Sport Science Relevance and Integration in Horseracing: Perceptions of UK Racehorse Trainers.

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Abstract

Whilst equestrian sport science research has expanded over recent years, and technologies to positively impact training and performance have been developed, long-standing traditions and experiential learning in the racing industry still appear to impede the integration of sport science knowledge. This study used semi-structured interviews to investigate the perceptions of eleven national hunt and flat-based racehorse trainers to determine the current status of sport science integration within the racing industry, the perceived barriers to its uptake, and areas where trainers sought further knowledge. Three key higher order themes emerged from the interviews: the current training and monitoring principles for health and fitness of racehorses, trainers' attitudes toward sport science research, and areas for potential future research and integration of sports science in training. Subjective methods grounded in personal experience were found to form the basis of racehorse training principles, with the application of sport science minimal, namely due to poor integration strategies. Negative connotations arising from a general lack of understanding of the application of knowledge and a scepticism toward adapting already successful principles, as well as pressure from industry stakeholders, appear to create barriers to sport science uptake. Trainers felt a stronger evidence base emphasising performance benefits is needed to overcome these. Where trainers identified areas of research potential, many studies had already been undertaken, highlighting the necessity for effective dissemination strategies to demonstrate how research could apply to industry practice. Increased educational initiatives to showcase technology and improve trainer understanding and application of currently available sport science knowledge is also warranted.

Keywords: performance analysis, training, monitoring, technology, equestrian

Introduction

Equine sport science research has expanded in recent years, with our understanding of the mechanical attributes of the musculoskeletal system of the horse, and the biological and pathological systems that create equine 'athleticism', far better than ever before (Back and Clayton, 2013). There is however, a general concern that transfer of information from scientists to industry professionals is poor (Balague et al, 2016; McGreevy and Mclean, 2007). One of the main reasons thought to prevent the widespread application of knowledge is the restriction of many research studies to laboratory settings, due to cumbersome equipment, difficulties with standardizing field based tests and lack of reliability of some technologies (Vermeulen and Evans, 2006; Williams, 2013), making some data and techniques inaccurate in applied field environments (Foreman, 2017). More recently the introduction of wearable technologies and lightweight, simple-to-use monitoring systems has led to more clinically applicable research being undertaken, however equestrianism's long standing reliance on anecdotal knowledge, experience and tradition (Ely et al, 2010) may create barriers to the successful uptake of sport science. Traditional learning practices are particularly prevalent in racehorse training (O'Brien, 2017), despite substantial funding from the Horserace Betting Levy Board to improve training methods through scientific research (Marr, 2011). To ensure new knowledge of horse health, training and performance is integrated into industry practices, work is needed to establish racehorse trainers perceived barriers to sport science uptake.

Application and Integration of Sport Science in Human Sport

Within human sport, the identification of barriers between sport scientists, coaches and athletes has helped to develop techniques to facilitate dissemination of new science knowledge (Martindale and Nash, 2013; Reade et al, w 2008; Williams and Kendall, 2007). Coaches are the primary target for integration of new information due to their highly involved role in the management and training of the athletes, and it has been proposed they should be sufficiently knowledgeable about the scientific aspects of the sport in which they train (Blundell, 1984), as well as adopt the questioning approach of scientists to further their skills (Draper, 1987). Coaches however, prefer to gain knowledge through that which has been tried and tested in the field as opposed to a controlled study (Williams, 2007), and would elect to educate themselves further by attending competitions or speaking to colleagues (Gould et al, 1990). This leads to concern over a pyramid style of knowledge transfer, with less experienced coaches getting information from their more experienced high level peers, leading to a potential opportunity to exhaust personalised information sources (Irwin, 2004).

One of the main barriers to the successful dissemination of science into human sport is that coaches feel research scientists do not contribute information to the areas where it is desired (Reade et al, 2008). This suggests more needs to be done to improve coach-scientist communication. William and Kendall (2007) highlighted that coaches placed significant importance on a successful collaboration when seeking new information. This working relationship is also important due to the potential negative consequences of coaches or athletes applying sport science research without guidance or adequate understanding of the information (Elliot, 1997). Ineffective application may lead to further scepticism over the value of sport science use (Martindale and Nash, 2013), therefore the research scientist must hold responsibility for ensuring barriers to the transfer of knowledge into a practical setting are addressed (Elliot, 1997). For example, by increasing the sport science content of coaching programmes, there is an opportunity to allow sport scientists to interact with and learn from those in the sport which they are working, as well as giving the coach an opportunity to understand the potential benefits of having another source of knowledge with which to work (Goldsmith, 2000).

Sport Science as a Tool in Equestrianism

For generations the management of athletic horses has been based on tradition (Hodgson et al, 2014; O'Brien, 2017; Williams, 2013), with an absence of ethology and learning theory despite evidence of its incorporation into horse training accelerating success and reducing horse wastage (McGreevy and Mclean, 2007). Pressure from the public toward horse welfare, and the financial interest at stake in elite equestrian sport, suggests evidence-based approaches will become more prominent in the coming years, however uptake is still slow (van Weeren, 2017; Williams, 2013). The first major innovation in equine sport science was the development of the high-speed treadmill (Erickson, 2006), which allowed the study of horses working up to their maximum speed in controlled conditions. Many equine scientists questioned how comparable these studies could be to a field setting, and doubted the use of the treadmill-generated data in everyday exercise (Fredericson et al, 1983). In fact, Barrey et al (1993) showed that horses working overland had greater heart rate and blood lactate responses than those working at the same speed on a treadmill. It was the development of portable heart rate monitors (Evans and Rose, 1986), GPS systems (Kingston et al, 2006), lactate analysers (Grosenbaugh et al, 1998) and gas analysis masks (Art et al, 2006) that allowed investigations to move back into the field setting, generating sport science knowledge that was more acceptable to a wider audience of equestrian trainers (Foreman, 2017). Interestingly barriers to application of equine sport science are of a greater extent than just the concerns around the generated data. In a summary of his experience of sport science in the equestrian world, a leading equestrian veterinary surgeon commented that "*just talking about science makes people go cold*" (Naylor, 2009). Hodgson et al (2014) suggests that the problem lies in a communication gap between both research scientists and industry professionals, and that a lack of understanding of each others needs is preventing both the transfer of knowledge from human sport science experience and the practical application of equine science into the field. Several researchers have highlighted and addressed this issue in the human sports field (Bishop et al, 2006; Bishop, 2008; Burke, 1980; Eisenmann, 2017; Finch, 2011), stating that if practitioners are to effectively implement evidence-based methods they must first be able to understand and negotiate with the "*all-knowing*" disposition of a sports coach.

Horse racing is a global industry, where economic success is implicitly associated with superior racehorse performance. The focus on success is analogous to drivers in the elite human sport environment where the uptake of sports science and performance analysis techniques have been successfully integrated into mainstream practice. Yet despite the potential benefits, the racing industry has not been an early adopter of sports science within equestrianism. Therefore, this study aimed to assess the current status of sport science application in the equestrian discipline of horse racing, to determine any perceived barriers to successful integration and investigate what areas of research trainers would endorse.

Methods

Participants

A convenience sampling approach was used with participants recruited via the first author's personal contacts and supported by snowball sampling (Browne, 2005) and cold emailing and calling (Sadler et al, 2010). A total of 178 racehorse trainers were contacted by telephone and email through recommendation by initial recruits and random selection from the British Horseracing Authority's website. The response rate was 14%, with 6% of the respondents agreeing to participate in the study. This is lower than previous research evaluating coaches perception of sport science, which achieved response rates of 54% (Reade et al, 2008) and 48% (Martindale and Nash, 2013) respectively. The high dropout rate may be due to trainers busy daily schedule (Miller, 2010), with anecdotal responses suggesting they were willing to take part in the study but felt they did not have the time. Participants were recruited using the following criteria: (1) hold a training licence themselves or be employed as an assistant to a licenced trainer, (2) have been in the [training] role for a minimum of 3 years, and (3) be in charge of, or assist with, the training of a minimum of 10 thoroughbred racehorses engaging in either national hunt or flat racing in the UK. A survey (Supplementary File 1) prior to interviewing revealed participants age, gender, average number of years in their role, number of horses in their yard, training discipline and number of group or graded wins[1] (Figure 1).

Figure 1. Demographic profile of the participants in the study. A) gender, B) age, C) years in role, D) number of horses in training, E) discipline, F) number of group/graded winners[1].

Interview Procedure

Face-to-face and telephone semi-structured interviews were selected for both theoretical and practical reasons. Racehorse trainers and assistants can be compared to elite athletes and coaches who are deemed difficult to study due to their busy schedules and travel demands (Keegan et al, 2014). Additionally, trainers are similar to other equestrian athletes who rely on owners to fund and provide the horses, and competition for owners is high and often associated with the individuals persona and their training system (Williams, 2013). It is therefore common for trainers to be reluctant to engage in research where their professional practices are discussed. The use of snowball sampling allowed recommendation of the authors credibility between participants and helped to instil trust and encourage full openness and confidence in their answers (Browne, 2005). Due to the time constraints of trainers lifestyles a choice between face-to-face and telephone interviewing was offered, with 54% of interviews taking place over the telephone and 46% of participants undertaking face-to-face interviews. Once the participant agreed to the study, a convenient setting was arranged in which to undertake the interview; in all cases these occurred in racehorse trainers office at lunchtime or after their day had finished. This created a relaxed environment, free from their daily distractions, but with enough formality to ensure the best quality responses (Qu and Dumay, 2011).

The semi-structured interview was designed to allow exploration of the participants perceptions and experiences, whilst giving opportunity to elicit true open-ended responses. The interview questions were developed from a theoretical framework into a questioning guide (Supplementary File 2), focusing on three topics drawn from the literature: sport science encounters (Williams and Kendall, 2007), experiences of sport science integration (Martindale and Nash, 2013) and areas of research potential (Reade et al, 2008). The format of the guide provided time for the interviewer to build a rapport with the participant by asking them to discuss their background and basic principles, which enhanced trust and confidence to

[1] Group (flat) and Graded (jump) winners refer to the highest level of racing that are the most valuable in terms of prize money and stature, with horses carrying level weights; in comparison to lower level racing where horses carry an allotted weight based on their ability.

allow the researcher to probe and explore in greater depth throughout the interview (Newton, 2010). Once a brief introduction was given explaining the nature of the study, and confidentiality and anonymity were agreed upon, questions were deployed with additional probes to expand on themes that evolved throughout the course of the interview (Qu and Dumay, 2011). To ensure validity, the primary researcher (HR) conducted all interviews, which were recorded digitally using a Sony voice recorder ICD-PX333 and had a mean duration of 32 minutes and ranged from 19 to 56 minutes.

Data Analysis

The interviews were transcribed *verbatim* and a six-step model of analysis was adapted from Lamperd (2016) to identify meaning from the data collected. The first step involved thoroughly checking and re-reading the transcriptions to ensure familiarity with the data. Then inductive grounded theory analysis was undertaken, which involved line-by-line open coding using tags to represent the interpretation of a participant's response using either their own words or words that represent common concepts from the literature or the industry. Using these emergent codes, a directed content analysis was used to create common themes between the participants, which were organised into three distinct dimensions. Summative content analysis also allowed understanding of the usage of certain words or context throughout the interview (Hsieh and Shannon, 2005). This involved counts of words or alternative terms to explore the frequency of certain content, including the interpretation of the underlying meaning behind the terms, for example positive experiences versus negative experiences. To ensure validity of the coding and category data, three members of the research team then performed an iterative consensus validation. This was followed by the high standard validation technique of referring themes back to the participants (Duffy, 1987), for which there were no discrepancies. These triangulation techniques have been shown to limit researcher bias (Miles and Huberman, 1994), which may have occurred due to the involvement of all authors within the equestrian industry leading to personal beliefs influencing category identification.

Results and Discussion

A total of 9 UK based national hunt and flat racehorse trainers and 2 assistant trainers took part in the study, with a male to female ratio of 8:3 and an age range of 35-64 years (mean±standard deviation (SD): 48 ±10). The average number of years the participants had in their role was 18±11 years and the size of the yard varied greatly from a minimum of 10 horses up to 200 (mean±SD: 81±67 horses). The number of group or graded winners throughout the trainers career showed the participants fairly represented those trainers who have not yet had a group winner through to the high profile trainers with over 300 group wins (mean±SD: 36±92 group winners). The interviews in this study had varying durations (range: 19 - 56 minutes, mean±SD: 35 ±12 minutes), most likely due to differences in trainers' busy schedules and their time availability to discuss concepts in detail (Miller, 2010).

Through analysis of the racehorse trainers perceptions of equine sport science, three higher order themes emerged: 1) Training and Monitoring, 2) Attitudes to Research and 3) Future Research. The first theme discusses current training and monitoring methods applied within the industry, the second looks at the trainers attitudes toward sport science research, and the third considers future research potential and integration. Within these categories further lower order themes are explored.

Theme 1: Training and Monitoring

Discussion of the ways in which sport science is currently used to facilitate racehorse training developed in to the higher order theme of trainers overall daily training and monitoring principles (Figure 2). Three lower order themes emerged from this: overall training principles, methods of performance monitoring, and the current application of sport science in training.

Training

The key training principle highlighted by participants was that the horses they trained must be fit and must be healthy (100%, n=11):
'We aim to get our horses as fit as possible, and have them as healthy as possible. If they're not fit and not healthy they're not going to perform their best for you are they?' (Interviewee 2)

Figure 2. Current training and monitoring principles used by the racehorse trainers interviewed. Themes emerged through open and focused coding techniques of the interview transcripts.

All of the interviewees emphasised the requirement for their horses to be free from illness and injury, as well as fit enough to perform at their best in races. Maximum fitness was not always the intended outcome however, particularly in short distance runners. The mental wellbeing of the horses was also a priority for trainers, with 91% (n=10) expressing that their horses needed 'to be happy' in order to excel in training:
'If they are happy and going forward and they're not jibbing and they're wanting to do their work then its normally a pretty good sign that they're in good shape and they're willing to go and run for you.' (Interviewee 4)
This reflects trainers recognition that racehorse training requires the conditioning of multiple factors to ensure maximal athletic performance (Hodgson et al, 2014). The importance of understanding detail on the aerobic and anaerobic training phases and metabolic demands of fitness to underpin equine performance are well documented (Hiraga and Sugano, 2016; Persson et al, 1983; Stucchi et al, 2017). This is something not explored by the trainers in this study who generally applied a subjective and observational approach to assessment of equine performance rather than utilising objective measures. This approach suggests a potential lack of knowledge regarding exercise physiology perhaps revealing inadequate trainer education in this area or a lack of effective dissemination of research into practice.
Other themes that emerged as important principles for success were a '*simple*' routine (36%, n=4), a desire for trainers to improve themselves (82%, n=9) and an emphasis on ensuring each horse had optimum race selection to give the maximum chance of winning (46%, n=5). Trainers also alluded to the principle that horses must be trained on an individual basis (55%, n=6). Individualisation was not always achievable in practice however, indicating that although trainers perceive implementation of individualised training as advantageous to equine performance, this approach was advocated to create an impression to key stakeholders [owners], as opposed to being a principle they believed would actually enhance performance. This viewpoint could stem from the pressure to ensure their system has the highest standards, due to the need to retain and attract owners that ultimately provide their income (Dashper, 2014). Indeed, the intense competition for owners is not always dependent on trainer performance, with those who act in the best interest of the owner most likely to attract a higher number of client owned horses (Boyle, 2007).

Monitoring

All trainers (100%, n=11) primary method for performance monitoring was via visual observation of their horses during exercise and forming a judgement on horses general wellbeing:

'So everything we do is from the eye and from memory really, it sounds pretty basic but it works, and I think 90% of people in the horse world do the same thing don't they?' (Interviewee 1)

'The thing we use to test how fit they are is our eye. We use a system of two assistants and myself, and a head girl so there are four of us looking at them. But obviously using your eye is subjective.' (Interviewee 6)

Using observation as a single method of performance analysis has been accepted as out-dated in human sports for a number of decades (Franks and Goodman, 1986). Modern technology supports the objective quantification of an athlete's observable behaviour during training, providing the construction of a database that can lead to improvements in training regimes and an increase in performance (Hughes and Franks, 2007). Trainers however, explained their observational monitoring was based upon years of experience and in many cases trial and error learning (82%, n=9). Tradition is considered to govern racehorse-training regimes (Ely et al, 2010; O'Brien, 2017), despite modern techniques such as interval training and tapering being found to improve human and equine performance (Burgomaster at al, 2006; Mujuka et al, 2000; Shearman et al, 2002). The 'art' of racehorse training is thought to prevail over science due to the strong need to understand animal motivation, however without scientific foundations, training principles can become obscured by subjective impressions (Rose and Evans, 1990).

Feedback from stable staff, jockeys and work riders is another subjective source of information on the current fitness and wellbeing of each horse (64%, n=7). The reliability of this verbal feedback requires trust and confidence between the trainer and member of staff:

'I like to make sure all my work riders have enough experience that they will be able to comment on how the horse went, and that they feel the confidence to speak up when they feel the slightest thing that doesn't feel normal.' (Interviewee 11)

This high level of communication and feedback is key within multi-disciplinary human sports teams, who are recruited to manage the performance of a single athlete, and a breakdown in the team dynamic can have significant negative effects on the athletes progression (Reid and Thorne, 2004). Some trainers voiced an active disregard of staff feedback as a way of monitoring horse performance if they had doubts over their team members capabilities (36%, n=4), reducing the level of monitoring each horse could potentially receive. Horse racing in the UK is currently suffering a staffing crisis (The Racing Foundation, 2016), therefore education and coaching support from trainers or peers could assist staff in developing rider 'feel', which could both enhance verbal feedback as performance monitoring tool (Lagarde et al, 2005) and aid staff retention in the wider industry.

Trainers consider monitoring a horses progression in training as a necessity for the purpose of performance prediction and health, however occasionally it is thought of as a requirement to provide more detailed feedback to satisfy the horse's owner (46%, n=5). Once again this highlights the influence owners hold over the trainers role. Across elite equestrian sport, horses are seen as commodities, with the reflected glory a primary attraction for owner involvement often creating competing agendas between trainers and owners (Edwards and Corte, 2010). In some instances this may jeopardise horse welfare, for example where an owner may demand a horse take part in a race where the ground conditions are unsuitable; (Dashper, 2014), however with regard to an increase of performance monitoring, it can only be viewed as in the best interests of the horse's health and well-being (Williams, 2013).

Use of Science

Participants utilised varying levels of sport science and technology in their training regimes. Aspects of sport science were often discussed as part of a training regime, however interestingly without self-recognition that what was being described would be defined as data, or evidence based practices (73%, n=8). For example, seven participants referred to weighing horses as a method to monitor training, yet only two identified that this was data collection of any form:

'We weigh everything before and after their races, so you get an idea of what their best racing weight is', and from the same participant: *'We measure nothing…I don't know, sometimes you can have too much information' (Interviewee 4)*

This highlights trainers' aversion to the thought of using data in their training, as specific questioning on their use of data resulted in a dismissive response, as opposed to general discussion of performance monitoring where the use of data collection becomes apparent. Scientific language fostered negative connotations to the participants, a perspective common across equestrianism due to the stereotype that science is incompatible with feel, truth and the relational complexity that exists between horse and rider (Thompson and Haigh, 2018). Challenging these beliefs through the use of language that presents an alternative view, such as "*science does not have all the answers, but research suggests….*" (Schwarz et al, 2016), may facilitate language desensitisation to allow trainers to proactively embrace their use of sport science in training (Osborne, 2010).

Heart rate monitors were used by 46% (n=5) of the participants, in contrast to previous studies suggesting the absence of their application in the field (Kingston et al, 2006), although the remaining six trainers had experienced negative encounters with their use. Coinciding with this, 82% (n=9) of participants had used blood testing either routinely or as part of a diagnosis into poor performance, but seven of these participants reported a negative experience and would be discouraged to blood test again in the future:

'I spent a fortune on blood testing and I thought it was just a complete and utter waste of money, no one could tell me what was wrong, and a lot of your bloods come back alright and the horses they just couldn't get out their own way.' (Interviewee 5)

Negative experience of sport science application occurs generally due to a lack of understanding, ineffective application of science or theoretical knowledge to a practical setting or due to user frustrations with the unreliability of technology (Martindale and Nash, 2013). For example, accredited equestrian coaches rated negative reinforcement as an unhelpful form of learning theory despite being unable to correctly explain its use in training horses (Warren-Smith and McGreevy, 2008). Similarly, Olympic coaches negatively rated academics and researchers who imposed time-consuming tests that they perceived had no specific relevance to their sport (Partington and Orlick, 1987). There is a requirement for sport scientists to understand the needs of the individual racehorse trainers and the sport of horse racing as a whole when integrating new principles to facilitate the uptake of science into practice (Pain and Harwood, 2004).

Theme 2: Attitudes to Research

Participants expressed their thoughts towards equine sport science throughout the interviews, shown in Figure 3 as the higher order theme of attitudes to research. Three lower order themes emerged from this: trainers underlying interest, their perception of sport science integration, and barriers they felt restricted them to engaging further with sport science.

Figure 3. Racehorse trainers attitudes towards equine sport science and research. Themes emerged through open and focused coding techniques of the interview transcripts.

Interest

The majority of trainers (82%, n=9) demonstrated a level of interest toward sport science and research throughout their interview. This was centred upon learning how sport science could help them to get ahead and find what every elite performer pursues, the '*winning edge'* (Ludlam et al, 2016):

'We're all trying to improve and get better, like I said everyone can get a horse fit nowadays, so you've got do to everything extra that you can to get ahead.' (Interviewee 9)

In contrast, there were also many dismissive and doubting thoughts toward the usefulness of science and research (64%, n=7):

'Well if I was being polite I would say yeah very interested but if it was the truth I would say I don't have the time and not really you know... I just can't see myself turning to a piece of paper with numbers on telling me how that's going to make them win better.' (Interviewee 5)

The division of opinion creates a dichotomy between trainers' disinterested attitude toward sport science and their interest to seek a performance advantage. A similar contradiction was previously noted in football, where long-standing negative connotations prevented the integration of sport psychology despite coaches recognition of its demand (Pain and Harwood, 2004). Training courses in youth academies were established by the Football Association, to introduce the concepts and benefits of sport psychology early as part of their development process. This led to better understanding of what the field of psychology constitutes, increasing its acceptance and resulting in a positive impact on some aspects of performance such as strategy and mental familiarisation (Nesti, 2010; Pain and Harwood, 2004). The racing industry could learn from this example, by introducing the performance enhancing aspect of sport science into the compulsory trainer modules taken prior to gaining a training licence. Such an arrangement may stimulate interest at an earlier stage, and allow acceptance of sport science without the need for any direct intervention (Pain and Harwood, 2004).

Perception

Participants agreed that sport science has a place in the future of the racing industry (100%, n=11), however many trainers showed scepticism towards the ability to integrate science into their training (82%, n=9), primarily due to their apprehension with regard to adapting principles with which they have already had success:

'We've had 37 jump winners this season, which is more than anybody in the XXXX of England, and because of that I'm not likely to change too much too quickly.' (Interviewee 10)

'We have been building up our yard and getting better horses and good owners and we've been having some good winners so you just think well why change what we do if it's going well you know?' (Interviewee 11)

To gain the performance advantage trainers desire, they must overcome the apprehension to adapting their training regimes regardless of current strengths and successes (Ludlam et al, 2016). Working more closely with sport scientists could aid this process (Martindale and Nash, 2013), as their scientific understanding would help to see the areas in which an already successful system could use smaller more achievable goals to increase overall performance (Hughes and Bartlett, 2002). This concept is well recognised throughout elite sport as the aggregation of marginal gains (Hall et al, 2012), and has been demonstrated most prominently in Team GB cyclists, who are now dominant within their discipline (Slater, 2018). Trainers may be more accommodating of this method to maximise performance due to the reduction in scope for error and failure (British Cycling, 2018), something that likely underlines their opposition to change because of high pressure from owners to achieve results (Dashper, 2014).

Barriers

Many trainers (64%, n=7) felt that sport science equipment was too complicated, leading to confusion and an inability to produce beneficial data:
'I have a lot of trouble with heart rate monitors on the horses getting good connections. Obviously because you've got hair, getting a good contact was always really really difficult, I don't know they've advanced. But you'd get the thing all up and running, you'd start your piece of work and then the damn thing would stop. So from that point of view I struggled.' (Interviewee 7).

In a recent review of commercially available technologies in sport, only 10% were found to have been developed for and used in research (Peake, 2018). Companies producing these products rarely consulted consumers to assess real-world need, resulting in their reduced effectiveness due to the extra time required to set up and interpret the data produced. As with new technologies in equine sport science, collaboration between research and industry would be advisable for future product development (Baron et al, 2017), to ensure reliability and validity as well as a focus on ensuring user-ability is addressed for all parties' needs.

Trainers justified their unwillingness to utilise sport science as an aid due to time constraints throughout their daily routine (55%, n=6), financial implications (82%, n=9) and their own traditional beliefs (82%, n=9):
'We were just finding we were wasting time faffing around with the monitors and the data we actually got back wasn't that useful or that consistent either to be honest. The way we train now is from years and years of experience, it beats a five minute study every time.' (Interviewee 2)
'If you're going to have to fork out a thousand pounds a time for a load of heart monitors to gallop them in the mornings then are you going to put them to my boss who says 'I've been watching these things for the last forty years and I've done alright, so I'm alright without them.''' (Interviewee 4)

Where participants mention time and money as a restriction for using sport science, it is likely that they believe the benefits of sport science are not worth the investment required (Reade et al, 2008). Racehorse trainers rely on private funding from owners for which there is fierce competition (Daspher, 2014), and increasing training fees could be influential in the decision for owners to support a yard (Peacock, 2016). Bishop (2008) suggests that for successful uptake of research outcomes into a sporting setting, evidence must be provided to show that the innovation is more effective than current practice, and is worthy of investment despite limited time and resources. It is therefore important for equine sport science researchers to continuing focusing on studies that provide strong evidence from a clinically applicable field setting (Foreman, 2017).

Some trainers also felt that their owners didn't have 'expensive' enough horses to warrant the use of sport science, or were concerned their owners would lose confidence in them for trialling new concepts (46%, n=5). This once again highlights the strong influence owners have over the trainers role, resembling other equestrian disciplines where owners possess the majority of control as opposed to it being a two-way dynamic relationship (Daspher, 2014). For this reason, it is worth considering the involvement and education of owners in the future integration of sport science in racing.

Theme 3: Future Research

When discussing the future use of equine sport science in racing, two lower order themes of integration of sport science principles and areas of research potential became evident (Figure 4).

Integration

Trainers indicated sales representatives were their main source of new information (82%, n=9), however this was considered a negative experience due to the lack of credible evidence given when presenting products or information:
'We would get approached an awful lot being the stable we are, and the amount of horses we have, so we then sort of sift through it a bit and try and take the good stuff and leave the bad stuff behind if that makes sense? Obviously not all these things are going to work, and not all these things are viable economically, you know? There's a lot of people selling stuff they don't know a huge amount about so you have to sort of make sure you're going to the right person who knows what's going on and who knows the science behind it.' (Interviewee 4)
Sales representatives are commonly negatively perceived as having little or no specialised scientific qualifications (Tian et al, 2009), and their capability to stretch the truth or lie about what they are selling (Roman, 2005).

Figure 4. Future research integration and areas of research potential highlighted by racehorse trainers. Themes emerged through open and focused coding techniques of the interview transcripts.

The use of sales as a primary method for sport science integration into the racing industry could be detrimental to the endeavours of equine research scientists who aim to successfully apply high quality evidence-based research (van Weeren, 2017).
Information from veterinary professionals (55%, n=6) and from a British Horseracing Authority issued magazine (55%, n=6) were also highlighted as methods from which trainers would seek new knowledge, however 'word of mouth' with other trainers and industry professionals was the preferred source for knowledge exchange (64%, n=7). Trainers required an established evidence base (82%, n=9), with proof of a performance enhancement to validate new ideas. This proof was often most reliable for a trainer when their higher profile colleagues had success with the implementation of a new principle or technology, as opposed to from the results of a scientific study. Similar approaches are reported in coaches in human sports, for example Gilbert and Trudel (2001) demonstrate ice hockey coaches would rather implement a new team strategy that had been tested by a respected peer than one developed from education programmes. Coaches generally prefer new information to be sourced from other coaches, even those based in universities with easy access to sport science and academic programmes (Reade et al, 2008). This coach-to-coach transfer system is concerning as it could lead to existing practice being reproduced at the expense of innovation and critical analysis (Cushion et al, 2003), particularly in racehorse trainers where the need to gain a competitive advantage, which could reduce knowledge transfer, is crucial to success.
The age of this cohort varied between 35 and 64 years of age. Around half of the trainers (55%, n=6) felt that sport science integration was better targeted toward younger trainers, due to their greater familiarity with technology as well as having less years in the role to be influenced too highly by experience.
'If you look at the trainers table, there are now a young brigade of trainers coming through, they're the ones that need to be approached, they might be a bit more susceptible because

they're younger and although they've got their principles they're still able to change you know' (Interviewee 1)

The racing industry is renowned for its experiential learning and pyramid style of knowledge transfer (Williams, 2013), and therefore to break this cycle, targeting the next generation of trainers who may be more accustomed to using scientifically informed learning and modern technology could prove a successful strategy (Pavulri, 2017). As a greater proportion of 'younger' trainers become represented at the senior level, sport science acceptance and understanding will have improved across the horseracing industry implicitly and without the need for direct intervention (Pain and Harwood, 2004).

Potential

The area most commonly highlighted (82%, n=9) as a subject in which further research is in demand was injury reduction, something trainers felt a lack of control over:

'The thing that bothers me most is horses getting injuries at home. We train them pretty hard, we get very good results but we train the horses quite hard and we get our fair share of injuries on the way. I bought a horse for this year's grand national, I had to scratch him, he's got a stress facture, he's out. I've got another very good horse who has had a run of injuries, he's now got a fractured pastern and he's out. They got those injuries from home. They've not been on a track for months those two, so anything I can do to reduce them breaking down on the way that would be the number one priority for me. If I could, if I knew the answer to that question, I would very happily invest in the facilities to change it and change the way we do things.' (Interviewee 3)

The epidemiology and risk factors for racehorse injuries has been at the forefront of thoroughbred research for the past decade (Stirk, 2017). The British Horseracing Authority has applied results of research studies with great success onto the track, reducing fatality and severe injury rates through changes to the going and fence structure (Allen et al, 2017). The next step is to accumulate data from training yards; to assess what aspects of a horse's regime may lead to injury and how this could be prevented (Allen et al, 2017). It will be pivotal in equine sport science integration to include trainers in this research, to give them confidence that science and research can be used to enhance their training.

Many trainers expressed bringing a horse to fitness after a period of rest was a grey area in their knowledge (64%, n=7):

'The only time I get myself a bit confused, or the main time, is when we should start working them' (Interviewee 1)

'There's a certain amount of guesswork when a horse is coming back; for example I've got a horse that will probably run at the weekend, its his first run back after a while, I'd quite like to know just how fit he is, is he going in there needing the run or is he actually ready to win the race?' (Interviewee 3)

Modern technology has advanced the assessment of the equine athletes fitness, with the use of heart rate monitors, portable chemical analysers and GPS systems taking the guesswork out of traditional observational techniques (Foreman, 2017). Scope exists for increased integration of these systems in racehorse training regimes to provide objective data that could aid trainers in assessing a horse's progress in rehabilitation and return to racing.

An area not proposed by participants explicitly as research potential, but which emerged implicitly from the interviews, was the uncertainty around the length of time required for a horse to recover from the exertions of a race, and how long is needed in between runs:

'One of the biggest things I would say in racing is sometimes it is quite difficult to know where the horses actually are, not so much getting them fit to run, but if they've had a very hard race, knowing that you've got them back to the best again, you'll see it time and time

again on the track people returning them and obviously they think they're fit and well at home and they're giving you all the signs, but when you actually put the gun back to their heads again they haven't fully recovered and that is quite a difficult thing to tell' (Interviewee 7)

A number of treadmill-based studies have explored the lasting effects of high intensity exercise in thoroughbred horses, with findings such as decreased tissue respiration (Gollnick et al, 1989) and a compromised innate immune system (Wong et al, 1992), yet none have characterised the lasting physiological effects of exertion during a race. Regardless, modern fitness monitoring techniques, such as portable blood chemistry analysers to monitor the depleted respiratory capacity of tissues (Foreman, 2017), could again be implemented in training on a more regular basis to allow trainers to recognise more accurately when a horse has recovered from a high intensity race.

Jockey influence on race performance was also frequently emphasised as important (64%, n=7), in particular their physical fitness and mental health. In the last 20 years, horseracing has become a year round sport, seven days a week, and the requirement for jockeys to reach their weight limit on a daily basis presents a large physical and mental challenge (Wilson, 2014). With the majority of focus on preparation of the horse for a race, jockeys often disregard their own needs (Cullen et al, 2015), which leads to adverse health and performance implications (Dolan et al, 2013). This is unprofitable for racehorse trainers, and therefore further research to fully understand the physiological demands of race riding, as well as nutrition and training guidelines, is necessary to assist jockeys in the optimal preparation for their sport.

Future Directions

Participants conveyed an initial sense of disinterest toward the use of sport science in racehorse training, however as scientific concepts and technologies were discussed they became more engaged and open to discussion. This led to all trainers agreeing that equine sport science will have a place in the future of racehorse training, regardless of their own personal opinion:

'I see people using these technologies more and more so I'm sure it will get bigger you know, but not for me personally, but then there are lots of younger lads coming through now who are more interested in that sort of stuff so you never know it will probably be a big part of training in years to come.' (Interviewee 5)

By showing consideration towards new knowledge in their sport, despite their initial dismissal, trainers align themselves with elite athletes in human sport, who consistently show a questioning personality that leads to lifelong learning (MacNamara et al, 2010). This aspect of trainers personality has been extracted primarily due to the prompting nature of the interview, in which explanation of sport science examples gave them the opportunity to recognise the benefits of scientific methods. This could be seen as a limitation in the study, due to the discussion influencing the answers too greatly and leading to inherent bias (Doody and Noonan, 2013), particularly during questions surrounding sport science encounters.

Previous literature has suggested combining interviewing methods is a limitation to the study due to differences in the quality of data collected (Cresswell and Poth, 1998), for example face-to-face interviewing allowing more open discussion of sensitive topics (Fenig and Levav, 1993). Advances in technology have shaped the way research can be carried out, with telephones now being used in everyday life for both brief and longer expressive conversations (Sturges and Hanrahan, 2004). In that case the use of telephones in qualitative data collection becomes transparent. In fact both Sturges and Hanrahan (2004) and Vogl (2013) found no difference in the research outcomes when using both methods for qualitative study, giving no reason to consider this a limitation in this study, particularly where participant recruitment is difficult (Tausig and Freeman, 1988).

The results of this study highlight future research possibilities, with further in-depth interviewing of trainers a next logical step. Longer duration, more in-depth discussions with trainers could provide further insight to how the identified barriers to sport science integration can be overcome, and to develop research questions and study designs that may benefit the industry. Younger trainers in particular could be targeted, as they have been recognised as the group with the most potential for utilising sport science in the next generation of racehorse training, as well as owners, who have consistently been shown to influence trainers' rationale and principles of training.

The outcomes of this study, along with future in-depth work, also give the opportunity to utilise trainers insight to establish and reduce risks to equine welfare arising from racehorse training regimes, as well as integrate into training evidence-supported knowledge from studies into performance and welfare. A recent report by the British Horseracing Authority (2018) accentuates the collective responsibility of the racing industry to continually improve horse welfare due to decreasing public tolerance of risks to racehorse safety. It is therefore imperative to apply the findings of this study to increase integration of evidence-based practices and improvement of equipment and facilities to advance the monitoring of racehorse performance, health and well-being.

Conclusions

Training and monitoring, attitudes to research and future research were the three higher order themes identified by racehorse trainers during semi-structured interviews. It is apparent that training principles and methods to monitor performance are currently centred on subjectivity and experience with an inadequate scientific basis, and can be influenced by owners and staff. The use of sport science in racehorse training is minimal, although where it is used, improved dissemination from sport scientists could increase its relevance to trainers. Negativity towards sport science across the industry, as well as scepticism to embrace change due to owner pressure, create barriers to the uptake of scientific principles in racing; however stronger evidence of performance enhancement could overcome these, and convince trainers sport science is worthy of investment. One strategy could be to target the younger generation of trainers with more experience of technology and data as a way forward. Trainers highlighted gaps in their knowledge where they desired further research, without realising that general improvement of their understanding and application of sport science technologies in training would likely give them the information they require. Further studies incorporating in-depth interviewing with younger trainers and racehorse owners could provide a deeper insight into how barriers to the integration of sport science into the racing industry could be overcome.

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