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

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Abstract

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

Key words: perception; biomechanics; psychometrics; football codes; artificial turf

Introduction

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

Despite the fact that players report a dislike for AT (Johannson & Nilsson, 2007) no differences have been reported in physiological indices across the two surfaces (i.e., metabolic cost of running (Sassi et al., 2011)), with only small differences for turning when playing on AT compared to NT. Research has found that players reported a dissatisfaction with safety aspects of AT, and while they felt AT was acceptable as a surface this was dependent on past experience (Burillo, Gallardo, Felipe, & Gallardo, 2014). In light of the limited research to date, further consideration is warranted regarding player perceptions of performing on different surfaces (Hughes et al., 2013). This is particularly salient given that previous research with elite players has reported a negative perception of both physiological and technical aspects of match play on AT compared to NT (Andersson, Ekblom, & Krustrup, 2008; Zanetti, 2009). Additionally, as player perception may be influenced by inference, memory, and knowledge representation (Vickers, 2007), underpinning factors that may contribute to both the real and perceived differences reported between AT and NT (Johannson & Nilsson, 2007; Potthast, Verhelst, Hughes, Stone, & De Clercq, 2010; Poulos et al., 2014; Roberts, Osei-Owusu, Harland, Owen, & Smith, 2014; Ronkainen, Osei-Owusu, Webster, Harland, & Roberts, 2012; Young, 2007) need to be considered. Player acceptance of the surface is central to turf development and the introduction of AT within and across team-based sports, a desire that has been publicly communicated by the international governing body of soccer (FIFA, Quality Report). In addition to soccer, artificial surfaces are also being used at the highest level of rugby union in both training and competition. Insights from examining perceptions of performers and contrasting them across the respective codes of football (soccer and rugby union) would be desirable. The current research aims were to examine professional athletes' movement characteristics when playing on NT and AT and their perceptions of playing on these surfaces, while controlling for any bias of opinion. The following hypotheses were proposed: First, biomechanics of technique during a sport-specific manoeuver differs between NT and AT, when players are aware of the surface type. Second, players perceive the playing surface differently, when they are aware of the surface type and third, perceptions and biomechanics of technical performance differ across codes of football.

Methods

An interdisciplinary cross-sectional design was used to examine the impact of playing surface type on a defined set of sport-specific movements and the players' perceptions of the turf. Fifteen elite professional soccer players (age: 18.4 ± 1.2 years, height: 1.80 ± 0.04 m, mass: 74.7 ± 5.4 kg) and 15 elite rugby players (age: 18.8 ± 1.1 years, height: 1.81 ± 0.07 cm, mass: 94.6 ± 13.2 kg) performed a warm-up and familiarisation on a neutral NT surface in both masked and normal perception condition. Following this, athletes completed four repetitions of a sport-specific movement task (Figure 1b) on a NT and a third generation (3G) AT surface and answered a player perceptions questionnaire. Institutional ethics approval of the Cardiff Metropolitan University, Cardiff School of Sport and Health Sciences Ethics Committee was granted and informed consent obtained. The movement task comprised a 10 step accelerated run to maximum velocity, a 180° turn, a 6 step accelerated run followed by a cut (Figure 1b). The task was performed four times each in masked (M) (visual - blindfolds, auditory - ear plugs and olfactory - nose clips) and normal (N) perception conditions on both NT and AT in randomised order.

---Inset Figure 1 ---

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

All data were collected at a national rugby and soccer training centre, the 3G AT pitch used was a FIFA 2* quality and a World Rugby Union approved pitch and is used by both codes of sports. A separate soccer and rugby NT was used for data collections, approved for quality by their respective codes. Prior to each testing session, each surface was measured for hardness with a Clegg Impact Soil Tester Type CIST/883/Stor/Blu (2.25kg). To exclude very hard (dry) and very soft (wet) surface conditions due to the weather on individual testing days, testing was only undertaken when the Clegg Impact Value (CIV) was between 55 – 90 CIV. The soccer NT hardness ranged between 59.3 - 72.3 (CIV), the rugby NT ranged between 81.1 - 82.7 CIV and the 3G AT pitch ranged between 80.8 - 85.5 CIV.

For the biomechanical data collections the movement task was recorded with two high speed cameras (2 x acA2000-50gc, Basler AG, 100 Hz, Ahrensburg, Germany) using Templo software (v. 7.0.292, Contemplas GmbH, Kempten, Germany). Each camera collected data of 10 m (2000 x 480 pixels on each camera) of the initial and final accelerated sprint, turn and cut (Figure 1c). These tasks were selected to fulfil the requirements a) high relevance for each code of sport and b) be able to be detected by a 2D-video analysis by being performed in one plane of action. The set-up of the movement task allowed for the velocity, the step lengths, the contact and flight times and the absolute distance to each step form acceleration task, the distance to when the turn occurred and the contact time of the cutting foot could be analysed. Data from seven soccer players had to be excluded from biomechanical analysis, as these participants moved outside of the desired movement path for 2D-video analysis in masked condition. For the biomechanical analysis in detail the videos were transferred into Vicon Motus 10.0 (Vicon Motion System, Inc., Oxford, UK) software for manual digitising. For each foot strike (FS), the first frame where the foot contacted the ground and for each foot off (FO), the first frame where the foot has left the ground was defined as foot strike (FS) and foot off (FO) event to identify contact time [s] (acceleration task and cut), flight time [s], step frequency (1/ (contact time + flight time) [1/s]) and absolute time between the start and each FS [s]. Additionally, the position of the toe (identified via the tip of the shoe) as well as the trochanter position (visual assessment) was digitised, to identify step length (distance the toe marker travelled between FS events) [m], distance covered with each step until the turn (trochanter position) [m], and velocity at each FS (distance/time of each FS) [m/s]. For each condition the trial with the fastest velocity at step 5 was used for further analysis. Even though participants were rehearsed to accelerate 10 steps, not all did in the given set of four testing trials (12±1 steps (N) 12±2 steps (M)). Therefore, data for the acceleration phase were calculated until contact 8, as this was the minimum number of contacts taken by a participant before entering the turn. The parameter for the turn was the contact phase of the foot that realised the turn to the full 180°.

The psychological analysis aimed to identify the player's perceptions of the surface via a multi-dimensional psychometric instrument, consisting of the four main scales: a) physical effort; b) manoeuver perception; c) Technology-Acceptance-Model (TAM) (Davis, 1989); and d) Pleasure-Arousal-Dominance, PAD (Mehrabian, 1996). The physical effort scale (a) comprised of a visual-analogue scale (Andersson et al., 2008). Players were asked how hard the trials were in general, which effort they made during the trials, how hard the trials were physically at that day and how tired they were. The manoeuver perception items (b) were used to triangulate with the biomechanics measures. A six item scale interrogated perception of the soccer-specific movement task via five-point rating scales. Players were asked if the surface hindered manoeuvres supported their acceleration and deceleration, supported the cutting manoeuvre, produced good force generation and good grip. The TAM (Davis, 1989) (c) was utilised to understand the acceptance of AT and NT from a perceived usability perspective. Participants were asked to rate on a five point scale the perceived 'Usefulness' and 'Ease of Use' of the surface just performed on. Finally, the PAD (Mehrabian, 1996) scale (d) was used to assess players' affective responses to the surface, as it measures the underlying dimensions of pleasure (valence), arousal (anxiety) and dominance (control). Participants were asked to indicate on a five point scale the extent to which they are experiencing pleasure-displeasure, arousal-nonarousal and dominance-submissiveness. Additionally, general perception (e) was asked as a validity check via the two overarching questions: A) if players would 'like to play an important match on the surface' and B) 'how other players would like to play on it'. Last, athletes were asked whether they realised the surface type they just performed on including a confidence rating of this guess (questionnaire; a complete copy of the questionnaire used is available from the corresponding author). For the psychometric analysis the subscales scores for each item were identified.

Statistics were calculated using SPSS (version 17.0, IBM, Armonk, NY, USA). All variables met normality via the Kolmogorov-Smirnov test. For the biomechanical data the effect of the factor code of football (Soccer vs. Rugby – between participants) was identified in a first step via a three-factorial (Perception (M, N) – within participants) x (Surface (AT, NT) – within participants) x code of football (Soccer, Rugby) - between participants) multivariate (steps 0 – 8) ANOVA. For parameters showing a difference between codes of football the following analysis was performed for the participants of each football code separately to overcome the delimitation of using their specific natural turfs, otherwise all participants were pooled together. As such both, the biomechanical and questionnaire data were subjected to a 2 x 2 ANOVA, (Perception (M, N)) x Surface (AT, NT) with the dependent measures being the steps (biomechanics) and the subscale scores (psychology). A Bonferroni correction was used and statistical significance was set to $p=0.05$. Effect sizes were calculated via partial eta squared (η_p^2; small >0.01, medium >0.05, large >0.14 (Cohen, 1973). For the questionnaire data, to guard against Type 1 errors arising from multiple comparisons, a doubly-multivariate test was completed, to include the within-participants factors and all the scale scores. The main effects and interactions that reached significance in this overall test were then used to guide in-depth analysis of each sub-scale.

Results

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

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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 similarly favoured to be played on for an important match, whereas for normal perception conditions, players showed a significant preference for NT over AT (Figure 3e).

With respect to the third hypothesis, a significant interaction effect between code of football and surface effect was detected in the TAM scales. While for masked conditions no differences in the TAM of the surface existed regardless of surface type and code of football, soccer players rated the AT significantly lower than rugby players when they were aware of the surface type: Since higher levels of perceived Usefulness and Ease of Use indicate greater technology acceptance, this suggests rugby union players are more likely to accept the AT than soccer players and use it out of choice; Forty percent of the athletes realised independently of their sport the surface they were on, 40% did not realize the surface they just performed on and 20% were not sure (Figure 3e).

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Discussion and Implications

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

The key finding that emerged from the questionnaire data was that professional soccer players demonstrated on the investigated surfaces a pre-existing bias in favour of NT compared to AT. Perception is well known to be influenced by past experience (Duncker, 1939) and knowledge (Vickers, 2007, 2009). There is substantial literature, that suggests players recall a negative impression of AT; there is a perception of increased injury risk, even though no evidence of an actual increase in injury rate for AT exists (e.g. Williams et al., 2013). Consequently, NT is generally preferred (Andersson et al., 2008; Ekstrand, Timpka, & Hagglund, 2006). This would appear to be driven more by a cognitive bias than actual surface properties.

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

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

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

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

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

The strength of this research rests with the interdisciplinary approach that examines psychological and biomechanical responses. Both of which will be necessary for future research to increase the understanding of why these perceptions emerge. Throughout this study a balance between ecological validity, scientific rigour and logistical considerations had to be found. Until now, studies such as Burillo et al. (2014) have only asked players their opinion of a named surface; this method does not allow the removal of player response biases to determine the true perception of a surface. The nature of this research, with the masked condition requires consideration when making a direct link to the 'game of soccer/rugby'. Notably the performance in masked condition was slower than in the normal condition, which may have confounded our results. A further limitation of this study is the restriction to 2D video analysis and tracking based on body-landmarks, which only allows for basic data analysis and some differences might remain undetected by this method, hence the effect of surface type on 3D joint kinematics, joint kinetics, muscle activation and ground contact forces on running as well as on other skills, such as ball and team playing remains yet to investigate.

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

Conclusion

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

Practical Implications

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

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Figure legends

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

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

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

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

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