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Faults in International Showjumping are not random

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ABSTRACT

Performance analysis (PA) involves the systematic observation and analysis of factors identified to enhance performance to improve athlete decision-making in a specific sport. PA is commonplace in human sports, yet despite potential advantages, its application remains limited in equestrianism. This study aimed to evaluate if factors anecdotally associated with performance in elite showjumping influenced competitive success. 250 combinations attempting 3052 jumping-efforts across 2nd round European FEI Nations Cup 2017 competition were analysed. Types of fault (e.g. pole down, refusal etc) were recorded as well as characteristics of the jump (e.g. jump type, approach angle). Combinations jumped clear at the majority of attempts (93.6 %; n=2857) with faults only occurring at 6.4% of jumps (n=195). The most common faults were: knock-downs (5.5 %); time penalties (0.8 %); faults at water jumps (0.3 %); refusal (0.2 %). Faults were distributed across all fence types, however were more common at upright fences (49 %) and within combination fences (41 %). A linear relationship was found between jumping-effort number and number of fences knocked-down ($r = 0.7$; $P < 0.001$). There were 2.8 times more knock-downs for the second half of the course (efforts 9 - 15) compared with jumping-efforts 1 - 7 ($P < 0.05$). Faults were 4 times more likely at jumping-efforts 3, 4, 5 and 8 in the first half of the course ($P < 0.03$) which increased to being 9 times more likely in the 2nd half of the courses (jumping-efforts 9, 10, 11, 12, 13 and 14; $P < 0.006$). A straight approach to a jumping-effort reduced the chance of faults by 48 % ($P < 0.0001$) compared to a non-straight approach. These preliminary results suggest faults are not randomly distributed in elite showjumping and that patterns exist within fault accumulation demonstrating that the application of PA techniques in equestrian sport could lead to a performance advantage.

Keywords: Jumping; Horses; Equestrian; FEI; Competition; fault

30 INTRODUCTION

31 Performance analysis is an essential tool that systematically evaluates factors identified to enhance
32 performance to provide accurate, effective and objective feedback, which can then inform athlete
33 decision-making with the aim of increasing future competitive success (Nicholls et al., 2018; Nelson
34 and Groom, 2012). To be successful, performance analysis usually occurs within a defined context
35 and is used synergistically with the athlete, their coach and performance analyst using the
36 information gained to inform skill development, design training regimes and competition strategies
37 aligned to periodization and performance targets (McGarry, 2009). Once a defined goal is set, the
38 performance analyst will aim to describe, explain and predict the athlete's performance by
39 identifying associations between sport-specific behaviours (actions) and outcomes (key performance
40 indicators or goals), whilst considering the influence of extrinsic variables, such as other competitors
41 and the environment, to develop performance improvement strategies (McGarry, 2009; Williams,
42 2013).

43 Performance analysis can be used within training to assess athlete progress or within competition
44 environments to reflect on the success of competition strategies and to analyse specific aspects of
45 athlete performance (Williams, 2013). Traditionally, human sports feedback involved subjective
46 observations based predominately on an athlete's coaches' perceptions and experiences (Maslovat
47 and Franks, 2015). Unfortunately, the success of using subjective observations to inform training and
48 competition strategy development is reliant on the ability of the athlete's or coach's memory recall,
49 which is reported at best to be ~50 % (Nicholls and Warsfold, 2016; Laird and Waters, 2008). How
50 athletes can access feedback is changing through the advent of technology and the increased
51 implementation of performance analysis techniques enabling coaches and the athletes themselves
52 to review and analyse multiple facets of an individual or team. The effectiveness of applied
53 performance analysis has been documented in football and rugby. Within these area, studies have
54 demonstrated the use of a performance analyst and coach combination, using video analysis
55 techniques aided athlete recall, encouraged self-critique, expedited unemotional reflection on their
56 performance and improved player confidence as well as changing athlete behaviour (Groom and
57 Cushion, 2004; Francis and Jones, 2014). Performance analysis should therefore be considered a
58 fundamental tool to facilitate athlete learning and development, and competitive success.

59 Despite the widespread uptake of performance analysis across human sports, its application within
60 equestrianism is still in its infancy (Williams, 2013; Randle and Loy, 2019). The welfare of the horse is
61 becoming an ever more important focus across all horse sports (Waran and Casey, 2005) leading to
62 increased calls for the application of evidence-based practice. Performance analysis techniques can
63 provide an approach that encourages professionals to use the best evidence possible when making
64 decisions about the methods, treatments and actions employed to achieve their performance goals
65 whilst concurrently safe guarding the welfare of the equine athlete (Waran and Randle, 2013).
66 However equine performance analysis traditionally focuses on subjective assessment of
67 performance through observation or 'feel' (Williams, 2013; Ely et al., 2010), concepts that are
68 subject to individual perception, bias and rely on memory recall rather than being evidence based.
69 Analysing performance in equestrianism is also complex, requiring focus on the individual
70 performance characteristics in the horse (influenced by the rider), the rider (which can be influenced
71 by the horse), the horse and rider as a partnership, and the 'performance' as a holistic entity
72 (Williams, 2015). This is complicated further by the reliance on self-analysis required as many
73 equestrian partnerships train in relative isolation compared to equivalent partnerships in human
74 sport. Parallels could be drawn with this complexity to the dynamics which exists in team sports in
75 the human field, where performance analysis techniques have proved successful (Groom and

76 Cushion, 2004; Francis and Jones, 2014). Scope therefore exists to apply performance analysis
 77 techniques across equestrian sport to gather objective data that will add to the developing evidence
 78 base to enable riders, trainers and coaches to make informed decisions when implementing training
 79 regimes and competition tactics to enhance equine performance and welfare.

80 Showjumping is the most popular equestrian sport amongst the Fédération Equestre Internationale
 81 (FEI) disciplines (FEI, 2017; Gorecka-Bruzda et al. 2013). Yet despite this, little research
 82 contextualised to performance analysis for the sport exists (Williams, 2013; Murphy et al. 2009). The
 83 key aim of the equestrian discipline is for horse and rider combinations to complete a course of
 84 jumping obstacles within a defined time or in the fastest time without scoring any penalties (faults).
 85 A successful elite showjumping horse needs to have superior physical abilities to be able to jump and
 86 clear successfully various fence types of heights up to 1.60 m and widths of 2.00 m for oxers (a fence
 87 with 2 - 3 rails or poles that may be set at the same or different heights), 2.20 m for triple bars and
 88 up to 4.50 m for water jumps (FEI, 2017). Elite horses also need to possess a suitable temperament
 89 to facilitate 'rideability' (Visser et al., 2003) and sufficient fitness to meet the physiological demands
 90 to successfully complete the competition itself (Williams, 2015). Tactics are a central component of
 91 success in sport (Rein and Memmert, 2016) including showjumping with riders determining the
 92 speed and approach their horse takes to fences. Therefore, implementing an effective competition
 93 strategy in the ring is essential to enable optimal performance (Williams, 2013; Sampaio and Macas
 94 2012).

95 Accruing faults is a key negative performance indicator in showjumping. It is commonly believed by
 96 showjumping riders and trainers that faults do not occur by chance, but are associated with
 97 particular types or location of fences. This study aimed to use notational analysis, a performance
 98 analysis technique designed to assess competition strategies (Duthie et al., 2003), to characterise
 99 faults as defined by the FEI (knocking down a fence pole/rail/plank, displacing an obstacle, a foot
 100 landing in a water jump, refusal or "run-out"). The hypothesis was that faults at elite level
 101 showjumping are not random.

102

103 **MATERIALS & METHODS**

104 All rounds of horse and rider combinations competing in the Second Round of the FEI Nations Cup¹
 105 2017 competition in European Division 1 at ten different outdoor events were reviewed (see Table
 106 1). The competitions were publicly available on Sky Sports HD and each competition was recorded
 107 using a Sky Box. The competitions took place between May and August. Five competitions took place
 108 on grass and three on artificial surfaces. All competitions were held outdoors. All competitions
 109 consisted of 15 fences with the exception of St Gallen (n = 14 fences) and La Baule and Lummen (n =
 110 16 fences), and also comprised a double and a treble (n = 8 competitions), two doubles (n = 1) or
 111 three doubles (n = 1).

112 Table 1. Competitions in the 2017 FEI Nations Cup European Division 1 and competitions from which
 113 data was obtained.

Venue	Country	Date	Division	Level
Lummen	Belgium	26-30 Apr 2017	Europe 1	5*
La Baule	France	11-14 May 2017	Europe 1	5*

¹ Further information regarding the FEI Nations cup series is available at: <https://inside.fei.org/fei/events/fei-nations-cup-series/jumping>

Rome	Italy	24-29 May 2017	Europe 1	5*
St Gallen	Switzerland	1-4 Jun 2017	Europe 1	5*
Rotterdam	Holland	22-25 Jun 2017	Europe 1	5*
Falsterbo	Sweden	13-16 Jul 2017	Europe 1	5*
Hickstead	Great Britain	27-30 Jul 2017	Europe 1	5*
Dublin	Ireland	9-13 Aug 2017	Europe 1	5*
Sopot	Poland	8-11 Jun 2017	Europe 1	5*
Gijon	Spain	30-04 Sep 2017	Europe 1	5*

114

115 Notational analysis is an inexpensive and accessible method of providing insight into the technical
 116 demands of sport activities, by recording and quantifying athlete movement patterns that
 117 characterize skilled performance in relation to performance goals (Duthie et al., 2003). This
 118 technique was applied to assess if relationships existed between fence type, approach and direction
 119 with faults. Fences were classified from video recordings by jumping effort (jump number,
 120 incremental including the individual elements of combination fences), jump type (upright, oxer,
 121 Liverpool [oxer with water underneath], water, triple bar, gate, upright-planks, upright-wall; single,
 122 double, triple), approach line (straight approach [4 or more strides after a turn or following on from
 123 a previous fence], left-rein [more than 45° from previous fence], slight-left [less than 45°], right-rein
 124 [more than 45° from, [previous fence], slight-right [less than 45° from previous fence]) and direction
 125 (in relation to the collecting-ring: away; towards; across). Faults/penalties were recorded as: pole
 126 knocked down; refusal; error of course; foot in water. Total faults and the distribution of faults for
 127 every quarter of the course were calculated. The completion time and any time penalties incurred
 128 over the optimum course time were also recorded for each horse and rider combination.

129

130 Data analysis

131 Frequency analysis identified patterns in fault accumulation and fence number, type, horse and rider
 132 approach to the fence and the location of the fence on the course. Chi squared goodness of fit
 133 analyses identified if there was a difference between the expected and observed frequency of faults
 134 across the Nation Cup competitions. Pearson's correlation examined if relationships existed between
 135 fault accrual and fence number sequentially within a jumping round. A series of T-tests and ANOVA
 136 analyses with post-hoc LSD tests, determined if differences occurred between the percentage of
 137 faults accrued and the direction of approach to a fence and the distribution of faults throughout the
 138 course: first vs. second half and between each quarter of the course. Significance was set at $P < 0.05$.

139

140 Logistic regression

141 Fence level and course level variables were analysed through univariate analysis to inform
 142 multivariable model building using the dichotomous variable: faults vs. no faults. Three fence level
 143 variables were included in the final model: jumping effort (incremental), fence type (e.g. upright,
 144 oxer), approach line (redefined as a binary variable: straight vs. not-straight). Two course level
 145 variables were also included: faults in the first vs. second half of the course and time (s) if the
 146 combination finished over the optimum time allocated, if a horse and rider completed the course
 147 within the allocated time they scored 0 s. Factors were considered eligible for inclusion in the final
 148 multivariate model if the level of significance found during univariate regression was $P < 0.1$ or if the

149 removal of the factor had a significant impact on the model ($P < 0.05$) (Williams et al., 2013a). All
 150 models were refined through a backward stepwise process with variables retained if Likelihood ratio
 151 P-values were < 0.05 (Williams et al., 2013a). At each step of model building Omnibus tests identified
 152 if factors had a significant effect on the model fit and should be retained ($P < 0.05$) (Pallant, 2010).
 153 Model fit was assessed using the Hosmer-Lemeshow goodness of fit test ($P > 0.05$) (George and
 154 Mallery, 2010). The predictive ability of the model was examined through receiver operating
 155 characteristic (ROC) curve analysis (Reardon et al., 2012). All statistical analyses were conducted
 156 using Statistic Packages for Social Sciences (SPSS) version 21 (Chicago, IL, USA).

157

158 **RESULTS**

159 A total of 250 horse and rider combinations attempting 3052 jumping efforts were analysed. Courses
 160 contained on average 15 jumping efforts (JE) and field size ranged between 18 and 23 combinations.
 161 The most common fence types were: Upright (65 efforts, 42.5 %); Oxer (58 efforts, 37.9 %); Water
 162 (10 efforts, 6.5 %); Liverpool (9 efforts, 5.9 %); Triple-bar (6 efforts, 3.9 %); Planks (3 efforts, 2.0 %);
 163 Gate (2 efforts, 1.3 %). None of the competitions analysed included a wall jump. Combinations were
 164 clear at the majority of JE (93.6%; $n=2857$) with faults only occurring at 6.4% ($n=195$) of the JE
 165 reviewed.

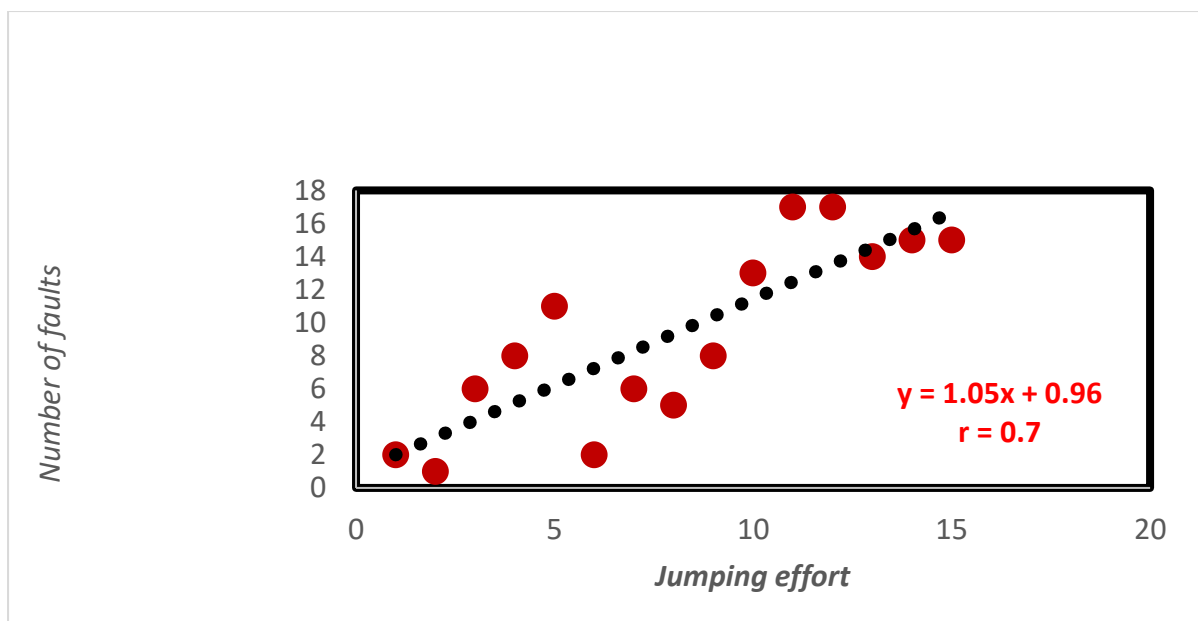
166 Nineteen countries were represented, with Holland having the highest number of horse and rider
 167 combinations ($n=30$), followed by Ireland ($n = 28$) and France ($n = 26$). Team selection resulted in
 168 some horse and rider combinations jumping at multiple venues, but across all competitions only 1
 169 horse and rider combination retired and 4 combinations were eliminated. The average time allowed
 170 was $78.9 \pm 3.5s$ (range 75-84s). Of the 250 horse and rider combinations that completed the course,
 171 81 % ($n = 202$) were inside the time limit, whilst 19 % ($n = 48$) were outside the time limit for the
 172 course.

173 *Fault type*

174 The most common faults were: knock-downs (5.5 %); time penalties (0.8 %); fault at a water jump
 175 (0.3 %); refusal/run out (0.2 %). Faults were distributed across fence types, however interestingly
 176 faults occurred more commonly at upright fences (49 %) and at jumping efforts that were part of a
 177 combination fence (41%).

178 *Fault location on the course*

179 A linear relationship was found between jumping-effort number and number of fences knocked-
 180 down ($r = 0.7$; $P = 0.001$) (Figure 1). There were 2.8 times more knock-downs for the second half of
 181 the course (efforts 9-15) compared with jumping efforts 1-7 ($P < 0.05$). Distribution of faults also
 182 varied significantly between the four quarters of the course ($P = 0.0001$). Post hoc analyses identified
 183 the number of faults increased sequentially between the 1st ($n = 13$, mean faults = 4) and 3rd ($n =$
 184 53, mean faults = 6, $P = 0.03$) and 1st and 4th quarters ($n = 83$, mean faults = 7, $P = 0.0001$), as well as
 185 between the 2nd ($n = 43$, mean faults = 5) and 4th quarters ($P = 0.0001$), and the 3rd and 4th
 186 quarters ($P = 0.03$).



187

188 *Figure 1: Linear increase in risk with increasing number of efforts - 70% of variance observed is due to*
 189 *jumping effort number*

190

191 *Fence approach*

192 Faults were more common (percentage of attempts) when fences were jumped straight-on (7.9%)
 193 on a left or right rein (>45° from previous fence; 3.8%; $P < 0.001$) but were similar to either at a slight
 194 right or slight left approach (<45° from previous fence; 6.2%).

195

196 *Logistic regression*

197 Combinations which completed their round above the optimum time were 1.1 times more likely to
 198 have faults for every 0.1 seconds they were over the time ($P < 0.0001$). Faults were also on average 4
 199 times more likely to occur at jumping efforts 3, 4, 5 and 8 in the first half of the course ($P < 0.03$).
 200 The probability of scoring faults then increased to being 9 times more likely in the second half of
 201 courses at jumping efforts 9, 10, 11, 12, 13 and 14 ($P < 0.006$). A straight approach (defined as
 202 straight vs. not straight) to a jumping effort reduced the chance of faults by ($P = 0.0001$) by 48 %
 203 compared to a non-straight approach. Interestingly, although fence type was not significant in the
 204 model ($P > 0.05$), its inclusion did improve model fit. Receiver operating characteristic determined the
 205 model had moderate predictability (ROC: 68%).

206

207 **DISCUSSION**

208 This preliminary performance analysis of elite showjumping suggests that for these competitions,
 209 faults were not randomly distributed. The results also demonstrate that simple notational analysis
 210 techniques have been effective and identified factors which could inform competitive tactics to
 211 reduce the probability of horse and rider combinations gaining faults in Nations Cup competitions.

212

213 ***Influence of the course***

214 Faults increased sequentially though the course with horse and rider combinations more likely to
 215 incur faults in the second half of the courses evaluated. This is in contrast to the anecdotal opinions
 216 of show jumping riders who often reflect that horses are more likely to score faults at the first and
 217 last fences. Interestingly, Harris et al. (2018) reported similar performance patterns across a British
 218 Equestrian Federation (BEF) World Class Performance three-day training session when evaluating
 219 horse's showjumping performance. They found horses' recorded higher mean heart rates, increased
 220 faults and scored lower in coach graded assessment of their jumping technique in the third quarter
 221 of the course. Generally, horses which scored lower for jumping technique recorded a closer take off
 222 position to the fence, which would then require an increased physical effort to create the required
 223 trajectory to clear the fence without incurring faults, contributing to the higher heart rates observed
 224 (Harris et al., 2018). The approach and the position of the horse's centre of gravity and hind limb
 225 placement at take-off determines if the resultant jump is successful or not (Powers and Harrison,
 226 1999, 2002; Walker et al., 2018). However, rider positioning is also influential on a successful jump,
 227 this is proposed to be due to the rider's instruction and resultant effect on the horse's behaviour
 228 during the approach to the fence rather than inertial effect of the rider's position on the horse
 229 (Powers and Harrison, 2002). The positive relationship found between a straight approach and
 230 reduced propensity to incur faults in the multivariable model, supports the importance of good rider
 231 positioning and control during showjumping. The increased faults recorded across the second half of
 232 competitions here, could therefore represent differences in horses' approach and take off stride or
 233 the influence of the rider for fences 9 to 14. To further enhance the application of performance
 234 analysis within showjumping, more detailed notational analysis evaluating horse and rider
 235 positioning and the linear projectile kinematics of individual combinations would be worthwhile.

236 ***Influence of rider tactics***

237 It is the role of the rider within showjumping competitions to dictate the horse's speed, approach to
 238 fences and stride pattern to guide their equine partner to success. Therefore, the sequential
 239 increase in faults observed in Nation Cup competitions could reflect changing tactics in the rider as
 240 the course progresses. Increased falls in jump racing have been associated with increasing speed
 241 (Williams et al., 2013a, b; Pinchbeck et al., 2001). However here, horses which recorded slower
 242 times, that were over the optimum time allowed, were more likely to incur faults, suggesting
 243 average speed is not a contributing factor to scoring more faults. The slower times recorded could
 244 reflect control issues on the course and a lack of 'rideability'. For example, if the horse refused a
 245 fence, had a run out or the rider found it difficult to control the horse on the course, or if it had a
 246 pole which upsets the horse's rhythm, the time taken to complete would likely increase. Hall and
 247 Barlow (2016) investigated if behavioural events influenced jump success in elite showjumpers,
 248 finding that horses which scored faults recorded increased lateral head shake and ears twitched back
 249 behaviours compared to horses that cleared the fence. Whilst these behaviours may be indicative of
 250 pain, they could also be a visual representation of a temporary breakdown in communication
 251 between horse and rider. Therefore, the relationship identified between time and faults could
 252 provide a proxy measure for rideability and suggests this concept may be key to success in elite
 253 showjumping.

254 ***Fence type***

255 We expected fence type to be influential on horse performance, as traditionally riders and coach
 256 have considered that upright or vertical fences can be more difficult to jump successfully.
 257 Interestingly, whilst faults were more common at upright fences and at JE within combinations, and

258 although the inclusion of fence type improved model predictability, fence type was not significantly
259 associated with an increased risk of incurring faults. Walker et al. (2018) reported elite horses, such
260 as those jumping in Nations Cup competitions, adopt consistent jumping kinematics regardless of
261 fence type, which could explain the lack of influence found. The increased percentage of faults that
262 occurred at jumping efforts cited within combination fences, could also reflect rider tactics, where
263 the stride patterning and rhythm of horse and rider combinations is key to successful jumping.
264 However, it should also be noted that performance is multifactorial and the definition of fence types
265 applied here may not have been detailed enough to expose relationships. Fence location and colour
266 have also been associated with jumping performance (Stachurska et al., 2002). Therefore, for future
267 work it would be beneficial to integrate fence location: topography, alone or in combination,
268 situation to course entrance, fence design: ascending, descending or parallel oxer, style: fillers and
269 decoration, and colour into performance analysis.

270 ***Implications for horse welfare***

271 Further research to evaluate the influence of performance analysis techniques on horse welfare
272 across competition seasons is warranted. However these preliminary results demonstrate that the
273 use of performance analysis techniques such as notational analysis can identify patterns within
274 horse and rider performance that could be influential to combinations competitive success. For
275 riders, increasing the understanding of what factors and tactics reduce fault accumulation within
276 individual combinations, can support the development of training and competition strategies to
277 enhance performance and by association potentially reduce the risk of horse falls, injuries associated
278 with poor jumping technique and negative welfare from a breakdown in horse and rider
279 communication, enhancing the welfare of the competition horse.

280 ***Limitations***

281 This study only evaluated one season of the second round of European Nations Cup competition.
282 Further analysis to identify if differences occurred in horse and rider performance and tactics
283 between the first and second rounds, and longitudinal analysis of combinations across multiple elite
284 level competitions would enable more accurate performance analysis that could identify patterns
285 related to courses, riders, horses or specific horse and rider combinations. However, the success of
286 the simple notational analysis used here, provides preliminary evidence that the use of performance
287 analysis techniques could inform training and competition strategies in showjumping.

288

289 **CONCLUSION**

290 Understanding the impact of factors which influence horse and rider performance can inform
291 training and competition strategies. These preliminary results suggest patterns exist within fault
292 accumulation in elite showjumping and that faults are not randomly distributed and that the
293 application of performance analysis techniques in equestrian sport could lead to a performance
294 advantage.

295

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