Sports betting, Horse Racing and Nanobiosensors - An Ethical Evaluation

ABSTRACT

Horse racing has begun to enter an economic decline in many countries, notably represented by a decline in revenues in betting volumes. A number of reasons may be attributed to this: the success of other sports; new online betting practices; and concerns over animal welfare. In response to this, horse racing institutions has begun to modify its practices, employing technologies such as GPS sensors and Wi-Fi active racetracks, with the aim of engaging a new generation of spectators, including betting spectators, to the sport. We consider a new biotechnological potential for the sport to develop through the use of nano/biosensors in horse racing. The biological data collected by these sensors in real time could be used to offer a number of potential benefits to the sport, such as new forms of bets, support for animal welfare and increased levels of immersive spectator experience. Despite these potential benefits, the use of nano/biosensors can also expose the sport to a number of disbenefits such as increased opportunities for corruption, technological determinism, and issues concerning unethical use of the data collected. We present a critical ethical evaluation of this potential development and argue that stakeholder consensus is required before the technology is implemented, and that an appropriate regulatory framework is established to support its (potential) implementation.

KEYWORDS – *betting, sports, horse racing, biosensors, nanobiosensors, nanotechnology, ethics, regulation, law*

Introduction

It is likely that elite sports and betting practices have been bedfellows, as long sports practices have existed. Though analytically distinct they have grown organically to the point where some sports or leagues only seem to include betting sponsors while horse racing, specifically, seems almost to have been developed in order to provide a platform for betting. Sports' betting is a thriving industry with a long history of highly successful and visible global financial links with major sports. Consequently there are now more than 8,000 operators offering sports bets all over the world, generating vital revenue streams and drawing greater numbers of spectators to live sporting events (ICSS 2014). Horseracing has benefited significantly from its relationship with betting, extracting substantial profits from betting markets and using it to boost its profile as an international sport across the world (Forrest 2006). Yet despite this, in recent years it has begun to witness a pattern of decline in many countries, which has consequently inhibited its betting revenues (Gibbs 2015; Hawkins 2014). There are a number of reasons for this, such as the increased popularity of other sports such as football for example, which has attracted large investment from betting companies. Whereas horseracing's reliance on more 'traditional forms' of betting such as on track bookmakers/betting shops, along with existing concerns relating to animal welfare has left it lagging behind in comparison (Liebman 2010; Wood 2016; Christiansen 2010). These factors have presented challenges for the sport, and have consequently impacted its commercial foundations.

In response, the horse racing industry has endeavored to rejuvenate its image, in an attempt to appeal to new markets and attract a new generation of gamblers, via the engagement of new betting modes and web-based applications. This is evident through the use of new technologies within the sport such as GPS sensors and Wi-Fi active racetracks, boosting the sports' online profile, and further promoting more immersive and interesting forms of betting (TPD 2013).

Despite such recent innovations within horse racing, new opportunities exist in order to push the boundaries of technology to innovate betting practices within the sport. One way this could be achieved is through the application of biosensors and future potential nanobiosensors to horse racing; this biotechnology could be used to collect biological data, opening potential benefits such as new betting forms, improved animal welfare, and greater levels of spectator immersion which could result in improved betting revenues (Evans et.al 2016). Despite these potential benefits, however, a number of disbenefits, such as increased opportunities for corruption, issues concerning technological determinism, and concerns in relation to the use/fairness of the biological data collected, also arise. We develop here an ethical evaluation of nano and other biosensor use in this article, having first discussed the intertwined history of sports betting within horse racing. We conclude that it is essential that an open ethical discussion of this biotechnology is undertaken prior to the potential implementation of it to the sport, and recommend that if such technology is to be applied, then a robust and flexible regulatory

framework/security system is put in place to ensure its done so in a safe and ethically justifiable manner.

A Brief Overview of Sports Betting

Sports' betting has a long history, with examples dating back at least as far as the Roman Empire, where bets were placed on circus events and chariot races (Moody 2013). Ever since, sports' betting has continued to evolve, becoming more professional in the 19th Century; developing into an effective means of generating profit especially from horse races, consequently leading to some of the first bookmakers operating in England (Kyrylenko 2017). Sports betting continued to develop into the second half of the 20th Century, where bookmakers began to take bets on all types of sports, such as football; further helping to drive revenue streams for the industry (Kyrylenko 2017).

One of the most significant factors for the growth of sports betting may be a result of the emergence of the Internet, altering the way in which bets were distributed, as well as allowing for an unprecedented expansion of the industry (ICSS 2014). The Internet, as a platform for sports betting, has been transformative for the industry, acting as an essential technological foundation layer for new betting practices/technologies to be built on, such as online bookmakers, betting exchange and GPS sensors (Kyrylenko 2017). Both of which offered new betting opportunities for both the bookmaker and player, and hence, allowing the industry to generate new levels of profit from almost all competitive sports (Kyrylenko 2017). Most of which is generated through

football (494.44 million) horse racing (315.56 million) and tennis (61.6 million) (Wood 2016). As a consequence, the global sporting betting market is a now lucrative business, with figures suggesting that it was worth $76.1 billion dollars in 2013, $104.31 billion dollars in 2017, and expected to reach $155.49 dollars in 2024 (Statista 2017; Zion 2018).

Consequently, it is clear that the sports betting industry is an established and financially successful industry. Moreover, as shown, it has been a longstanding feature of human society throughout our history in one form or another. But what drives this industry? Why has it become such a success within human society? When one considers such questions, its success would seem illogical. The sports betting industry wants people to place bets, spending their money, on events where outcomes are relatively unknowable (unless manipulated) in the hope of securing financial return and an intensive emotional sport experience. This on the surface would appear to be an act of madness; why would anyone partake in such an incredibly risky act, especially when the chances of financial loss are the basis for the industry itself? As with all sport betting, luck may confound research and sophisticated, statistically driven, betting patterns. This seems to be an essential element what makes the act of sports betting exciting; it taps into our base pleasures and provides an intense experience that many other activities are unable to match. A recent survey of 5,500 gamblers identified that one of the key motivations for gambling was the hope of 'winning big money', but this was closely followed by other factors such as fun and excitement (Baraniuk 2016). Consequently, even when a gambler is losing and the risks of loss are high, physiological

mechanisms (such as adrenalin and endorphin production), keeps them on the edge and provides them with a buzz - making gambling potentially addictive (Griffiths n.d, cited in Baraniuk 2016, para. 8). Gamblers are therefore not merely hoping to win their bet as the end result, they are also consuming an entertainment experience. This point has some empirical support as reported by the University of Stanford in California (Baraniuk 2016, para. 11) who found that:

> *Around 92% of people had "loss thresholds" below which they would not go. However, the fact that they lost money overall after visiting a casino, for example, did not necessarily impact their overall enjoyment of the experience.*

The desire to bet therefore goes beyond simply wishing to win, with those who do gamble regularly willing to sacrifice their potential personal and financial security in order to access the excitement that betting can offer. In some cases this is the very reason as to why many actually watch games within sport; for example - it's unlikely that someone would get up at 10.00am on a Sunday to watch an NFL team they do not follow unless they either have a passion for the game as whole, or have placed a wager on the match (Stewart 2013). Sports' betting is an ethically ambiguous activity, but that is what makes it exciting and addicting as part of the wider contest (Stewart 2013).

Sports betting companies have consequently tapped into this desire for excitement, and have exploited modern technology in order to promote the accessibility and immersive nature of sports betting. This can clearly be demonstrated by the emergence of sports betting apps, along with the seemingly endless variety of bets that are now possible in relation to any given sporting contest. Moreover, technology is altering betting habits, for example allowing gamblers to bet from their own homes. This means they no longer

have to attend live events or betting shops to do this, which can promote negative stigmas for some (Christiansen 2010). In summary, technology is increasingly playing a pivotal role in the development of sports betting, and with new and innovative technologies emerging, such as the focus of this paper on nanobiosesnors, sports betting is only likely to further to evolve.

A Case Example of Sports Betting – Horse Racing

The beginnings of horse racing can be traced back to early Central Asia and the Mediterranean, where major events such as the first Olympics in Greece included competitive equestrian events (Croupier 2016). It was not, however, until around 1880 when formal annual races began, especially in the UK, with professional jockeys competing against one another (Huggins 2000). This period, of course, is consistent with what is called the birth of modern sport in Victorian Britain (McIntosh 1979). Since then, betting on horses has flourished, with prize money available for those who won, which attracted people from all over the country to attend (Huggins 2000). This consequently had a domino effect across the UK, leading to the creation of racecourses all over England, along with generating public demand for more betting, further generating an increase in commercial practices such as entry fees and media coverage (Huggins 2000). This led to the emergence of the entrepreneurs, offering odds (i.e. the emergence of the phrase “bookmaker” where “book” was a pseudonym for the gambling odds) on races from the side of the track (ICSS 2014), which put betting at the very heart of the sport, supporting its expansion across the world. It has become particularly prevalent and profitable

in Asia, which itself is correlated with practices of illegal and irregular betting (The Economist 2012; Porteous 2016). In addition, horse racing has also been successful in the UK, and has embedded itself within British Culture with 59 racecourses across the country, and a worth of £1.1 billion to the UK economy (Croupier 2016).

Despite global successes, some institutions of horse racing that orbit and sustain the practice, particularly in countries such as the UK, Australia and America[1], appears to be entering a period of financial stagnation, and is no longer the main betting sport (Hawkins 2014). For example in the UK, despite large attendance figures for major festivals within the sport such as Cheltenham, average attendances at racetracks have fallen by 7.8% since 2015; additionally attendances at other jump meetings have been lowered further, down by 25.3% in 2018 compared to 2002 (Ingle 2019; Baxter 2018). Field sizes have dropped due to this, with new owners being reluctant to enter into races, resulting in a fall in overall prize money (Ingle 2019). This has in turn placed additional stress on betting companies, as in the eighties horse racing accounted for around 85% of betting revenues, compared with less than a third today[2] (Allen 2018). Consequently, Ladbrokes has stated that its in-store betting on horse racing is becoming unsustainable, and William Hill additionally declaring that turnover in relation to horse race betting is in

[1] As referred to earlier, in some countries this pattern of decline is yet to be seen. An example is Hong Kong, where horse racing is thriving (Economist 2012). But this is mostly due to monopoly the Hong Kong Jockey Club has over betting in the country, as it's the central regulator for all betting practices, thereby promoting horse racing as the main focus for sports betting in relation to other sports (Hawkins 2014; Sportsbetting n.d).

[2] Some within the industry argue that in more recent years horse racing has seen a slight (although a debated) revival. As the UK Gambling Commission noted that in March 2017, revenues were up 9% on the back of a 10.9% rise in turnover, and it still remains the second largest betting sport in the period (Allen 2018, para.5)

significant decline (Thomas 2014; Allen 2018). This has of course had an impact on the overall betting revenues generated by the sport (Ingle 2019).

There are a number of causes for horse racing's recent decline as a betting sport. One such reason is due to the fall in the number of horses being trained for races, with more than a 7 percent decline since 2010 due to a lack of money from failing spectatorship and betting revenues (Gibbs 2010). Its epithet, the "sport of kings" is well earned, given the cost of maintaining and training a race horse is an expensive endeavor, available to the very few. The average cost for a race horse is approximately £22,696 ($30,000) per year (Murray 2017). A vicious circle of decline may reasonably be envisaged; reduced revenues are likely to result in less horses being bought and trained, diminishing the pool of entrants into competitions. A reduction of races would ensue, creating downward pressures on race cards (number of races per day) and total event numbers.

A further issue here is that horseracing has not responded sufficiently swiftly to technological advancements in betting, and has in the past been opposed to wagering away from the track, especially in the 1970s and 1980s (Christiansen 2010). This fails to recognise that people often want to bet in places that are convenient to them, and has resulted in its falling behind sports such as football which has harnessed the transformative nature of the Internet in order to establish Online betting platforms; moving betting away from its traditional live-at-venue base (Christiansen 2010). Hence, this has resulted in spectators turning away from the sport, opting to embrace new forms of immersive

betting systems offered in other domains such as football, moreover, attracting a younger demographic of gamblers to the sport by generating new levels of immersion (Viuker 2015). A prime example of this is the Scottish football club, Celtic FC, who have installed a powerful Wi-Fi service into their stadium (MacLeod 2014; Mayton 2014) which enabled the development and installation of a specific mobile application that not only allows spectators to see replays and check statistics, but also bet on live in-play odds due to its partnership with Unibet (MacLeod 2014; Maytom 2014). This has helped to draw new spectators and increase betting revenues for the sport.

A decline in interest in traditional sports driven by factors such as ever-decreasing media coverage has also raised issues within horse racing, working to lower its profile in comparison to other sports such as football (Liebman 2010). As a consequence, spectator numbers have fallen, with people only turning out in numbers for the major events such as the Triple Crown, with very little interest now being shown in regards to everyday races that occur at race tracks, which is essential in helping to fund the sport and drive betting revenues (Liebman 2010).

The horse racing industry in the UK has started to attempt to stall this decline in a number of ways. In association with betting companies, horse racing institutions have begun to consider ways in which betting within the sport can be “reinvented” pursuant to the aim of attracting a new generation of gamblers to help boost revenues. To achieve this, horse racing is mainly turning to technological innovations and Internet connected devices/mobile applications

to enhance the spectators' betting experience, and consequently its Online betting profile. A prime example of this is the UK Jockey Club's modifications of key British racecourses such as Cheltenham, which has been upgraded with a high speed Wi-Fi network (XIRRUS 2014). This has also been supported by the Cheltenham Racecourse app [3], which provides spectators with additional features such as the ability to buy race tickets, see fixtures/race cards, and place bets, therefore simplifying the betting process on and off the track (HRA n.d.).

Cheltenham, home to the famous Gold Cup festival of jump racing, is not the only racecourse to modify its track in this manner - others such as Royal Ascot have also carried out similar upgrades. The result of which is helping the sport to encourage new ideas and revenue streams that were not possible before the integration of Wi-Fi to racetracks. For example, the company *Total Performance Data* have been working with racing organisations and have employed custom built wireless heart rate monitors and GPS tracking technology to 25, 000 horses across 9 racetracks, which has provided new levels of statistical data such as lap times and speed for around 3,000 races (TPD n.d.; TPD 2013). As a consequence this has opened up a new range of possibilities for all stakeholders within the sport, helping to generate a more immersive experience for all those involved, as it offers owners and trainer's performance data that can be accessed through the Wi-Fi network straight to mobile devices (e.g. video footage, heart rate data and sectional times) (TPD

[3] Cheltenham is one of the UK's most famous race tracks and home to the Gold Cup, first run in 1924, as the highpoint of the Cheltenham Festival.

2013). In addition, offering bookmakers new analytical data to generate increased numbers of bets for customers viewing the race (TPD n.d.).

Despite these developments, horse racing is still struggling to compete with other sports such as football, which has already carried out similar modifications. Consequently, horse racing must look at alternative avenues to ensure it is ahead of the curve in relation to betting innovation and immersion, remaining competitive with other sports going into the future. The recent integration of GPS sensors by TPD (n.d.) is an attempt to further add additional layers of immersive betting practices and technologies to sport, in order to boost its betting profile. One potential way of doing this is to turn to 'Biomedical engineering' and sensors such as 'biosensors', and in future, 'nanobiosensors'.

An Overview of Biosensors and Nanobiosensors in Sport

A biosensor can be defined as a device that associates a biological sensing element and a transducer to transmit biological data (Coulet 1991). Biosensors consist of two parts: a bioelement and a sensing element (Mohanty and Kougianos 2006). They comprise of a biorecongnition element that responds to a target compound that creates a biological response, which is then converted by the transducer to a detectable signal that is measured *inter alia* optically or acoustically (Touhami 2014). There are some biosensors already in use in horseracing, but these are mainly used in relation to the veterinary side of the sport. An example of this is the Pulse Oximeter, which is used to

monitor horses' haemoglobin and oxygen saturation levels, essential for ensuring that the animal is in peak physical condition, protecting its welfare (Price 2011).

Nevertheless, biosensors have limitations such as the (i) volume of biological data they are able to collect; (ii) practical functionality for elite athletes (and non-human sporting animals) in terms of size and movement inhibition or restriction; and (iii) over-sensitivity that can sometimes lead to false data measurement. In consequence, sports and biomedical engineers have sought to overcome these deficiencies in the form of nanobiosensors.

Nanobiosensors differ in scale from biosensors, and may be defined as a sensor consisting of nanomaterials with the dimensions on the nanometer (1 nm = 10–9 m) (Nada et.al 2011, p.92). The incredibly small size of nanobiosensors has multiple advantages, due to the large surface area to volume ratio; many of the nanomaterial atoms are located near their surface, resulting in improved transducing and signaling capabilities (Malik et.al 2013). This increases the sensors ability to detect and provide more accurate data recording. An example of which is currently being researched at The Institute of Optoelectronics Systems and Microtechnology at the Universidad Politecnica de Madrid, who have fabricated optical nanosensors that can be attached to uneven surfaces such as those presented by human and animal skin (Nanowerk 2015). Consequently, these sensors could allow for in depth and real time analysis of biological parameters such as temperature, lactate levels and heart pressure for example (Nanowerk 2015). Moreover, such sensors

would also be low cost, as they can be constructed from cheap materials such as polycarbonate compact disks, aluminum tapes and adhesive tapes, promoting the potential to easily mass produce them for whole scale use (Nanowerk 2015).

Nanobiosensors and Horse Racing – An Ethical Discussion

Very few ethical discussions exist with respect to the use of biosensors and nanobiosensors within sport outside of the work on the potential application of nanobiosensors for performance analysis purposed by Evans et.al (2016). Further, the ethical application of these sensors to sports betting has yet to be discussed in any academic literature, and therefore by doing so we aim to address new grounds of ethical debate for this technology. It is quite possible that a variety of ethical theories or frameworks could be employed here. It is also true that a number of biotechnological discussions have queried the transformative nature of their use. Here we employ a generalized consequentialist framework. We do not discuss in detail other non-consequentialist ideas, nor do we rule out their relevance. Nor do we discuss specifically the more general debates on the ethics of gambling itself, though we do consider briefly the role such technology may have in exacerbating the problem of addictive gambling. The following section will develop an ethical discussion of the benefits and disbenefits of this technology, in preparation for its potential integration within horse racing for betting purposes. These are listed in the table outline below:

TABLE 1 - The benefits and disbenefits of using biosensors and nanobiosensors for horse race betting

Benefits	Disbenefits
New Forms of Betting	Concerns Over Data Use/Interpretation and Fairness
Increased Betting Immersion Through Technological Layering	Increased Risk of Corruption
A Multipurpose Application	Counter Productive to the Spirit of Betting

The Benefits

1. *New Forms of Betting*

There are a number of bets available in horse racing, such as straight bets (where a wager is made on a single horse to finish a race in a certain position) and in-play/running bets (where a wager is made whilst the race is still being run) both offering the spectator a number of gambling options (Eng n.d; GC n.d). Yet despite this, it is still argued that these are not immersive enough for the modern spectator and gambler. To increase spectator immersion, one could utilise biosensors and nanobiosensors, allowing for a horse's biological data to be collected throughout the race in real time, and simultaneously sent to a central hub, which in turn can be distributed to spectators via racecourse and betting apps. As a consequence, this could support the development of new

forms of pre- and mid-race bets. Examples could include the extent to which a horse's pulse rate or sugar levels fluctuate throughout the race, or how much lactate a horse may build up during the final lap, or latter stages of a sprint.

The sensors could also be used to support a form of technology forecasting, allowing gamblers to better predict the outcomes of bets, and for betting companies to generate more accurate odds. This form of forecasting would be based on evidence collected from a range of sources, allowing for more accurate predictions to be generated, and thus, creating more informed betting choices (Firat et.al 2008). It is reasonable to predict that from a better's perspective, good forecasting could work to maximize gains and minimize losses (Firat et.al 2008). This, for example, could be vital in helping to increase the accuracy of in-running betting through exchanges. As a betting mode, it requires judgments to be made in split seconds on many occasions. This generates considerable pressure and unpredictability. This in turn is exacerbated when the wager is high risk for example (OLBG n.d).

We may ask, however, whether the use of this sensor technology will be functional in better predicting event outcomes. For a betting industry to effectively function, there must be losers, as this provides the financial security for the industry. This generates a potential tension between stakeholders, and it could be argued that such forecasting enables gamblers to maximize their gains, whilst minimizing those of the industry. A zero sum game, not simply between the competitors, but between betters and the betting industry is thus ineradicable. Access to data is critical to the success of the

spectating better as it is to the odds setters in the industry. Horse racing like all sports rests on the "sweet uncertainty" of outcome (Fraleigh 1984). This uncertainty has been the subject of manipulation since its inception. It takes multiple forms such as equine doping, jockey manufactured losing, insider information, or even the manipulation of the horses physiology – by working them excessively hard at the beginning of a race so that they do not have sufficient available energy at the end to realistically compete for victory.

Despite increased data on horse form, and live data during the race, the unexpected still happens in sport, making the placement of a successful bet an increasingly difficult challenge. Consequently, although nanobiosensors will offer greater quality of data to place more informed bets, it will still require skill in order to interpret such data to determine the correct outcomes. This data will always be a hostage to the variety of forms of event manipulation stated above. It is therefore clear that inaccuracy of human judgment and corruption can still result in mis or under-informed betting; and chance still plays an intrinsic role in betting as a wider domain. An example of this can be seen when considering the famous win of *Mine That Bird*, who entered the Kentucky Derby in 2009 with 50/1 odds (Dineen 2017). This result was unprecedented, with only one horse previously winning the Derby with longer odds; that being Donerail who was 91/1 before winning the Derby in 1913 (Dineen 2017).

2. ***Increased Betting Immersion Through Technological Layering***

The drive to improve technology in horse racing has made significant leaps forward, especially with the development of Wi-Fi active stadiums. Nevertheless, the sport is looking to build on this further, identifying that technological immersion can help boost betting profits at home, at the track, and within betting shops. This is where biosensors and potential nanobiosensors could add another layer of immersion to new forms of betting technologies being integrated into horse racing. A prime example of this recent technological development can be shown through the betting operator William Hill's research into Virtual Reality applications within betting in order to enhance the spectators' experience, by providing a jockey's view of the race (ISFPR 2015). The technology would be supported by the use of sensor technology such as GPS, providing displays with key analytical data such as lap times and speed (ISFPR 2015). In addition, it would allow gamblers to access races all over the world, whether they are at the track, out and about, or at home (Davies 2015).

Despite such a technology still being it its research and development stages, the application of biosensors and nanobiosensors, will add an additional experiential layer to sports betting. As biological data to the VR screen readouts, such as a horse's lactate levels and heart rate for example. Such data can generate more informed betting choices, boost spectator numbers, and generate economic benefits for a sport in decline. As a consequence, the potential combination of these technologies could help to improve the betters'

experience of the sport, making it more exciting, and allowing gamblers to feel more a part of the action once they place their bets, instead of simply watching a screen for the results to be revealed.

3. *A Multipurpose Application*

Although this paper focuses on the potential of nanobiosensors for betting within horse racing, it is noteworthy that non-betting related benefits from such sensors could arise. A prime example of this is the positive role that it could play in supporting animal welfare, demonstrating its multipurpose potential as a technology. There has been a global recognition in recent years of the need for all sports to take ethical concerns more seriously. Horse racing is no different, and concern over animal welfare is one of the reasons why some spectators have turned away from it in recent years (Liebman 2010; Barnett 2006; Torres and Chen 2012; Wahlquist 2019; Peter 2019). It is felt by many that the sport fails to adhere to the notion of animal welfare, and does not take into consideration a horse's physical and mental state, ensuring that they are protected from unnecessary suffering (Rollin 2011). Examples such as the English Grand National, one of the sport's most lucrative races emphasises this point, claiming the lives of around 48 horses since 2000 (Merrit 2017). One of the main reasons for this is due to the course structure itself; the design is extremely challenging, with forty horses battling each other for space over a 4-mile track of obstacles, jumps and uneven terrain at high speeds (Bekhechi 2016). In consequence, immense strain is placed on the horses, often resulting in them collapsing from exhaustion or suffering serious

injuries such as leg fractures, which can in turn result in the horse having to be put down on the course. This can be demonstrated by the death of the 10 year old horse Willie Mullins in the 2019 Grand National after falling after the first fence, resulting in it being in clear and apparent pain, and consequently having to be put down (Ostlere 2019). This problem is not only limited to the English Grand National, with seven horses having died at the 2016 Cheltenham festival, as well as two at Aintree in 2019 (Bekhechi 2016; Ostlere 2019). Further, this issue is not confined solely to the UK; other countries such as America are facing similar concerns with frequent protests over the sport. According to the U.S Department of Agriculture data, more than 57,000 horses were shipped to from America to Mexico and Canada in 2019 for slaughter; either due to injury, retirement, or in the 'prevention of abandonment' (Peter 2019). This issue is also prevalent in South Korea, where at least 30% of racehorses imported from Australia in the last five years have been sent to slaughter (Wahlquist 2019, para.18).

Many have consequently turned away from the sport, looking to bet on other sports void of animal welfare concern such as football. Nanobiosensors could be used in order to address such concerns, as they will be able to monitor a range of biological factors as discussed earlier; helping to pin point more precisely when a horse's welfare may be at risk and from what specific pathologies. Furthermore, the reduced size of the sensors mean that they can be worn for longer periods of time, which can in turn allow for continuous monitoring of the horse's health outside of training and racing to further promote the animals' present and future welfare. One avenue available to the

sports regulatory bodies is to mandate the use of these sensors. This development would not incur high costs for owners, due to the potentially cheap production cost of nanobiosensors, and would have the effect of endorsing the priority of the horse's welfare over and above winning revenues with the additional benefit of promoting equine welfare (Nanowerk 2015).

The disbenefits

1. ***Concerns Over Data Use/Interpretation, and Fairness***

Despite the many benefits that data collated through biosensors and nanobiosensors could offer the sport in the future, it also raises a number of concerns. The improper use of such technology could be highly detrimental to many of the stakeholders involved in horse racing.

The use of biological data also raises concerns for owners, as a successful race horse involves significant financial investment. Data collected from the sensors could be vital to sporting success, allowing performances to be enhanced and optimising financial return. Yet the value of this data increases the likelihood of it potentially being stolen or leaked. This could offer opposing owners an insight into the strengths and weaknesses of another horse, therefore potentially providing an advantage over the rest of the field. Opposition owners could seek to gain a performance advantage, betting companies to fix bets, and further promote unregulated betting, which could

result in a loss of revenue and prestige for the owner, and reputational loss for the industry. Moreover, there would also be concerns regarding ownership of the data, as the person who collects the data is often the one who is legally presumed to own it (Socolow 2015). Consequently, if the betting companies are the ones to produce these sensors and therefore collect the data, they could be within their rights to withhold this information from the owners, and even use this data for third party uses against the owners wishes, again resulting in further reduced revenue (Socolow 2015). It could be argued that an issue such as this is largely irrelevant, as contracts would be put in place between stakeholders in order to determine data ownership. Yet this is uncharted territory. No precedent has been set in relation to data ownership. Extensive stakeholder consensus must be sought. It is unlikely that an owner who has invested significant sums of money into a race horse is likely to sign away such valuable data easily.

In addition to this, concerns can also be raised over the impact this data could have on trainers and breeders. Positive biological feedback and betting trends on a horse using this type of sensor technology could result in positive connotations for trainers and breeders, which would demonstrate effective training and development of that horse, and could bring with it increased status and subsequent commercial activity. Conversely, this viewpoint can also be reversed: if data reveals negative trends of betting on a horse's biology, and data feedback reveals signs of poor breeding choices, or, for example, demonstrates an increased heart rate before jumps that may indicate its anxiety, the reverse may occur. Given the importance of reputation to these

breeders and trainers, and how perceptions of expertise fuel those reputations, the possibility of loss of betting on their horses would immediate.

Another variable to be considered are jockeys on whom (nano)biosensor data could also have impact. Problematic betting trends[4] on a horse could be traced back to the jockey and their physical status or psychological capabilities to handle their horse. Might, for example, a horse's biological feedback demonstrate a failure in the jockey's ability to nurse their ride over a challenging fence? As the best jockeys are those who are able to relate intuitively to their horse, identifying their strengths and weaknesses gained through riding experience and the data analysis they have carried out off the track with training teams (Beam 2009). This allows for better control over the horse, and the ability to keep calm, steering the horse out of trouble when needed, or pushing for speed before the finishing post (Beam 2009); all of which combine to promote the best possible race outcome. Whereas data for a jockey or horse calls their ability into question, such as their skill of interpreting a horse's biological data in order to get the best out of their horse within a given race[5]. There may be significant consequences for the jockey's livelihood, and could lead to their replacement in favor of another jockey who generates better biological data when riding the same horse. Moreover, it could be used negatively in contract negotiations, with poor betting trends potentially devaluing a jockey's worth and inhibiting their earning potential,

[4] The term 'betting trends' in this sense refers to the number of bets placed on a given horse to win a race. The poorer the trend, the less likely people think that a horse is going to win a race.
[5] An additional point that could be made here relates to the potential for such sensors to provide inaccurate or false data readings, providing a false indication of the strengths and weaknesses of a jockey. Again, this could be highly detrimental to a jockey career, as it could either undermine their levels of performance or over inflate it, both of which could negatively impact their further.

something already witnessed in the National Basketball Association in the USA in the form of tracking technology (Socolow 2015).

In addition to the varying ways in which the data could be used and interpreted, this technology also raises concerns relating to fairness. For example, if a betting company receives the data first, which presumably it would in order to generate betting odds; then it could be argued that betting companies have inside knowledge as to how a horse may perform through receiving sensor data earlier than betters. This may allow for odds-manipulation to take place in the favor of the betting company, reducing the chances of a gambler making a successful bet outcome. In turn promoting a distrust of betting companies, which may discourage gamblers from placing further bets with them in the future.

There are also side effects that could impact sport beyond betting practices, which although not a central focus on this paper, are worthy of discussion. An interesting example of the potential impact biological data use could have can be demonstrated in relation to breeding practices. One use of the data collected from the sensors would be to refine current selective breeding programmes, in order to improve the quality of racehorses. As to obtain the perfect race horse (fast, strong, and light), breeding practices have focused solely on developing muscle concentrations, which has resulted in many horses having light and brittle bones (Clark 2001). The consequence of this being that horses become more prone to fractures and breaks, which leads to further suffering for the animal. An example of such was seen in 2006, where the US Kentucky Derby

winner, Narbaro, broke three bones in his hind legs due to weaknesses, and after a series of failed surgeries had to be euthanized (Clark 2011). Yet many horses do not even make it this far, as many foals are often identified as not having the ideal racing properties, which either results in them being aborted or sent to a slaughterhouse in some countries (Barnett 2006; Torres and Chen 2012). The use of technologies such as biosensors and nanobiosensors could further exacerbate this issue, as due to their sensing capabilities, selective breeding programmes could become far more effective, allowing for only those horses that present with superior biological attributes to make the cut.

This point may be counterbalanced by recognition that biosensors can act as an early detection device in order to limit a horses potential health risks. Of course, it could be argued conversely that the application and use of these sensors could potentially be used to put greater strain on a horse as they seek to maximise equine performance potential. This is because nanobiosensors could be used more precisely to inform jockeys, trainers and owners of when a horse is running comfortably, or when it is pushing hard and reaching its physiological limits. Again, one can argue that their presence may thus de-skill the jockey and promote system-technological domination over human capabilities (Loland 2002).

Like all elite sports, horse racing is results-based. The better a horse is, and the more it wins, the greater the fame and financial return for the stakeholders involved. It would therefore seem logical that stakeholders may encourage the animal to run to its physical limits more often, even if uncomfortable when

doing so. This could result in a greater risk to a horse's welfare, particularly in relation to over exertion. Hence, the use of nanobiosensors could encourage jockeys, trainers and owners to take more risks when considering a horse's welfare; using the data gained from the sensor as almost an 'energy bar' much like in a computer game, enabling horses to be pushed harder for longer in order to promote their chances of success both in and out of competition. This adds another dimension to the already challenging issue of animal welfare in the sport.

2. ***Increased Risk of Corruption***

Corruption is an ethical issue deeply intertwined in sports betting. The European Gaming and Betting Association (n.d.) state that unregulated betting, corrupt in nature, is far higher than the regulated market, particularly in Asia, where Interpol have determined the unregulated betting market is worth over $500 billion per annum, and worldwide figures looking closer to $1 trillion. There are many reasons for this problem, but technological progression has been cited as one of the prominent causes, allowing for greater levels of event manipulation (i.e. bet fixing) and addiction than ever before (EGBA n.d.).

The potential use of biosensors and future nanobiosensors may exacerbate such corruption, through promoting new opportunities for unregulated betting to take place, along with potential event manipulation (bet fixing) (EGBA n.d.). For example, the connection between the sensors and Wi-Fi network has

the clear potential to be hacked - also known as a 'man-in-the-middle' attack (Serrano and Dreiling 2012; Evans et.al 2016). This is when hackers create fake access points, enabling race data to be intercepted, not only from the sensors, but also from betting apps, which could result in event manipulation (or bet fixing) or information being sold to opponents in order to allow for unregulated bets to take place (Serrano and Dreiling 2012; Evans et.al 2016). Furthermore, there is also the potential for owners, trainers and jockeys to influence the sensors with the aim of manipulating results themselves. For example, they could feed the horse a sugar cube capsule to spike glucose levels as a method of fixing in-running bets (Evans et.al 2016). Or they could replace the sensor with a rogue version that transmits data to corrupt sources, allowing opportunities to manipulate results before they get to the spectator. Furthermore, the use of such sensors could also generate new opportunities for blackmail and extortion, as if people are able to learn of a potential breeding defect via a horse's biological data for example, it could in turn be used to blackmail breeders in order for them to maintain their reputations; resulting in significant damage to their livelihood. It is clear that the sensors are not in themselves unethical, but rather that they can be put to unethical uses in order to undermine the sports integrity in a number of ways.

3. *Counter Productive to the Spirit of Betting*

A further concern relating to the potential integration of nanobiosensors to horse race betting relates to that of counter-productivity. The reason why many choose to bet, as stated earlier, is because it is an exciting and

exhilarating practice, combining luck and informed judgment with the hope of beating the odds and winning big. Yet the integration of these sensors may actually counter-purpose, by promoting technological determinism; resulting in gambling becoming more formulaic, and potentially less exciting. The increased data offered by the use of such a data, along with the effective use of algorithms could result in betting becoming more predictable. The consequences of this increased predictability are various and contingent on a number of factors concerning the access to, and integrity of the data as we have discussed. It may give rise to negative impacts on gamblers by deterring or diminishing their betting activity, since the enjoyment of traditional betting is a complex amalgam of factors including; luck; planning, accessing information; analyzing form and its variability under different track conditions; and pitting one's knowledge and judgment against the odds to determine the eventual outcome or placing's. Once a bet is placed there is still a range of experiences for the gambler; waiting nervously for the start; imagining the tactics and form of other horse-jockey combinations; experiencing the highs of a win and the lows of a loss, then using this very experience to place another, and going through the motions all over again.

Technology such as nanobiosensors could therefore detract from this experience; reducing the element of luck during a bet due to increasing the amount of data that could be made available to a spectators – which in turn could vastly increase the odds of winning if the gambler is able to read the data to enable greater accuracy and control (MacKenzie and Wajcman 1999). This would therefore become counter productive to the purpose of betting and

what makes it exciting; that of intuition and luck, further promoting a form of technological determinism, which removes the fun and excitement of betting with technological control (MacKenzie and Wajcman 1999).

Potential Solutions to the Ethical Issues Presented By Using Nanobiosensors in Horse Racing

It is clear that the potential use of biosensors and future nanobiosensors offers a mixed bag of benefits and disbenefits for horse racing. Yet despite this, if planned carefully, and an open ethical dialogue of the theoretical pitfalls presented by this technology are discussed, it could be possible to integrate such sensor technology successfully into the sport. For this to take place, horse racing bodies such as *The British Horse Racing Authority* and the *Jockey Club* must look to anticipate their use for betting, and consider regulatory frameworks for their controlled and ethical use. To do this, it should be flexible enough to protect all from potential foul play and corruption (Evans et.al 2016). This could be based on existing horse race betting regulatory frameworks, and those already in place in other sports such a football, for example the UEFA (2015) Financial Fair Play framework, and accompanying betting fraud detection system policies. Potential modification of existing frameworks, policies, and codes of conduct such as this could help to ensure that these sensors are integrated in an ethically justifiable manner[6]. Until this is established, existing means of regulation could be adapted to govern this technology, such as the Data Protection Act in Gambling, which regulates the

[6] A potential indicative route that could be taken in order to underpin such a regulatory framework is to apply a weak version of the Precautionary Principle, as this is already playing a role in the regulation of existing nanotechnologies used in other fields of study (Schomberg 2012).

use of the information, third party use, consent and compliance, to ensure as fair as possible use of the data collected (Gambling Commission 2011).

It is also essential for thorough development of security systems to be implemented, as the biological data will be transmitted across a wireless network, and stored on central hard drives. This opens up the possibility of data theft, creating the need for an effective protection network to be developed to ensure the confidentiality of this data and preventative anti corruption measures (Evans et.al 2016)[7]. In addition, the handling of such technology could be implemented and managed by independent third party companies, who could also be used as outside adjudicators in order to apply, monitor, and ensure the correct implementation of biosensor and future nanobiosensors in order to deter their potential misuse, along with any other subsequent threats to the sports integrity. Moreover, a third party such as this could also monitor the stadium Wi-Fi signal and betting shops' use of this data to reduce the chances of hacking or corruption.

Conclusion

Sports betting is a large and lucrative industry. It is a constitutive element of the family of institutions that orbit the practices of sport. It generates vast revenue streams for a range of sports all over the world. It is also the mainstay of a sporting practice such as horseracing and has been for centuries. The development and integration of new technologies and online betting platforms

that have ensured that betting remains innovative but also continued support the very practices of sports, helping to increase spectator numbers, club profitability (via sponsorship) and betting revenues alike. This is a point clearly evidenced by sports such as football. This evolution has left other sports such as horse racing behind, relying as it does on more traditional forms of betting, which has in turn impacted the sports betting revenue streams in recent years.

Recent efforts by the horse racing industry to evolve and innovate using technologies such as Wi-Fi and GPS are to an extent an antidote to diminishing interest and financial returns. They have begun to draw more spectators and gamblers to the sport, by making betting more immersive. The introduction of biosensors and future nanobiosensors to collect biological data is an attractive option. It brings additional potential benefits such as new forms of in-running betting, greater spectator numbers and support combating animal welfare issues; all of which could potentially boost horse racing betting revenue streams.

Before the potential benefits of this technology can be exploited, however, the disbenefits must also be raised and discussed in an open manner, ensuring that the views of stakeholders have all been considered before fully integrating this technology into the sport. Once this discussion has begun in earnest, we recommend that the sports regulatory bodies look to develop a flexible and

[7] This could be based on wireless sensor security network solutions created by those such as TinySec, LSec, LISA and MiniSec, all of which have been developed to offer data protection and encryption services for wireless sensor technology for additional protection (Dender 2014)

robust governance framework, to ensure its safe and ethical application to horse racing.

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