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1                   **Player-surface interactions: Perception in elite soccer**  
2                   **and rugby players on artificial and natural turf**

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22 **Player-surface interactions: perception in elite soccer**  
23 **and rugby players on artificial and natural turf**

24 **Abstract**

25 Artificial turf (AT) is common at all levels of soccer and rugby. Employing an interdisciplinary  
26 design this study aimed to examine the extent to which the negative attitude commonly  
27 expressed by players concerning AT is based on difference in technique between AT and natural  
28 turf (NT), or due to pre-existing biases. Thirty professional soccer and rugby players performed  
29 a defined set of movements with masked and normal perception conditions on NT and AT.  
30 Two-dimensional kinematic analysis (100 Hz) of characteristics in parallel to a psychological  
31 assessment of the impact of cognitive bias for a playing surface was assessed. No significant  
32 interaction effects between level of perception and surface type were found. For AT, contact  
33 time (CT) was shorter across conditions, while for NT rugby players had longer CT during  
34 acceleration/deceleration phases and shorter flight times. Pre-existing negative bias against AT  
35 was found during the normal perception trials in the technology acceptance model (Usefulness  
36 and Ease of Use) and the general preference questions on how much the athlete would like to  
37 play a game on it. The results suggest that opinion was not driven by surface characteristics,  
38 but by a cognitive bias, players brought with them to the pitch.

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41 *Key words:* perception; biomechanics; psychometrics; football codes; artificial turf  
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## 44 **Introduction**

45 Replacing natural (NT) with artificial turf (AT) provides a durable, flexible and cost effective  
46 option, which can offer usable playing surfaces across the globe. Significant improvements in  
47 the quality of AT from first generation to current third generation (3G) emerged from two  
48 perspectives, firstly, materials including cushioning, different fibre polymers and infills  
49 (Strutzenberger, Potthast, & Irwin, 2018b) and; secondly, player-surface interaction, addressing  
50 injury occurrence (e.g. Ekstrand, Hagglund, & Fuller, 2011; Strutzenberger, Nokes, & Irwin,  
51 2018a; Williams, Akogyrem, & Williams, 2013), physiological fatigue and the biomechanics  
52 of cutting, turning, and kicking (Hughes et al., 2013; Strutzenberger et al., 2018b).

53 Despite the fact that players report a dislike for AT (Johansson & Nilsson, 2007) no differences  
54 have been reported in physiological indices across the two surfaces (i.e., metabolic cost of  
55 running (Sassi et al., 2011)), with only small differences for turning when playing on AT  
56 compared to NT. Research has found that players reported a dissatisfaction with safety aspects  
57 of AT, and while they felt AT was acceptable as a surface this was dependent on past experience  
58 (Burillo, Gallardo, Felipe, & Gallardo, 2014). In light of the limited research to date, further  
59 consideration is warranted regarding player perceptions of performing on different surfaces  
60 (Hughes et al., 2013). This is particularly salient given that previous research with elite players  
61 has reported a negative perception of both physiological and technical aspects of match play on  
62 AT compared to NT (Andersson, Ekblom, & Krstrup, 2008; Zanetti, 2009). Additionally, as  
63 player perception may be influenced by inference, memory, and knowledge representation  
64 (Vickers, 2007), underpinning factors that may contribute to both the real and perceived  
65 differences reported between AT and NT (Johansson & Nilsson, 2007; Potthast, Verhelst,  
66 Hughes, Stone, & De Clercq, 2010; Poulos et al., 2014; Roberts, Osei-Owusu, Harland, Owen,  
67 & Smith, 2014; Ronkainen, Osei-Owusu, Webster, Harland, & Roberts, 2012; Young, 2007)  
68 need to be considered. Player acceptance of the surface is central to turf development and the

69 introduction of AT within and across team-based sports, a desire that has been publicly  
70 communicated by the international governing body of soccer (FIFA, Quality Report). In  
71 addition to soccer, artificial surfaces are also being used at the highest level of rugby union in  
72 both training and competition. Insights from examining perceptions of performers and  
73 contrasting them across the respective codes of football (soccer and rugby union) would be  
74 desirable. The current research aims were to examine professional athletes' movement  
75 characteristics when playing on NT and AT and their perceptions of playing on these surfaces,  
76 while controlling for any bias of opinion. The following hypotheses were proposed: First,  
77 biomechanics of technique during a sport-specific manoeuvre differs between NT and AT,  
78 when players are aware of the surface type. Second, players perceive the playing surface  
79 differently, when they are aware of the surface type and third, perceptions and biomechanics of  
80 technical performance differ across codes of football.

## 81 **Methods**

82 An interdisciplinary cross-sectional design was used to examine the impact of playing surface  
83 type on a defined set of sport-specific movements and the players' perceptions of the turf.  
84 Fifteen elite professional soccer players (age:  $18.4 \pm 1.2$  years, height:  $1.80 \pm 0.04$  m, mass:  
85  $74.7 \pm 5.4$  kg) and 15 elite rugby players (age:  $18.8 \pm 1.1$  years, height:  $1.81 \pm 0.07$  cm, mass:  
86  $94.6 \pm 13.2$  kg) performed a warm-up and familiarisation on a neutral NT surface in both  
87 masked and normal perception condition. Following this, athletes completed four repetitions of  
88 a sport-specific movement task (Figure 1b) on a NT and a third generation (3G) AT surface and  
89 answered a player perceptions questionnaire. Institutional ethics approval of the Cardiff  
90 Metropolitan University, Cardiff School of Sport and Health Sciences Ethics Committee was granted  
91 and informed consent obtained. The movement task comprised a 10 step accelerated run to  
92 maximum velocity, a  $180^\circ$  turn, a 6 step accelerated run followed by a cut (Figure 1b). The task

93 was performed four times each in masked (M) (visual - blindfolds, auditory - ear plugs and  
94 olfactory - nose clips) and normal (N) perception conditions on both NT and AT in randomised  
95 order.

96 ---Inset Figure 1 ---

97 After each test setting, participants were transported to a survey room, where perception was  
98 returned to normal and athletes were asked to complete a questionnaire. When completed,  
99 players were transported to the next surface. During the masked conditions athletes were  
100 transported via a random course to disorient them so they remained unaware of the surface used  
101 for testing. The procedure was repeated for subsequent trials.

102 All data were collected at a national rugby and soccer training centre, the 3G AT pitch used was  
103 a FIFA 2\* quality and a World Rugby Union approved pitch and is used by both codes of sports.

104 A separate soccer and rugby NT was used for data collections, approved for quality by their  
105 respective codes. Prior to each testing session, each surface was measured for hardness with a  
106 Clegg Impact Soil Tester Type CIST/883/Stor/Blu (2.25kg). To exclude very hard (dry) and  
107 very soft (wet) surface conditions due to the weather on individual testing days, testing was  
108 only undertaken when the Clegg Impact Value (CIV) was between 55 – 90 CIV. The soccer  
109 NT hardness ranged between 59.3 - 72.3 (CIV), the rugby NT ranged between 81.1 - 82.7 CIV  
110 and the 3G AT pitch ranged between 80.8 - 85.5 CIV.

111 For the biomechanical data collections the movement task was recorded with two high speed  
112 cameras (2 x acA2000-50gc, Basler AG, 100 Hz, Ahrensburg, Germany) using Templo  
113 software (v. 7.0.292, Contemplas GmbH, Kempten, Germany). Each camera collected data of  
114 10 m (2000 x 480 pixels on each camera) of the initial and final accelerated sprint, turn and cut  
115 (Figure 1c). These tasks were selected to fulfil the requirements a) high relevance for each code  
116 of sport and b) be able to be detected by a 2D-video analysis by being performed in one plane  
117 of action. The set-up of the movement task allowed for the velocity, the step lengths, the contact

118 and flight times and the absolute distance to each step from acceleration task, the distance to  
119 when the turn occurred and the contact time of the cutting foot could be analysed. Data from  
120 seven soccer players had to be excluded from biomechanical analysis, as these participants  
121 moved outside of the desired movement path for 2D-video analysis in masked condition. For  
122 the biomechanical analysis in detail the videos were transferred into Vicon Motus 10.0 (Vicon  
123 Motion System, Inc., Oxford, UK) software for manual digitising. For each foot strike (FS), the  
124 first frame where the foot contacted the ground and for each foot off (FO), the first frame where  
125 the foot has left the ground was defined as foot strike (FS) and foot off (FO) event to identify  
126 contact time [s] (acceleration task and cut), flight time [s], step frequency ( $1 / (\text{contact time} +$   
127  $\text{flight time})$ ) [1/s]) and absolute time between the start and each FS [s]. Additionally, the position  
128 of the toe (identified via the tip of the shoe) as well as the trochanter position (visual assessment)  
129 was digitised, to identify step length (distance the toe marker travelled between FS events) [m],  
130 distance covered with each step until the turn (trochanter position) [m], and velocity at each FS  
131 (distance/time of each FS) [m/s]. For each condition the trial with the fastest velocity at step 5  
132 was used for further analysis. Even though participants were rehearsed to accelerate 10 steps,  
133 not all did in the given set of four testing trials ( $12 \pm 1$  steps (N)  $12 \pm 2$  steps (M)). Therefore, data  
134 for the acceleration phase were calculated until contact 8, as this was the minimum number of  
135 contacts taken by a participant before entering the turn. The parameter for the turn was the  
136 contact phase of the foot that realised the turn to the full  $180^\circ$ .

137 The psychological analysis aimed to identify the player's perceptions of the surface via a multi-  
138 dimensional psychometric instrument, consisting of the four main scales: a) physical effort; b)  
139 manoeuvre perception; c) Technology-Acceptance-Model (TAM) (Davis, 1989); and d)  
140 Pleasure-Arousal-Dominance, PAD (Mehrabian, 1996). The physical effort scale (a) comprised  
141 of a visual-analogue scale (Andersson et al., 2008). Players were asked how hard the trials were  
142 in general, which effort they made during the trials, how hard the trials were physically at that

143 day and how tired they were. The manoeuvre perception items (b) were used to triangulate with  
144 the biomechanics measures. A six item scale interrogated perception of the soccer-specific  
145 movement task via five-point rating scales. Players were asked if the surface hindered  
146 manoeuvres supported their acceleration and deceleration, supported the cutting manoeuvre,  
147 produced good force generation and good grip. The TAM (Davis, 1989) (c) was utilised to  
148 understand the acceptance of AT and NT from a perceived usability perspective. Participants  
149 were asked to rate on a five point scale the perceived 'Usefulness' and 'Ease of Use' of the  
150 surface just performed on. Finally, the PAD (Mehrabian, 1996) scale (d) was used to assess  
151 players' affective responses to the surface, as it measures the underlying dimensions of pleasure  
152 (valence), arousal (anxiety) and dominance (control). Participants were asked to indicate on a  
153 five point scale the extent to which they are experiencing pleasure-displeasure, arousal-  
154 nonarousal and dominance-submissiveness. Additionally, general perception (e) was asked as  
155 a validity check via the two overarching questions: A) if players would 'like to play an  
156 important match on the surface' and B) 'how other players would like to play on it'. Last,  
157 athletes were asked whether they realised the surface type they just performed on including a  
158 confidence rating of this guess (questionnaire; a complete copy of the questionnaire used is  
159 available from the corresponding author). For the psychometric analysis the subscales scores  
160 for each item were identified.

161 Statistics were calculated using SPSS (version 17.0, IBM, Armonk, NY, USA). All variables  
162 met normality via the Kolmogorov-Smirnov test. For the biomechanical data the effect of the  
163 factor code of football (Soccer vs. Rugby – between participants) was identified in a first step  
164 via a three-factorial (Perception (M, N) – within participants) x (Surface (AT, NT) – within  
165 participants) x code of football (Soccer, Rugby) - between participants) multivariate (steps 0 –  
166 8) ANOVA. For parameters showing a difference between codes of football the following  
167 analysis was performed for the participants of each football code separately to overcome the

168 delimitation of using their specific natural turfs, otherwise all participants were pooled together.  
169 As such both, the biomechanical and questionnaire data were subjected to a 2 x 2 ANOVA,  
170 (Perception (M, N)) x Surface (AT, NT) with the dependent measures being the steps  
171 (biomechanics) and the subscale scores (psychology). A Bonferroni correction was used and  
172 statistical significance was set to  $p=0.05$ . Effect sizes were calculated via partial eta squared  
173 ( $\eta_p^2$ ; small  $>0.01$ , medium  $>0.05$ , large  $>0.14$  (Cohen, 1973). For the questionnaire data, to  
174 guard against Type 1 errors arising from multiple comparisons, a doubly-multivariate test was  
175 completed, to include the within-participants factors and all the scale scores. The main effects  
176 and interactions that reached significance in this overall test were then used to guide in-depth  
177 analysis of each sub-scale.

## 178 **Results**

179 With respect to the first hypothesis, biomechanical parameters showing a significant perception  
180 or surface effect are displayed in Figure 2. Masking perception led on both surfaces to a  
181 significantly decreased velocity (by  $0.12 \pm 0.01$  m/s per step, averaged over all steps) in the  
182 acceleration phase, shorter step lengths (by  $8 \pm 10$  cm), absolute distance between start to each  
183 step (by  $18 \pm 18$  cm per step) and absolute distance at which the turn was executed (by  $1.03 \pm$   
184  $0.48$  m). For the cut masking perception lead to a significantly longer contact time (Figure 2).  
185 Comparing AT and NT lead to a significant surface effect only for the flight time, which was  
186 significantly decreased on NT for all participants and step contact times, which were  
187 significantly shorter by  $0.014 \pm 0.004$  s on AT for rugby players only. Interestingly, no analysed  
188 parameter showed an interaction effect between the perception and surface. This indicates that  
189 while the performance was different in masked condition, these differences occurred in equal  
190 values when performing on NT as well as AT.

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---- Figure 2 -----

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With respect to the second hypothesis, analysis of the psychometric data revealed: a) physical effort: Out of the four questions only the item ‘How tired are you at the moment?’ revealed a significant perception effect (Figure 3a); b) manoeuver perception: For the six manoeuver specific questionnaire items, the analysis revealed a significant difference (surface effect) for the single item ‘How well do you think the surface supported you in deceleration?’. Players favoured the NT surface compared to the AT across both perception conditions (Figure 3b); c) TAM: Statistical analysis of the mean scores for ‘Usefulness’ and ‘Ease of Use’ found besides a significant main effect of perception (Usefulness) and surface (Usefulness and Ease of Use) a significant interaction effect between perception x surface for both scales. This suggests that during masked conditions NT and AT were perceived as similarly useful and easy to use, whereas for normal perception conditions athletes perceived the NT as significantly more useful and easy to use than the AT (Figure 3c). d) PAD: Significant perception effects for PAD indicated players found normal perception more pleasurable and enabled better control. Additionally, a significant surface effect occurred only for the pleasure sub-scale, again favouring NT over AT. It has to be noted, that the perception x surface interaction approximated significance level for dominance, ( $p=0.052$ ), suggesting similar result to the TAM scale: When perception was normal athletes reported NT gave better control, but this was not apparent during masked perception (Figure 3d); e) general perception: Statistical analysis of the questions ‘How much would the player like to play an important game on the just used surface?’ and ‘How much does he think another player would like to play an important game on the just used surface?’ found a significant main perception (another player) and surface (himself & another player) effect and a perception x surface interaction for both questions, indicating similar results: While during masked conditions NT and AT were

217 similarly favoured to be played on for an important match, whereas for normal perception  
218 conditions, players showed a significant preference for NT over AT (Figure 3e).  
219 With respect to the third hypothesis, a significant interaction effect between code of football  
220 and surface effect was detected in the TAM scales. While for masked conditions no differences  
221 in the TAM of the surface existed regardless of surface type and code of football, soccer players  
222 rated the AT significantly lower than rugby players when they were aware of the surface type:  
223 Since higher levels of perceived Usefulness and Ease of Use indicate greater technology  
224 acceptance, this suggests rugby union players are more likely to accept the AT than soccer  
225 players and use it out of choice; Forty percent of the athletes realised independently of their  
226 sport the surface they were on, 40% did not realize the surface they just performed on and 20%  
227 were not sure (Figure 3e).

228

229 ----- Figure 3-----

230

## 231 **Discussion and Implications**

232 Employing an interdisciplinary design to address the issue of the introduction of artificial turf  
233 to soccer and rugby this research examined elite athletes' perceptions of, and actual  
234 performance on, a variety of surfaces while perception was both normal and masked.  
235 Specifically, this study examined the perception of performing on AT is based on their  
236 awareness of the surface and how this was influenced by football code.

237 The key finding that emerged from the questionnaire data was that professional soccer players  
238 demonstrated on the investigated surfaces a pre-existing bias in favour of NT compared to AT.  
239 Perception is well known to be influenced by past experience (Duncker, 1939) and knowledge  
240 (Vickers, 2007, 2009). There is substantial literature, that suggests players recall a negative

241 impression of AT; there is a perception of increased injury risk, even though no evidence of an  
242 actual increase in injury rate for AT exists (e.g. Williams et al., 2013). Consequently, NT is  
243 generally preferred (Andersson et al., 2008; Ekstrand, Timpka, & Hagglund, 2006). This would  
244 appear to be driven more by a cognitive bias than actual surface properties.

245 In general, the major observations from the biomechanical assessment found no difference  
246 when performing on natural compared to the artificial surfaces, though there may be possible  
247 intrinsic adaptation processes, such as e.g. leg stiffness alterations, at work (Newell, 1986).  
248 Concurrently, Hughes et al. (2013) found that fatigue and physiological responses to soccer  
249 activity did not differ markedly between these surface types. In the current study, variables  
250 showing a difference between the surfaces were a decrease in initial acceleration phase contact  
251 times (rugby players) and an increased flight time (all athletes) on AT compared to NT (Figure  
252 2).

253 Across both codes of soccer and rugby union, the contact time for the cutting manoeuvre was  
254 significantly shorter on AT. This may be due to a difference in ground reaction forces and the  
255 need to attenuate these when performing on AT (Strutzenberger, Cao, Koussev, Potthast, &  
256 Irwin, 2014). Expectedly, differences when perception was masked (Strutzenberger, Bath, Dill,  
257 Potthast, & Irwin, 2014) in running performance in terms of step length, step velocity and  
258 distance covered were observed. The organismic constraint of masking perception influenced  
259 running characteristics, whilst the influence of surface did not (Newell, 1986).

260 Combining the biomechanical and questionnaire measures the main finding is that overall  
261 performance outcomes remain constant across the investigated surfaces. Since the only apparent  
262 difference by turf for the psychometric data occurred when players were aware of the surface  
263 type, any perceived differences between AT and NT appears to be driven by a pre-existing  
264 negative bias that could be regarded as an attribution bias (Carey, 2009; Fiske & Taylor, 1991).  
265 While the elite soccer players' experiences seem to have resulted in a negative mind-set toward

266 AT, the elite rugby union players were more amenable to the surface and in some cases  
267 preferred this playing medium. This may be explained through the use of AT at the highest  
268 level of the sport in rugby union for both training and competition, whereas in male soccer this  
269 is not the case. Hence, there is a clear need to examine the origins of this soccer bias.

270 Although a central issue seems to be an attitudinal one, another consideration is player  
271 awareness of surface. With 40% of the players stating they were aware of the surface there is a  
272 strong indication that internal or external factors were allowing players to detect the playing  
273 surface. A post-hoc analysis for the TAM and PAD model with the factor Realisation of the  
274 surface indicated, that those who correctly realised the surface favoured the NT compared to  
275 the AT, while those who did not realize the surface type rated both surface types equally.  
276 Surface awareness is a crucial component to this biases in the professional players attitude  
277 towards AT as demonstrated by the fact that the rating between the used AT and NT in masked  
278 condition was similar. As such surface development is still required to address issues not  
279 attributable to this pre-existing bias.

280 The strength of this research rests with the interdisciplinary approach that examines  
281 psychological and biomechanical responses. Both of which will be necessary for future research  
282 to increase the understanding of why these perceptions emerge. Throughout this study a balance  
283 between ecological validity, scientific rigour and logistical considerations had to be found.  
284 Until now, studies such as Burillo et al. (2014) have only asked players their opinion of a named  
285 surface; this method does not allow the removal of player response biases to determine the true  
286 perception of a surface. The nature of this research, with the masked condition requires  
287 consideration when making a direct link to the 'game of soccer/rugby'. Notably the performance  
288 in masked condition was slower than in the normal condition, which may have confounded our  
289 results. A further limitation of this study is the restriction to 2D video analysis and tracking  
290 based on body-landmarks, which only allows for basic data analysis and some differences might

291 remain undetected by this method, hence the effect of surface type on 3D joint kinematics, joint  
292 kinetics, muscle activation and ground contact forces on running as well as on other skills, such  
293 as ball and team playing remains yet to investigate.

294 The direct implication of this research is that elite player perceptions of NT and well  
295 maintained AT, during the manoeuvres and surfaces used in this study, are driven more by  
296 preconceptions than actual differences between the surfaces.

297

## 298 **Conclusion**

299 Based on the biomechanical characteristics of performance and the key psychological variables  
300 associated with technology acceptance it was observed that professional players' perception of  
301 performing on AT was partly based on awareness of the surface and football code. The main  
302 finding of this research was that whilst the overall performance outcomes remain constant  
303 across the used surfaces players come to AT with a pre-existing negative bias; one that does not  
304 employ when they are unaware of the surface type. Knowledge of these issues related to AT  
305 need to be considered when introducing these surfaces to performances in rugby and soccer.

306

## 307 **Practical Implications**

- 308 • Overall performance outcomes remain mainly the same across surfaces.
- 309 • A pre-existing bias exists that influences negative player perception on artificial  
310 surfaces.
- 311 • A football codes marketing and development strategy is recommended to address the  
312 perception bias
- 313 • A more in depth analysis of the effects of artificial turf on joint loading is needed.

314

315

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396 **Figure legends**

397 Figure 1: Schematic overview over the measurement set-up: a) step definition, b) movement  
398 task and c) camera set-up.

399

400 Figure 2... Mean (SD) values for the biomechanical parameters showing significant differences.

401

402 Note: AT=Artificial Turf, NT= Natural Turf, \*P=significant perception effect (post-hoc  
403 analysis), \*S=significant surface effect (post-hoc analysis), p= p-value for main effects  
404 (ANOVA),  $\eta_p^2$ =partial eta of main effect.

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407 Figure 3: Mean (SD) responses for psychological-questionnaire items showing significant  
408 differences

409

410 Note: AT=Artificial Turf, NT= Natural Turf, P=perception effect, S=surface effect,  
411 PxS=interaction effect between perception and surface, TAM: Technology Acceptance Model,  
412 PAD Pleasure-Arousal-Dominance scale, \*= significant difference ( $p \leq 0.05$ ). The 95%  
413 confidence intervals were adjusted for within participants as Cousineau<sup>17</sup>

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