is really to ensure the best performance of the greyhounds. This in turn is linked to the gambling, so we have a situation where good welfare practices actually stem from betting on the winner (or whatever the punter deems to be a good bet). Coming back to another line of thought: am I as veterinary surgeon comfortable with working with animals whose sole purpose is to win money? Based on the findings that the trainers are running their greyhounds at their optimum race rate, and that the veterinary surgeons' examinations are based on detecting common injuries, one would be moved to say that gambling has generated a good welfare outcome for the greyhounds. The other side to the argument is that there will be a loss rate whereby injured greyhounds are by definition compromised in their welfare, yet their injury helps to improve the knowledge of both trainers and veterinary surgeons so that they can modify their own practice to reduce the likelihood of another injury of the same type occurring. So the welfare of the greyhound population is improved (best racing frequency, efficient and targetted veterinary examinations) at the expense of reduced welfare at the point of injury for the unfortunate greyhounds which do receive an injury. Within this subject, I have to include the track physics work I have performed, since the greyhounds run on wet sand tracks, and the knowledge I have produced in the this area can also be sued to improve track quality. Here I can bring together two lines of research: injury data and track quality, which also brings me back to why I started the research in the first instance. My interest was initially in why certain injuries occur and what impact does track quality have on injury rates. The lack of data on either of these major subjects was the stimulus behind becoming engaged in research specifically aimed at addressing this lack of data, which has been investigated in parallel by the STRI (Cook and

Baker, 1998a, b). My development of a specific database is discussed elsewhere in this document.

Linked with the whole subject of injury rates is the injury known as a sand-burn, which are small abrasions on the webs of the hind feet, for which many causes have been ascribed. These are problem for some greyhounds, and I believed a problem for certain trainers. As a pilot project I was asked to investigate sand burn incidence and prevalence, producing a paper for the GBGB (Payne, 2009f). This project was interesting in that I could use a combination of questionnaires and event data to try to form some idea of the risk factors. The limitation of this one study was that it was performed at one stadium, so between-stadium differences could not be assessed. However the study did show some interesting results, for example the lack of sand-burns on the forefeet, and a bias to the right hind, which lead me to consider whether the sand friction causing the sand-burns was also a logical reflection of the forces experienced by the limb. Indeed comparing injury rates for each limb did show the same pattern as for sand burns, and this simple comparison assisted my understanding of the cornering mechanics of greyhounds which had been investigated by other researchers (Williams et al., 2009a) who found that greyhounds do not decelerate when negotiating corners. This understanding was also linked with observations of greyhounds cornering (personal videos and stills) where I was able to calculate cornering speeds using the trigonometric balance of centripetal acceleration and gravitational force (i.e. mass x acceleration due to gravity). This also showed that cornering speed and the angle of lean were not dependent on the body mass, something that had often been quoted as being a factor in injury rates. Indeed there were some rather wild internet

webpages giving voice to these ideas of balance and body mass, and linking them to huge coefficients of friction.

Applying basic rules of trigonometry enabled these to be resolved these principles into simple formulae, which were validated by the research I was doing into the available friction of wet sand tracks. This was pleasing as I had calculated the friction from first principles, and my experiments confirmed these values. I also calculated the contact areas for the limb joints and again found no link between mass and joint pressure, showing that nature had already thought of that and made the limbs proportionate to the body weight, thus meaning that the joint pressures were the same regardless of mass. This again resolved the oft-quoted mantra that heavier greyhounds were more likely to be injured (in fact injuries are more common in unfit greyhounds, regardless of size). These calculations were not published, but I performed them as ways of proving or disproving certain ideas. Another issue which I resolved was the common belief that split webs (tearing of the skin between the digits) followed on from sand-burns. My data showed that split webs occur in all four feet, yet sand-burns occur only in the hind feet, thus removing the causal link between the two syndromes. Sand-burns are more common in the winter, which is thought to be linked to the use of salt as an antifreeze. This provided a nice link to the work I have done on antifreeze choice and use, and as such created relevance from the clinical aspect of treating the sand-burn to the research aspect of trying to lower the risk of sand-burns.

Analysis of the questionnaires revealed that the trainers' management styles had a marked effect on whether the greyhounds in their care suffered from sand-burns, which was contrary to the accepted belief that sand causes sand-burns. The idea that a kennel management routine impacted on a race injury was certainly new as many trainers believed that all injuries occurred at the time of the race. In fact the physical stress of racing acts to focus any weaknesses, as it does for any athletic activity, and so subclinical injuries show up at the time of racing. This lag of initial injury and appearance of a clinical injury makes the proper analysis of injury data more difficult, since the exact point of the original injury will not be recorded in many cases, with the follow-on that the incorrect risk factors may be chosen when deciding where to concentrate efforts to reduce the incidence of a particular injury. This need not deter the seeking of risk factors, but the analyst needs to be cognisant of this inherent error in a proportion of any injury data sets. This can be offset by some extent by analysing for drops in performance which may indicate a subclinical injury. Since I have access to a large dataset of injuries and raceform, I am in the position to be able to conduct such analyses in the future, and the fact that I have been a track veterinarian makes me aware of these pitfalls, and also allows me to select injuries that I know are the most troublesome either in terms of frequency of occurrence or in terms of likelihood of returning to racing.

**Inherited Defects**

This research exercise was set a specific question by the GBGB, and was actually poorly understood by myself at the time. This did not make me feel inadequate, but rather stimulated an urgent desire to gain knowledge. The paper itself reflects this since it is essentially

a list of conditions with overviews, which is then expanded when the section on sudden deaths is described. What is seen in this paper is a combination of initial learning (overview of inherited defects) with detailed analysis (sudden deaths), and is a good example of my way of synthesizing existing knowledge with my specific research knowledge.

Greyhounds, like many dog breeds, have a small collection of inherited defects, and the GBGB wanted some background information on such defects. The short paper I wrote basically listed the defects with a brief description (Payne, 2009d). What was interesting was the lack of musculoskeletal defects such as hip dysplasia and osteochondrosis, which could be supposed to be of a low incidence due the effect on performance such defects, would produce. Continuing with this thought process, it is logical that musculoskeletal fitness would be linked with a lack of related genetic defects, and serves as an example of man's influence on breeding for speed and soundness. The main defect I was interested in was von Willebrand Disease (vWD) which is a defect blood clotting linked with poor platelet function (this is typified as small haemorrhages rather than the overt bleeding seen in haemophilia). Platelets are small cells within the blood stream that are responsible for stemming small points of bleeding from small blood vessels and capillaries. A deficiency here results in multiple small haemorrhages after tissue damage. My specific interest with vWD was in the syndrome of sudden death post-exercise, which I termed Exercise-Induced Abdominal Haemorrhage (EIAH), where one of the hypotheses was that greyhounds with vWD were more likely to die from EIAH. I am still working on this project since the disease is rare. Gathering information about the incidence of vWD in greyhounds and trying to link this with EIAH tests the quality of the data and also the

ability to detect significant links. Whilst EIAH itself is unlikely to be hereditary, there will no doubt be certain factors of the syndrome which have a genetic basis.

**Vision in Greyhounds**

This apparent side-step in my investigations is another example of an instance where I was presented with a question: "What do greyhounds actually see?" and found that although I knew the basics of animal vision, I did not know the exact details of canine vision. In my brain this represented a new, but empty, box. Thus in order to fill the box with the necessary knowledge to answer the question properly, I needed to perform an extensive literature research exercise. Although one might think that I would just fill an existing knowledge box (maybe labelled "vision in animals"), my view was that the question was so specific that a new box was needed, to which I would link my existing knowledge. A small research study was commissioned by the GBGB to investigate vision in dogs (Payne, 2012a). The thinking behind this study was to try and improve the visual appeal of the artificial hare. Most hares follow the standard wind-sock pattern, but beyond having a selection of primary colours, there was no formal basis on which to decide what colours would be useful, and the type of movement which was needed. The other issue was that of greyhounds which "failed to chase", i.e. showed no interest in the hare, and seemed content to run with a group of other greyhounds. A greyhound which failed to chase could then be offered for adoption. The obvious grey area was in deciding whether the hare design was at fault, or whether the individual had indeed lost interest in chasing. My work indicated that provided the artificial hare flapped and was of contrasting colours, then the maximum appeal would be had. The colours that I suggested would be best

were yellow/blue chequers, since these colours are seen best by dogs, and the light-dark contrast would help visualization on a variety of backgrounds, since many tracks have different outer barriers (e.g. rails or boards). This is an interesting example of anthropomorphism in which humans, as in most primates, have excellent colour vision which includes red. The idea that red is a warning colour is entrenched in our psyche, yet most quadrupeds see red very poorly ("a red rag to a bull" is a complete fallacy) and really see the world as a mixture of greens, yellows and blues. Many hare lures are orange or red and are readily chased by greyhounds, thus giving false evidence to the idea that the dogs are attracted to the colour. The fact that red is seen as dull brown and what the dogs are really keyed to is the movement is rarely considered, since humans look for colour rather than movement.

Alongside this is the fact that dogs use their hearing much better than we do, and I have witnessed greyhounds in the starting traps listening intently for the hare as it comes along the rails. Once we realize that animals' senses are not the same as our own, we will make much better informed decisions as to what will be pleasing and most suitable for our companions. There is good observational evidence to support the ideas covered in the paper, and again it is a case of making people aware of the significance of what they are seeing and then realizing that action can be taken. An example is using a white lure against white border fences – a simple colour change to black/white chequers solves the problem of poor contrast even though the resultant lure does not fit the anthropomorphic view that the lure should look like hare. Knowing that movement, contrast and noise are better cues than "looking like a hare" helps the understanding of why some dogs will chase and some will not.

This brings up the rather upsetting claim that some trainers use live baits to supposedly sharpen the greyhound's chasing instinct. Whilst this has caused a significant political problem in Australia recently (March 2015), the practice does not appear to be being used in the United Kingdom. In any event, there is no real evidence to support the use of live baiting, and it goes against so many laws that the threat of prosecution would deter all but the determined few. Certainly reports I have heard from trainers with greyhounds that will not chase suggests that if they do not want to chase, then nothing will convince the greyhound otherwise, and such dogs are retired fairly quickly to live a completely domesticated life. It would not be worth the trainer's time to re-educate such a dog since there would always be the risk that its poor chasing instinct would affect a race, for example by getting in the way of dogs which are chasing. The chasing instinct is not peculiar to greyhounds, it is inherent in all dogs, but the difference is that greyhounds, being sighthounds, are able to see movement at long distances and thus react sooner than dogs which rely more on the senses of hearing or smell. Greyhound racing is built upon the athletic prowess of the greyhound coupled with its keen sight, and although greyhound racing in its current from dates from 1926, the use of dogs as hunting aids goes back hundreds of years, and even to prehistoric times when men first shared kills with dogs. So what we see today is the result of the evolution of the man-dog relationship transformed from, but still showing, the basic essence of hunters and prey.

**Ethics and Welfare in Greyhound Racing**

As a veterinary surgeon I have a duty of care towards all animals I treat. Since I am interested in greyhound welfare and wish to improve their lot I need to also understand that I cannot change the nature of the gambling industry. A duty of care is seen as a deontological ethical stance (i.e. morality based on rules), but in reality all veterinary surgeons need to have a utilitarian approach (moral actions based on the well-being of the animals) though not a consequentialistic ("the ends justify the means") aspect to their ethical considerations, since many methods of animal husbandry require a balance between productivity and perfect welfare. The need to take account of the reasons behind the use of animals as productive units is important since cattle and sheep are raised for meat, milk, wool and leather, and yet without that need we would have no use for these animals and they would not have been bred in the first place. The same is true of greyhound racing in that the betting industry is a major stakeholder, and without the want of humans to gamble, any form of racing would not exist. To turn one's back on such activities does not make them go away, and it is this approach that I followed in order to justify my involvement.

The fact animals cannot understand ethics has been taken to mean that they do not have any rights, whereas in fact their welfare needs to be protected in order to generate a fair situation for them, in other words, their welfare needs are met by the actions of protecting bodies and individuals who declare that they do have rights. In this sense the Animal Welfare Act 2006[15] defines five freedoms which must be maintained in order to ensure good welfare standards. The

[15] The Animal Welfare Act 2006 can be found at http://www.legislation.gov.uk/ukpga/2006/45/contents

underpinning framework of the AWA 2006 and the Welfare of Animals (Transport) Order 2006[16] are central to the regulations enforced by the GBGB, and it is in this area of improving welfare that I have seen where my efforts have had an effect.

An example is the enforcement of the so-called 15 minute rule, whereby all greyhounds must wait for 15 minutes post-race before being transported away from the stadium. This stemmed from the requirement within WATO 2006 that all journeys must be separated by 60 minutes where only short distances or travel times (less than six hours) are involved (longer distances and times require longer rests). Since greyhounds must rest for 45 minutes pre-race, it followed that the 15 minutes needed to make up the 60 minutes legally required should also be enforced. It was by making representations to the GBGB that this was firstly implemented as voluntary code, known as the "15 minute rule", and which then became mandatory as a Rule of Racing. The fact that this is now a Rule of Racing shows that with proper evidence and reference to UK Law, changes can be made which are embodied into the regulations governing racing greyhounds' welfare.

At its introduction at the tracks the rule was met with some resistance since trainers wanted to travel home as soon as possible. It was only by physically standing in the exit doorway from the kennels was I able to enforce the rule at the track I worked at. There is a sound basis behind resting any animal before transport. During exercise the muscles release large amounts of lactate and carbon dioxide, and this can only be removed by maintaining an

[16] The Welfare of Animals (Transport) Order 2006 can be found at www.legislation.gov.uk/uksi/2006/3260/pdfs/uksi_20063260_en.pdf

adequate blood flow to the muscles. Confining an animal to a cage deprives the muscles of this blood flow, and thus the metabolic products become trapped within the muscles. It is know that this will reduce subsequent performance, and that walking or trotting after a race for 10-15 minutes greatly improves muscle recovery and prevents Delayed Onset Muscle Soreness (DOMS). I performed some blood sampling from greyhounds which had not run properly, and these results showed the rise and fall of lactate from immediate post-race to recovery, and the time course was about 20-30 minutes. Thus my small study helped to confirm the need for a 15 minute post-race rest (ideally walking). It would have been more acceptable to ask for 30 minutes rest, but this would mean that the pre-race kennelling would also be 30 minutes. So the 45/15 split seems the best compromise given the balance between the trainers' desires to return home versus the greyhounds' needs to recover.

This exercise demonstrated the links that were necessary between regulation, science and enforcement in order to safeguard the welfare of the racing greyhound, and is an example of the way I combine separate ideas into a new concept. The law clearly states the rest periods between journeys, and this was supported by the blood sample results. Thus the law could be enforced with confidence in order to complete the process, which in itself demonstrates that there is a need for enforcement where there is no opportunity to explain the background reasons – in other words the physical prevention of loading was used rather than an explanation. In order to facilitate the acceptance of new ideas the GBGB holds special training days where veterinary surgeons and trainers can be appraised of new regulations and scientific findings. The aim of these days is to promote the use of good science and to have the necessary forum to explain the reasons behind rule enforcement. Since I was involved in this process, it is quite a

nice example of how my research has represented part of the evidence base for specific rule changes, and the fact that it is accepted is shown by the fact that this particular rule is still in place.

Alongside the 15 minute rest, another consideration was the transport of injured greyhounds. According to legislation, any injured animal may only be transported between a veterinary practice and the usual place of residence[17] i.e. the journey can only be made where the animal is going to receive treatment, and then the return journey. When I was a Council member of the Society of Greyhound Veterinarians (SGV) from 2005-2007, I and a colleague drew up an informal guidance to assist track veterinarians with their decision-making in dealing with injured greyhounds (Payne and Allen, 2007). Specifically, the issue was whether an injured greyhound would be allowed to travel back to the trainer's kennels, as the Animal Welfare Act 2006 only permitted the transport of injured animals to and from veterinary practices. We investigated the law, and determined that the key feature was an examination by a veterinary surgeon at a veterinary clinic. Since all stadia had to have a veterinary surgeon in attendance during meetings, and were also required to provide a room dedicated for use by that veterinary surgeon, it was clear that the legal requirements could be fulfilled, and that the examination and first aid treatment of injured greyhound by the track veterinary surgeon in the dedicated room (which was therefore a clinic) counted as a genuine veterinary process. Therefore greyhounds treated at the stadium could be transported back to the trainers' kennels without breaking the law.

[17] Farm animals can also go to slaughter, but that is not an issue in small animal practice.

The reason for this legal exploration was that we deemed it a welfare issue for uninjured greyhounds to be transported to a veterinary clinic after the race meeting, purely for the examination of an injured greyhound, trainers having only one van in which to conduct the transport. In other words, we wished to ensure the treatment of the injured greyhound fell within the law, and also did not expose the uninjured greyhounds to unnecessary transport. Thus the resolution resulted in treatment of the injured greyhound at the stadium clinic and the transport of all the greyhounds back to the trainer's kennels with the minimum of disruption to normal routines. The SGV guidance added in the caveat that a re-examination was required at a stipulated time, thus ensuring that the injured greyhound received continuing care. Obviously in cases of severe injury, then direct referral to a veterinary practice was required, and all the variations are built into the SGV guidance. Linked with this guidance, we also produced a Transport of Injured Greyhounds certificate (TIGH, pronounced "*tig*") (Payne and Allen, 2007).

The TIGH certificate was produced as a set of triplicate sheets, which the track veterinarian completed, keeping one copy, and giving the second and third copies to the trainer and the track management. This written record could then be given to the next veterinarian to see the greyhound, and meant that there was a proper record of the injury and first aid treatment, and recommendations for further examinations. Should the trainer not have complied, then the TIGH could be used as evidence in any further investigations by the NGRC (or GBGB nowadays).

This guidance and the TIGH certificates are still in use by the GBGB at all licenced stadia, and are considered to be extremely useful for trainers and follow-up veterinary examinations. I am particularly pleased with this work since it came about after much delving into the minutiae of the Animal Welfare Act, coupled with deductive reasoning to come up with a standard document and certification process that has withstood the test of use over many years.

# CHAPTER FIVE – CONCLUSION

## Conclusion

The main avenues of my research may seem to be separate, but in fact they do all fit together to create a breadth and depth of information that not only links the disciplines of track physics, injury mechanics and disease control, but serves to show that working both as a researcher and as a veterinary surgeon has enabled me to bring these topics together to create new ideas and realizations. As discussed previously, the way I mentally arrange my ideas makes link formation necessary for my thinking, and also allows the creation of new ideas.

Looking back, it is curious to see that the various parts of my research actually stemmed from the initial desire to explain why specific injury patterns are seen in racing greyhounds. Finding that there was little knowledge about how the tracks physically behaved meant that in order to start to explain injury patterns, I first needed to explain wet sand track physics. From this point my research exposed more unknowns, each of which I then investigated in turn until eventually the various parts started to come back together to provide a full explanation of the properties of wet sand tracks, and from there the knowledge was consolidated into advice on how wet sand tracks can be managed.

Within this reflection, I can also see that my initial forays into research made several assumptions as to the existing level of knowledge, but once I realized this I was able to focus my research onto the areas where knowledge was lacking. In some cases this knowledge

reinforced accepted practice, for example the local knowledge used in track preparation was justified since I was able to show that the combination of sand type, local weather and track drainage was crucial in the preparation of a good running surface, and that a standard one-size-fits-all method of track preparation was not effective (and in some cases made the tracks worse). Now this is in place, my work can continue on its original course of exploring injury patterns with the added knowledge that I also need to have data on sand type and the management practices at each track.

In terms of how this has affected my practice, I can state that my broad and deep knowledge of track physics, disease control and data analysis relating to racing greyhounds has meant that I am called upon to provide my opinion within these areas. During my first involvements with greyhound racing, I found it hard to make my views known since I did not have the recognition within the industry to be present at significant internal GBGB meetings nor did I have a track record (excuse the pun) in providing evidence to reinforce my views. At the time of writing I am recognized as being knowledgeable in the fields of greyhound transmissible respiratory disease, sudden deaths at stadia and residential kennels, and the physics of wet sand tracks. With these different disciplines, my way of thinking keeps the ideas separate yet allows me to link the ideas to create an integration that I hope will be both unique and useful, and I plan to continue to use this knowledge for the advancement of evidence-based practices in greyhound racing.

Although much of my research has been completed on track physics, there is still plenty of research to be performed on event patterns, and this will form the focus of my future researches. My position at the University of Nottingham has exposed me to many more opportunities to continue and develop this research, and the easy access to specialists in the fields of epidemiology and statistical analysis is something which I look forward to with much eagerness. Professional development is never static.

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