

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

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### 6 7 **Abstract**

8  
9 Whilst equestrian sport science research has expanded over recent years, and technologies to  
10 positively impact training and performance have been developed, long-standing traditions and  
11 experiential learning in the racing industry still appear to impede the integration of sport  
12 science knowledge. This study used semi-structured interviews to investigate the perceptions  
13 of eleven national hunt and flat-based racehorse trainers to determine the current status of  
14 sport science integration within the racing industry, the perceived barriers to its uptake, and  
15 areas where trainers sought further knowledge. Three key higher order themes emerged from  
16 the interviews: the current training and monitoring principles for health and fitness of  
17 racehorses, trainers' attitudes toward sport science research, and areas for potential future  
18 research and integration of sports science in training. Subjective methods grounded in  
19 personal experience were found to form the basis of racehorse training principles, with the  
20 application of sport science minimal, namely due to poor integration strategies. Negative  
21 connotations arising from a general lack of understanding of the application of knowledge and  
22 a scepticism toward adapting already successful principles, as well as pressure from industry  
23 stakeholders, appear to create barriers to sport science uptake. Trainers felt a stronger  
24 evidence base emphasising performance benefits is needed to overcome these. Where trainers  
25 identified areas of research potential, many studies had already been undertaken, highlighting  
26 the necessity for effective dissemination strategies to demonstrate how research could apply  
27 to industry practice. Increased educational initiatives to showcase technology and improve  
28 trainer understanding and application of currently available sport science knowledge is also  
29 warranted.

30  
31 **Keywords:** performance analysis, training, monitoring, technology, equestrian

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## 34 **Introduction**

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36 Equine sport science research has expanded in recent years, with our understanding of the  
37 mechanical attributes of the musculoskeletal system of the horse, and the biological and  
38 pathological systems that create equine ‘athleticism’, far better than ever before (Back and  
39 Clayton, 2013). There is however, a general concern that transfer of information from  
40 scientists to industry professionals is poor (Balague et al, 2016; McGreevy and Mclean,  
41 2007). One of the main reasons thought to prevent the widespread application of knowledge is  
42 the restriction of many research studies to laboratory settings, due to cumbersome equipment,  
43 difficulties with standardizing field based tests and lack of reliability of some technologies  
44 (Vermeulen and Evans, 2006; Williams, 2013), making some data and techniques inaccurate  
45 in applied field environments (Foreman, 2017). More recently the introduction of wearable  
46 technologies and lightweight, simple-to-use monitoring systems has led to more clinically  
47 applicable research being undertaken, however equestrianism’s long standing reliance on  
48 anecdotal knowledge, experience and tradition (Ely et al, 2010) may create barriers to the  
49 successful uptake of sport science. Traditional learning practices are particularly prevalent in  
50 racehorse training (O’Brien, 2017), despite substantial funding from the Horserace Betting  
51 Levy Board to improve training methods through scientific research (Marr, 2011). To ensure  
52 new knowledge of horse health, training and performance is integrated into industry practices,  
53 work is needed to establish racehorse trainers perceived barriers to sport science uptake.

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### 55 *Application and Integration of Sport Science in Human Sport*

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57 Within human sport, the identification of barriers between sport scientists, coaches and  
58 athletes has helped to develop techniques to facilitate dissemination of new science  
59 knowledge (Martindale and Nash, 2013; Reade et al, w 2008; Williams and Kendall, 2007).  
60 Coaches are the primary target for integration of new information due to their highly involved  
61 role in the management and training of the athletes, and it has been proposed they should be  
62 sufficiently knowledgeable about the scientific aspects of the sport in which they train  
63 (Blundell, 1984), as well as adopt the questioning approach of scientists to further their skills  
64 (Draper, 1987). Coaches however, prefer to gain knowledge through that which has been tried  
65 and tested in the field as opposed to a controlled study (Williams, 2007), and would elect to  
66 educate themselves further by attending competitions or speaking to colleagues (Gould et al,  
67 1990). This leads to concern over a pyramid style of knowledge transfer, with less  
68 experienced coaches getting information from their more experienced high level peers,  
69 leading to a potential opportunity to exhaust personalised information sources (Irwin, 2004).

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

83 understand the potential benefits of having another source of knowledge with which to work  
84 (Goldsmith, 2000).

## 85 *Sport Science as a Tool in Equestrianism*

86 For generations the management of athletic horses has been based on tradition (Hodgson et al,  
87 2014; O'Brien, 2017; Williams, 2013), with an absence of ethology and learning theory  
88 despite evidence of its incorporation into horse training accelerating success and reducing  
89 horse wastage (McGreevy and Mclean, 2007). Pressure from the public toward horse welfare,  
90 and the financial interest at stake in elite equestrian sport, suggests evidence-based  
91 approaches will become more prominent in the coming years, however uptake is still slow  
92 (van Weeren, 2017; Williams, 2013). The first major innovation in equine sport science was  
93 the development of the high-speed treadmill (Erickson, 2006), which allowed the study of  
94 horses working up to their maximum speed in controlled conditions. Many equine scientists  
95 questioned how comparable these studies could be to a field setting, and doubted the use of  
96 the treadmill-generated data in everyday exercise (Fredericson et al, 1983). In fact, Barrey et  
97 al (1993) showed that horses working overland had greater heart rate and blood lactate  
98 responses than those working at the same speed on a treadmill. It was the development of  
99 portable heart rate monitors (Evans and Rose, 1986), GPS systems (Kingston et al, 2006),  
100 lactate analysers (Grosenbaugh et al, 1998) and gas analysis masks (Art et al, 2006) that  
101 allowed investigations to move back into the field setting, generating sport science knowledge  
102 that was more acceptable to a wider audience of equestrian trainers (Foreman, 2017).  
103 Interestingly barriers to application of equine sport science are of a greater extent than just the  
104 concerns around the generated data. In a summary of his experience of sport science in the  
105 equestrian world, a leading equestrian veterinary surgeon commented that “*just talking about*  
106 *science makes people go cold*” (Naylor, 2009). Hodgson et al (2014) suggests that the  
107 problem lies in a communication gap between both research scientists and industry  
108 professionals, and that a lack of understanding of each others needs is preventing both the  
109 transfer of knowledge from human sport science experience and the practical application of  
110 equine science into the field. Several researchers have highlighted and addressed this issue in  
111 the human sports field (Bishop et al, 2006; Bishop, 2008; Burke, 1980; Eisenmann, 2017;  
112 Finch, 2011), stating that if practitioners are to effectively implement evidence-based methods  
113 they must first be able to understand and negotiate with the “*all-knowing*” disposition of a  
114 sports coach.

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

## 124 **Methods**

### 125 *Participants*

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129 A convenience sampling approach was used with participants recruited via the first author's  
130 personal contacts and supported by snowball sampling (Browne, 2005) and cold emailing and

131 calling (Sadler et al, 2010). A total of 178 racehorse trainers were contacted by telephone and  
132 email through recommendation by initial recruits and random selection from the British  
133 Horseracing Authority's website. The response rate was 14%, with 6% of the respondents  
134 agreeing to participate in the study. This is lower than previous research evaluating coaches  
135 perception of sport science, which achieved response rates of 54% (Reade et al, 2008) and  
136 48% (Martindale and Nash, 2013) respectively. The high dropout rate may be due to trainers  
137 busy daily schedule (Miller, 2010), with anecdotal responses suggesting they were willing to  
138 take part in the study but felt they did not have the time. Participants were recruited using the  
139 following criteria: (1) hold a training licence themselves or be employed as an assistant to a  
140 licenced trainer, (2) have been in the [training] role for a minimum of 3 years, and (3) be in  
141 charge of, or assist with, the training of a minimum of 10 thoroughbred racehorses engaging  
142 in either national hunt or flat racing in the UK. A survey (Supplementary File 1) prior to  
143 interviewing revealed participants age, gender, average number of years in their role, number  
144 of horses in their yard, training discipline and number of group or graded wins<sup>1</sup> (Figure 1).  
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146 Figure 1. Demographic profile of the participants in the study. A) gender, B) age, C) years in  
147 role, D) number of horses in training, E) discipline, F) number of group/graded winners<sup>1</sup>.  
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#### 149 *Interview Procedure*

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151 Face-to-face and telephone semi-structured interviews were selected for both theoretical and  
152 practical reasons. Racehorse trainers and assistants can be compared to elite athletes and  
153 coaches who are deemed difficult to study due to their busy schedules and travel demands  
154 (Keegan et al, 2014). Additionally, trainers are similar to other equestrian athletes who rely on  
155 owners to fund and provide the horses, and competition for owners is high and often  
156 associated with the individuals persona and their training system (Williams, 2013). It is  
157 therefore common for trainers to be reluctant to engage in research where their professional  
158 practices are discussed. The use of snowball sampling allowed recommendation of the authors  
159 credibility between participants and helped to instil trust and encourage full openness and  
160 confidence in their answers (Browne, 2005). Due to the time constraints of trainers lifestyles a  
161 choice between face-to-face and telephone interviewing was offered, with 54% of interviews  
162 taking place over the telephone and 46% of participants undertaking face-to-face interviews.  
163 Once the participant agreed to the study, a convenient setting was arranged in which to  
164 undertake the interview; in all cases these occurred in racehorse trainers office at lunchtime or  
165 after their day had finished. This created a relaxed environment, free from their daily  
166 distractions, but with enough formality to ensure the best quality responses (Qu and Dumay,  
167 2011).  
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169 The semi-structured interview was designed to allow exploration of the participants  
170 perceptions and experiences, whilst giving opportunity to elicit true open-ended responses.  
171 The interview questions were developed from a theoretical framework into a questioning  
172 guide (Supplementary File 2), focusing on three topics drawn from the literature: sport  
173 science encounters (Williams and Kendall, 2007), experiences of sport science integration  
174 (Martindale and Nash, 2013) and areas of research potential (Reade et al, 2008). The format  
175 of the guide provided time for the interviewer to build a rapport with the participant by asking  
176 them to discuss their background and basic principles, which enhanced trust and confidence to

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<sup>1</sup> 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.

177 allow the researcher to probe and explore in greater depth throughout the interview (Newton,  
178 2010). Once a brief introduction was given explaining the nature of the study, and  
179 confidentiality and anonymity were agreed upon, questions were deployed with additional  
180 probes to expand on themes that evolved throughout the course of the interview (Qu and  
181 Dumay, 2011). To ensure validity, the primary researcher (HR) conducted all interviews,  
182 which were recorded digitally using a Sony voice recorder ICD-PX333 and had a mean  
183 duration of 32 minutes and ranged from 19 to 56 minutes.

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#### 185 *Data Analysis*

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

206

#### 207 **Results and Discussion**

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

219

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

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227 *Theme 1: Training and Monitoring*

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

233

234 *Training*

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236 The key training principle highlighted by participants was that the horses they trained must be  
237 fit and must be healthy (100%, n=11):

238 *'We aim to get our horses as fit as possible, and have them as healthy as possible. If they're*  
239 *not fit and not healthy they're not going to perform their best for you are they?'* (Interviewee  
240 2)

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

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246 All of the interviewees emphasised the requirement for their horses to be free from illness and  
247 injury, as well as fit enough to perform at their best in races. Maximum fitness was not always  
248 the intended outcome however, particularly in short distance runners. The mental wellbeing of  
249 the horses was also a priority for trainers, with 91% (n=10) expressing that their horses  
250 needed 'to be happy' in order to excel in training:

251 *'If they are happy and going forward and they're not jibbing and they're wanting to do their*  
252 *work then its normally a pretty good sign that they're in good shape and they're willing to go*  
253 *and run for you.'* (Interviewee 4)

254 This reflects trainers recognition that racehorse training requires the conditioning of multiple  
255 factors to ensure maximal athletic performance (Hodgson et al, 2014). The importance of  
256 understanding detail on the aerobic and anaerobic training phases and metabolic demands of  
257 fitness to underpin equine performance are well documented (Hiraga and Sugano, 2016;  
258 Persson et al, 1983; Stucchi et al, 2017). This is something not explored by the trainers in this  
259 study who generally applied a subjective and observational approach to assessment of equine  
260 performance rather than utilising objective measures. This approach suggests a potential lack  
261 of knowledge regarding exercise physiology perhaps revealing inadequate trainer education in  
262 this area or a lack of effective dissemination of research into practice.

263 Other themes that emerged as important principles for success were a 'simple' routine (36%,  
264 n=4), a desire for trainers to improve themselves (82%, n=9) and an emphasis on ensuring  
265 each horse had optimum race selection to give the maximum chance of winning (46%, n=5).  
266 Trainers also alluded to the principle that horses must be trained on an individual basis (55%,  
267 n=6). Individualisation was not always achievable in practice however, indicating that  
268 although trainers perceive implementation of individualised training as advantageous to  
269 equine performance, this approach was advocated to create an impression to key stakeholders  
270 [owners], as opposed to being a principle they believed would actually enhance performance.  
271 This viewpoint could stem from the pressure to ensure their system has the highest standards,  
272 due to the need to retain and attract owners that ultimately provide their income (Dashper,  
273 2014). Indeed, the intense competition for owners is not always dependent on trainer  
274 performance, with those who act in the best interest of the owner most likely to attract a  
275 higher number of client owned horses (Boyle, 2007).

276

277 *Monitoring*

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

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

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

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

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

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

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

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

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## *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.



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

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### 380 *Interest*

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

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

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

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

393 The division of opinion creates a dichotomy between trainers' disinterested attitude toward  
394 sport science and their interest to seek a performance advantage. A similar contradiction was  
395 previously noted in football, where long-standing negative connotations prevented the  
396 integration of sport psychology despite coaches recognition of its demand (Pain and  
397 Harwood, 2004). Training courses in youth academies were established by the Football  
398 Association, to introduce the concepts and benefits of sport psychology early as part of their  
399 development process. This led to better understanding of what the field of psychology  
400 constitutes, increasing its acceptance and resulting in a positive impact on some aspects of  
401 performance such as strategy and mental familiarisation (Nesti, 2010; Pain and Harwood,  
402 2004). The racing industry could learn from this example, by introducing the performance  
403 enhancing aspect of sport science into the compulsory trainer modules taken prior to gaining a  
404 training licence. Such an arrangement may stimulate interest at an earlier stage, and allow  
405 acceptance of sport science without the need for any direct intervention (Pain and Harwood,  
406 2004).

407

### 408 *Perception*

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

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

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

419 To gain the performance advantage trainers desire, they must overcome the apprehension to  
420 adapting their training regimes regardless of current strengths and successes (Ludlam et al,  
421 2016). Working more closely with sport scientists could aid this process (Martindale and  
422 Nash, 2013), as their scientific understanding would help to see the areas in which an already  
423 successful system could use smaller more achievable goals to increase overall performance  
424 (Hughes and Bartlett, 2002). This concept is well recognised throughout elite sport as the  
425 aggregation of marginal gains (Hall et al, 2012), and has been demonstrated most prominently  
426 in Team GB cyclists, who are now dominant within their discipline (Slater, 2018). Trainers

427 may be more accommodating of this method to maximise performance due to the reduction in  
428 scope for error and failure (British Cycling, 2018), something that likely underlines their  
429 opposition to change because of high pressure from owners to achieve results (Dashper,  
430 2014).

431  
432 *Barriers*

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434 Many trainers (64%, n=7) felt that sport science equipment was too complicated, leading to  
435 confusion and an inability to produce beneficial data:

436 *'I have a lot of trouble with heart rate monitors on the horses getting good connections.*  
437 *Obviously because you've got hair, getting a good contact was always really really difficult, I*  
438 *don't know they've advanced. But you'd get the thing all up and running, you'd start your*  
439 *piece of work and then the damn thing would stop. So from that point of view I struggled.'*  
440 *(Interviewee 7).*

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

448 Trainers justified their unwillingness to utilise sport science as an aid due to time constraints  
449 throughout their daily routine (55%, n=6), financial implications (82%, n=9) and their own  
450 traditional beliefs (82%, n=9):

451 *'We were just finding we were wasting time faffing around with the monitors and the data we*  
452 *actually got back wasn't that useful or that consistent either to be honest. The way we train*  
453 *now is from years and years of experience, it beats a five minute study every time.'*  
454 *(Interviewee 2)*

455 *'If you're going to have to fork out a thousand pounds a time for a load of heart monitors to*  
456 *gallop them in the mornings then are you going to put them to my boss who says 'I've been*  
457 *watching these things for the last forty years and I've done alright, so I'm alright without*  
458 *them.''' (Interviewee 4)*

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

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

476

477 *Theme 3: Future Research*

478

479 When discussing the future use of equine sport science in racing, two lower order themes of  
480 integration of sport science principles and areas of research potential became evident (Figure  
481 4).

482

483 *Integration*

484

485 Trainers indicated sales representatives were their main source of new information (82%,  
486 n=9), however this was considered a negative experience due to the lack of credible evidence  
487 given when presenting products or information:

488 *'We would get approached an awful lot being the stable we are, and the amount of horses we*  
489 *have, so we then sort of sift through it a bit and try and take the good stuff and leave the bad*  
490 *stuff behind if that makes sense? Obviously not all these things are going to work, and not all*  
491 *these things are viable economically, you know? There's a lot of people selling stuff they*  
492 *don't know a huge amount about so you have to sort of make sure you're going to the right*  
493 *person who knows what's going on and who knows the science behind it.'* (Interviewee 4)

494 Sales representatives are commonly negatively perceived as having little or no specialised  
495 scientific qualifications (Tian et al, 2009), and their capability to stretch the truth or lie about  
496 what they are selling (Roman, 2005).

497

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

501

502 The use of sales as a primary method for sport science integration into the racing industry  
503 could be detrimental to the endeavours of equine research scientists who aim to successfully  
504 apply high quality evidence-based research (van Weeren, 2017).

505 Information from veterinary professionals (55%, n=6) and from a British Horseracing  
506 Authority issued magazine (55%, n=6) were also highlighted as methods from which trainers  
507 would seek new knowledge, however 'word of mouth' with other trainers and industry  
508 professionals was the preferred source for knowledge exchange (64%, n=7). Trainers required  
509 an established evidence base (82%, n=9), with proof of a performance enhancement to  
510 validate new ideas. This proof was often most reliable for a trainer when their higher profile  
511 colleagues had success with the implementation of a new principle or technology, as opposed  
512 to from the results of a scientific study. Similar approaches are reported in coaches in human  
513 sports, for example Gilbert and Trudel (2001) demonstrate ice hockey coaches would rather  
514 implement a new team strategy that had been tested by a respected peer than one developed  
515 from education programmes. Coaches generally prefer new information to be sourced from  
516 other coaches, even those based in universities with easy access to sport science and academic  
517 programmes (Reade et al, 2008). This coach-to-coach transfer system is concerning as it  
518 could lead to existing practice being reproduced at the expense of innovation and critical  
519 analysis (Cushion et al, 2003), particularly in racehorse trainers where the need to gain a  
520 competitive advantage, which could reduce knowledge transfer, is crucial to success.

521 The age of this cohort varied between 35 and 64 years of age. Around half of the trainers  
522 (55%, n=6) felt that sport science integration was better targeted toward younger trainers, due  
523 to their greater familiarity with technology as well as having less years in the role to be  
524 influenced too highly by experience.

525 *'If you look at the trainers table, there are now a young brigade of trainers coming through,*  
526 *they're the ones that need to be approached, they might be a bit more susceptible because*

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

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

536  
537 *Potential*

538  
539 The area most commonly highlighted (82%, n=9) as a subject in which further research is in  
540 demand was injury reduction, something trainers felt a lack of control over:

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

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

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

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

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

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

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

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

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

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

588 Jockey influence on race performance was also frequently emphasised as important (64%,  
589 n=7), in particular their physical fitness and mental health. In the last 20 years, horseracing  
590 has become a year round sport, seven days a week, and the requirement for jockeys to reach  
591 their weight limit on a daily basis presents a large physical and mental challenge (Wilson,  
592 2014). With the majority of focus on preparation of the horse for a race, jockeys often  
593 disregard their own needs (Cullen et al, 2015), which leads to adverse health and performance  
594 implications (Dolan et al, 2013). This is unprofitable for racehorse trainers, and therefore  
595 further research to fully understand the physiological demands of race riding, as well as  
596 nutrition and training guidelines, is necessary to assist jockeys in the optimal preparation for  
597 their sport.

598

## 599 **Future Directions**

600

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

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

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

618 Previous literature has suggested combining interviewing methods is a limitation to the study  
619 due to differences in the quality of data collected (Cresswell and Poth, 1998), for example  
620 face-to-face interviewing allowing more open discussion of sensitive topics (Fenig and Levav,  
621 1993). Advances in technology have shaped the way research can be carried out, with  
622 telephones now being used in everyday life for both brief and longer expressive conversations  
623 (Sturges and Hanrahan, 2004). In that case the use of telephones in qualitative data collection  
624 becomes transparent. In fact both Sturges and Hanrahan (2004) and Vogl (2013) found no  
625 difference in the research outcomes when using both methods for qualitative study, giving no

626 reason to consider this a limitation in this study, particularly where participant recruitment is  
627 difficult (Tausig and Freeman, 1988).

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

636 The outcomes of this study, along with future in-depth work, also give the opportunity to  
637 utilise trainers' insight to establish and reduce risks to equine welfare arising from racehorse  
638 training regimes, as well as integrate into training evidence-supported knowledge from  
639 studies into performance and welfare. A recent report by the British Horseracing Authority  
640 (2018) accentuates the collective responsibility of the racing industry to continually improve  
641 horse welfare due to decreasing public tolerance of risks to racehorse safety. It is therefore  
642 imperative to apply the findings of this study to increase integration of evidence-based  
643 practices and improvement of equipment and facilities to advance the monitoring of racehorse  
644 performance, health and well-being.

645

## 646 **Conclusions**

647

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

664

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666

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