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Incorporating 'in-game' scenarios into player-surface studies

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ABSTRACT

To gain understanding of how different movements, in-game scenarios and surface properties affect the loading of the musculoskeletal system research is needed that combines all of these aspects. Before conducting this research it is important to know what soccer players themselves consider important with regard to their movements in a game situation, and what surface properties they prefer.

From the results of a focus group and a questionnaire (completed by 58 players) it is clear that there are several movements and one-on-one situations that they consider important. There were differences in ratings between playing positions and playing levels, and it is important to consider these aspects in any future studies.

All surface properties were considered important by the players and there were no differences in playing level or playing position. However, surface characteristics such as stud penetration and uniformity were rated lower in importance than: evenness of the surface, a smooth ball roll and predictable ball bounce. For most other properties intermediate values were preferred. A comparison between the rating of the two Loughborough University artificial turf pitches showed a significant difference in the rating for traction, which was confirmed by previous mechanical measurements. There were also differences in the rating for hardness and shock absorption between the surfaces, though this was not confirmed by previous mechanical measurements. This paper presents the findings of the player feedback study and makes recommendations for an experimental player-surface interaction study design from the outcomes.

INTRODUCTION

Since the development of third generation artificial turf (3G) it has been gaining popularity and acceptance in soccer. Still a lot of players and coaches complain that the artificial turf influences the game. Maybe even more important a lot of people think that playing on artificial turf leads to more injuries than playing on natural grass. These issues contribute to the fact that many players are hesitant to play on artificial turf.

In the past, several studies have looked at the influence of different surface properties on musculoskeletal loading. The movements used in these studies are limited to straight line running, cutting manoeuvres and jumps/landings (Arampatzis et al., 1999, Ferris et al., 1999, Kaila, 2007, Queen et al. 2007). There are however many more relevant movements in soccer, which have been identified by studies in the field of time-motion analysis (Bloomfield et al., 2004). Therefore it is questionable how relevant the outcomes of previous studies are to actual in-game scenarios.

Another limitation of many studies is that they do not provide sufficient information on the surface(s) used. Therefore the results of these studies are only of limited use as it is hard to relate the found effects on musculoskeletal loading to any surface properties. This is a vital part in the player-surface interaction as the different parameters involved in the design of artificial turf can influence the loading characteristics (Ferris et al., 1999, Livesay et al.

2006, Villwock et al. 2009), e.g. type of carpet, shockpad and infill, and substructure construction. This becomes even more relevant when considering that there are more than 200 different artificial turf products for soccer alone.

Therefore to increase current knowledge and understanding, research is needed that combines different movements and in-game scenarios with different surface properties. Before incorporating different movements and surfaces properties it is important to know what soccer players themselves consider to be important and what their preferences are regarding the surface properties. The first aim of this study is to understand from the players perspective, which movements they find important, which they perform the most and which lead to the highest musculoskeletal loading. The second aim is to gain knowledge in what surface characteristics the players prefer and to see if they behave differently on different surfaces. The results from this study will help to guide the movements, in-game scenarios, and surface characteristics to be used in future studies.

METHOD

To gain an initial idea of the movements, in-game scenarios and surface characteristics/properties that are relevant and important for soccer players a focus group was organised. The focus group consisted of three defensive minded players, defenders and defending midfielders, and three offensive minded players, forwards and attacking midfielders, from the first team of Loughborough University.

To prevent any bias by input of the interviewer the focus group was set up such that the interviewer gave as little guidance as possible. The session was split up in two parts. The first part involved identifying what movements and in-game scenarios they considered to be important. Whereas the second part focussed on the surface preferences of the players. The whole session was recorded and informed consent was given by all participants.

Using the input from the focus group, including the terminology used, on the different movements and in-game scenarios the players considered to be relevant for soccer, and their opinions on important surface properties and characteristics, a questionnaire was constructed. The questionnaire was divided into four main sections. The first involved general questions about age, position, playing level, amount of experience on playing on artificial turf and their training, match and recreational exposure both on natural grass and artificial turf. This was followed by a section on the importance, frequency and loading of 17 movements and the frequency and loading of 6 different in-game scenarios. The third section consisted of preferences for surface properties and characteristics and how they experienced the surface properties and characteristics of two artificial turf pitches on the campus of Loughborough University (Table 1).

Table 1. Characteristics of the two Loughborough University artificial turf pitches

Pitch	Pile	Infill Depth	Sand	Rubber	Shockpad	Base
PEC	61mm	40-50mm	10mm	30-40mm	None	Bound Asphalt
EHB	35mm	25mm	10mm	15mm	25mm	Bound asphalt

The final section involved questions about their view on different aspects of their match pitch and the two university artificial pitches. Apart from the first section a Likert scale (1-7) was used by which the players could rank the movements, one-on-one situations and surfaces. The questionnaire was completed by 58 players in four different Loughborough University teams. For this study the players of these teams were categorised into two

playing levels (Table 2), upper for the players in the 1st and 2nd team, and lower for the players in the 4th and 5th team.

Table 2. Overview of playing positions and standard of participated players

Playing level	Goal keepers	Defenders	Defending Midfielders	Attacking Midfielders	Forwards	Not Specified	Total
Upper	4	8	5	9	3	0	29
Lower	3	8	7	7	3	1	29
Total	7	16	12	16	6	1	58

Data analysis

The focus group session was transcribed using the audio and video data. Using the rankings of the five most important movements selected by the players an overall top five was compiled for later comparison with the results of the questionnaire.

The results of the questionnaires were analysed with SPSS using a Mann-Whitney U test to compare the results of the different playing levels and a Kruskal-Wallis H and Mann-Whitney U test to analyse the results of the different playing positions. The positions were divided in the following 5 categories: goal keeper, defender, defending midfielder, attacking midfielder, and forward. The results on the different playing fields were compared using a Wilcoxon test. For all statistical tests significance was set at a p –value of 0.05.

RESULTS

Focus group

From the focus group it was clear that not all movements were considered equally important for all positions, e.g. arc run was considered more important for offensive players whereas stop & turn or shuffle were considered more important for defensive players. When the players were asked to make an individual top 5 of relevant movements, ‘change of direction’ was placed 1st by all the players, whereas straight line running/sprinting was placed on 2 by the majority (Table 3). Movements that were named in the individual top 5’s but did not make the group top 5 were ‘planting non-kicking foot’ and ‘tackle’ suggesting that these are also important to some players.

Table 3. Focus group results for top 5 of movements that are important for soccer

1	Change of direction
2	Straight line running/sprinting
3	Sidesteps/Shuffle
4	Jump/Land
5	Stopping

Situations the players considered as in-game scenarios were one-on-one situations, unit work, set pieces, formations and counter attacks. One-on-one situations are the most suitable to recreate in the lab and were also rated the most important by the players. Examples of one-on-one situations were: “taking someone one” and “trying to get past a

player”. To benefit the understanding of the questionnaire, the term ‘in-game scenarios’ was changed to ‘one-on-one situations’. This was to make sure that that section was understandable to all participants.

Of the surface characteristics a flat surface with smooth ball roll was considered to be very important. Generally none of the players were very satisfied with the artificial turf playing characteristics. They regarded it as being too hard, low shock absorption, bad for stud penetration, and expressed that their boots got caught in the fibres and rubber, that the ball roll was not smooth, and that ball bounce was different compared to natural grass. In relation to performance and injuries they preferred to have a reduced physical performance, e.g. lower running speed, if that would result in fewer injuries. Their main argument for this was: “It comes down to the player, at the end of the day it is you versus someone else. If the pitch is quicker you both will be quicker. So if it is a boggy pitch you both are going to be a bit slower.”

Questionnaire

Section 1. General questions

The soccer experience of the 58 players ranged from 5 – 18 years, and experience on artificial turf ranged from 0.5 – 16 years (average 7.5 years). On average they train 0.9 hours per week on natural grass and 4.3 hours on artificial turf. All players train at least 2 hours per week on artificial turf, the majority (39 players) never train on natural grass. All players play matches on natural grass ranging from 10 – 60 per season (average 32). 22 players reported that they also play matches on artificial turf (1 – 10 per season). 33 players reported to play recreationally on artificial turf (1 – 6 hours per week) and 23 players reported to play recreationally on natural grass (1 – 5 hours per week). Between playing levels the players in the upper playing level group train significantly more on artificial turf and play significantly more matches on natural grass (Table 4). Players in the lower playing level group play recreationally significantly more on artificial turf.

Table 4. Comparison exposure of both playing levels (mean+SD)

Playing level		Lower	Upper
Training (h/week)	natural grass	0.5 ± 1.0	1.3 ± 2.5
	artificial turf*	3.9 ± 0.9	4.8 ± 2.2
Matches (season)	natural grass*	25 ± 9	37 ± 18
	artificial turf	2 ± 3	1 ± 3
Recreational	natural grass	1.1 ± 1.2	0.5 ± 1.2
	artificial turf*	1.7 ± 1.6	0.8 ± 1.3

*Significant difference between both playing levels

Section 2. Movements rating

The movements rated as most important were sprinting, a general change of direction and stop and turn with averages rating of 6 or higher (Fig. 1a). The movements considered as the least important were walking and diving. The frequency of the movement types were rated very similar. Running, planting non-kicking foot, and a general change of direction were rated to be performed the most frequently (Fig 1b).

For the 'loading of the body' question the players rated sprinting, stopping, jump/land and 'stop and turn' to have the highest loading with an average rating higher than 5 (Fig. 1c). Whereas walking, jogging and diving were rated as the movements with the lowest loading.

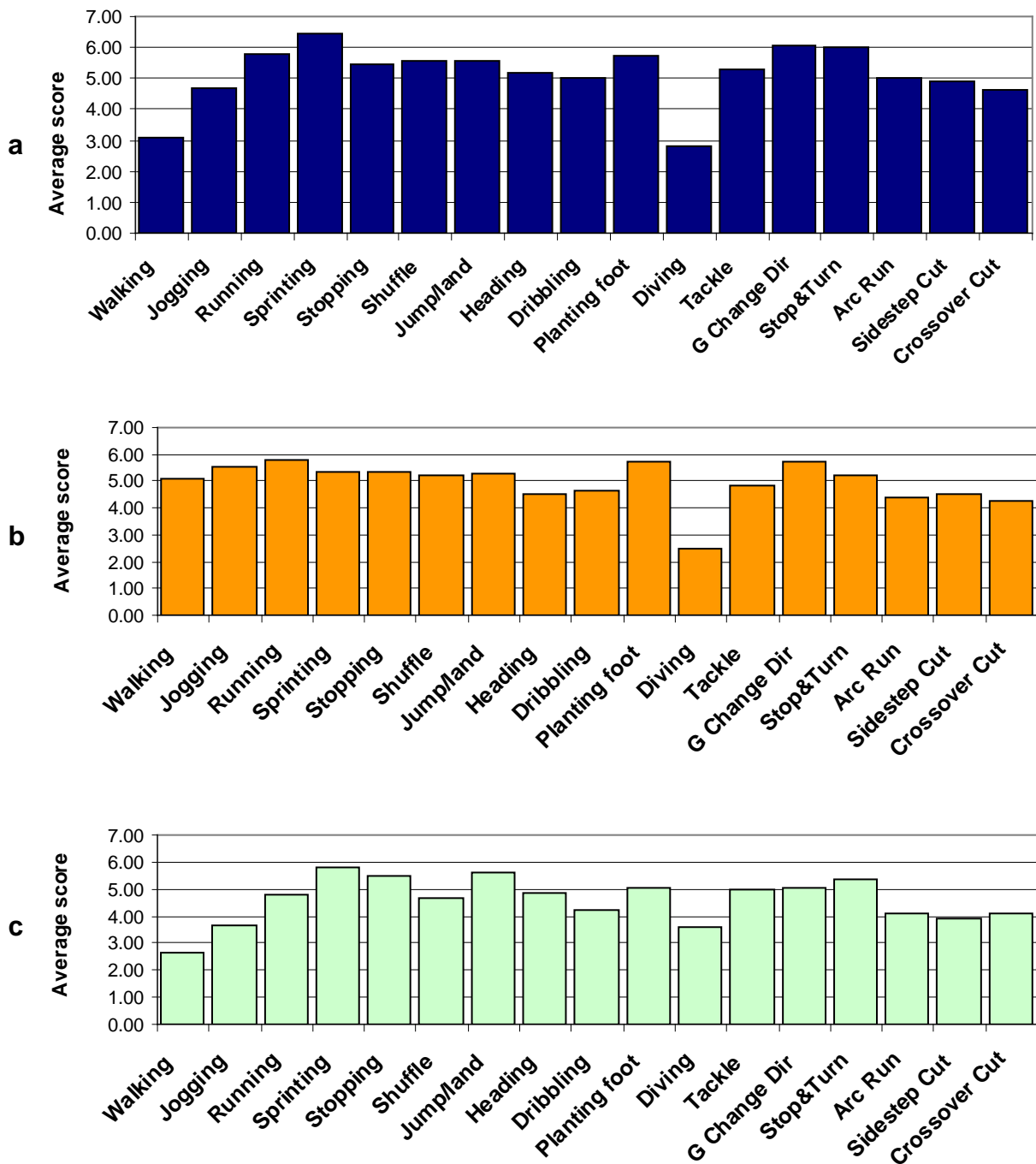


Figure 1. Average rated scores for movement types on (a) importance, (b) frequency and (c) experienced loading

Between the playing levels there were a few significant differences (Table 5). The importance and frequency of a general change of direction, and frequency of planting non-kicking foot were all rated significantly higher by the players of the lower playing level group. No significant differences were found in the rating of the experienced loading of the different movements.

Table 5. Significant differences in average movement ratings between playing levels (mean±SD)

Playing level		Lower	Upper
Planting non-kicking foot	Frequency	6.1 ± 1.0	5.4 ± 1.4
General change of direction	Importance	6.2 ± 1.1	5.9 ± 0.7
	Frequency	6.0 ± 1.0	5.6 ± 1.0

Table 6. Significant differences in average movement ratings between playing positions (mean±SD)

Playing position		Goal keeper	Defender	Defending Midfielder	Attacking Midfielder	Forward
Jogging	Importance	3.0 ²⁴ ± 1.3	5.1 ¹ ± 0.8	4.6 ± 1.9	5.0 ¹ ± 1.7	4.5 ± 1.4
	Frequency	4.0 ²³⁴⁵ ± 1.2	5.8 ¹ ± 0.7	5.6 ¹ ± 1.3	5.8 ¹ ± 1.3	5.8 ¹ ± 0.8
Running	Importance	4.1 ²⁴ ± 1.1	6.3 ¹ ± 0.7	6.0 ± 1.0	5.8 ¹ ± 0.8	5.8 ± 1.5
	Frequency	4.1 ²³⁴⁵ ± 0.4	5.8 ¹ ± 0.9	6.3 ¹ ± 0.5	6.1 ¹ ± 0.9	6.0 ¹ ± 0.6
Sprinting	Importance	5.0 ²³⁴⁵ ± 1.2	6.8 ¹ ± 0.4	6.4 ¹ ± 0.7	6.6 ¹ ± 0.6	6.5 ¹ ± 0.8
	Frequency	3.4 ²³⁴⁵ ± 1.0	5.3 ¹ ± 1.2	5.4 ¹ ± 1.5	5.7 ¹ ± 1.3	6.3 ¹ ± 0.7
Jump/Land	Importance	6.4 ³⁴ ± 0.8	5.9 ± 0.8	5.1 ¹ ± 1.0	5.3 ¹ ± 1.1	5.5 ± 1.0
	Frequency	6.4 ³⁴ ± 0.8	5.3 ± 1.6	5.0 ¹ ± 1.0	4.7 ¹ ± 1.3	5.7 ± 0.8
Heading	Importance	2.3 ²³⁴⁵ ± 1.4	6.3 ¹³⁴ ± 0.9	5.2 ¹² ± 1.3	4.9 ¹² ± 1.2	6.0 ¹ ± 1.9
	Frequency	1.6 ²³⁴⁵ ± 0.8	5.1 ¹⁴ ± 1.7	4.8 ¹ ± 1.5	4.2 ¹²⁵ ± 1.4	6.0 ¹⁴ ± 0.6
Dribbling	Importance	2.9 ²³⁴⁵ ± 2.0	5.1 ¹ ± 1.2	5.1 ¹ ± 1.3	5.6 ¹ ± 1.2	5.5 ¹ ± 1.6
	Frequency	1.9 ²³⁴⁵ ± 1.1	3.8 ¹³⁴⁵ ± 1.4	5.3 ¹² ± 1.5	5.5 ¹² ± 1.4	6.0 ¹² ± 0.6
	Loading	3.0 ⁴⁵ ± 1.2	3.8 ± 1.4	4.3 ± 1.6	4.7 ¹ ± 1.4	5.0 ¹ ± 0.9
Diving	Importance	6.9 ²³⁴⁵ ± 0.4	2.3 ¹ ± 1.6	2.3 ¹ ± 2.0	2.1 ¹ ± 1.9	2.8 ¹ ± 2.1
	Frequency	6.9 ²³⁴⁵ ± 0.4	1.7 ¹⁵ ± 1.7	1.6 ¹ ± 1.4	1.8 ¹ ± 1.5	3.5 ¹² ± 2.5
	Loading	6.0 ²⁴ ± 1.0	2.9 ¹ ± 2.0	4.1 ± 2.3	2.8 ¹ ± 2.1	4.2 ± 2.2
Tackle	Importance	3.7 ²³⁵ ± 1.0	5.9 ¹ ± 1.0	5.9 ¹ ± 1.0	5.0 ± 1.5	5.0 ¹ ± 1.1
	Frequency	2.0 ²³⁴⁵ ± 1.2	5.7 ¹⁴ ± 1.0	5.6 ¹ ± 1.1	4.4 ¹² ± 1.8	5.0 ¹ ± 1.4
	Loading	2.7 ²³⁴⁵ ± 1.7	5.6 ¹ ± 1.1	5.3 ¹ ± 1.1	4.8 ¹ ± 1.4	5.5 ¹ ± 1.4
Arc Run	Importance	3.7 ⁴⁵ ± 1.8	4.6 ⁴⁵ ± 1.1	4.7 ± 1.8	5.7 ¹² ± 1.0	6.0 ¹² ± 0.9
	Frequency	2.6 ³⁴⁵ ± 1.6	3.9 ⁴ ± 1.6	4.4 ¹ ± 1.7	5.3 ¹² ± 0.9	5.2 ¹ ± 1.5
Crossover Cut	Importance	3.0 ⁴ ± 2.3	4.3 ⁴⁵ ± 1.1	4.7 ± 1.8	5.3 ¹² ± 1.4	5.5 ² ± 1.8
	Frequency	2.4 ³⁴⁵ ± 1.6	3.8 ⁴ ± 1.7	4.5 ¹ ± 1.6	4.9 ¹² ± 1.2	4.8 ¹ ± 1.6

significant difference with 1: Goal keepers 2: Defenders 3: Defending Midfielders 4: Attacking Midfielders 5: Forwards

Between playing positions significant differences were found in the rated importance and frequency of jogging, running, sprinting, jump/land, heading, dribbling, diving, tackle, arc run, crossover cut (Table 6). For the rated experienced loading of the different movements

significant differences were found for dribbling, diving and tackle. The most differences existed between the goal keepers and the other positions.

One-on-One situations rating

Overall there were no large differences found for the rating of the one-on-one situations. The frequency of one-on-one situations had average ratings between 4.3 and 5.1 (Fig. 2). Marking an opponent and a heading duel were rated to be the most frequent one-on-one situations, whereas avoiding a tackle was rated to be the least frequent.

The loading of the different one-on-one situations was on average rated between 4.1 and 5.0 (Fig. 2). A heading duel was rated as the one-on-one situation with the highest loading, while marking an opponent and avoiding a tackle were rated the lowest.

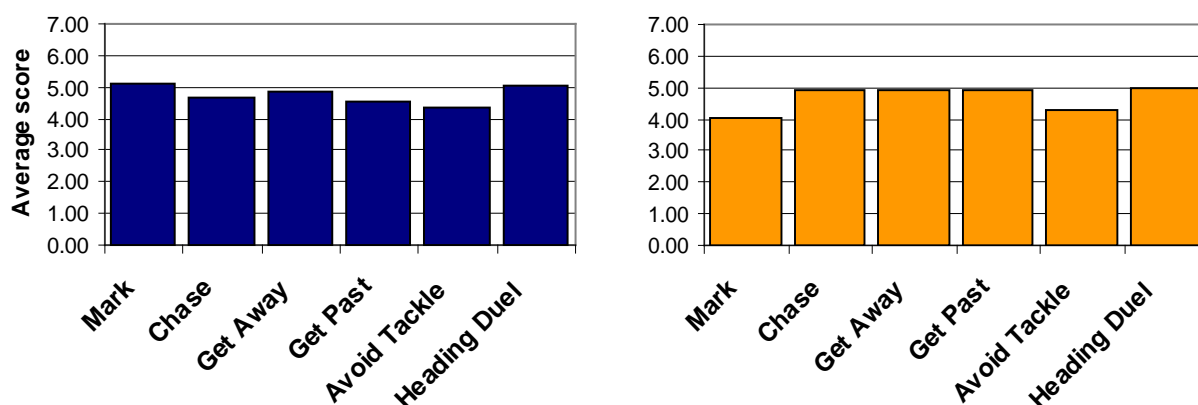


Figure 2 . Rated frequency (left) and loading (right) of different one-on-one situations

Table 7. Significant differences in one-on-one situation ratings between playing positions (mean+SD)

Playing position		Goal keeper	Defender	Defending Midfielder	Attacking Midfielder	Forward
Mark	Frequency	1.0 ²³⁴⁵ ± 0.0	6.6 ¹⁴⁵ ± 0.7	6.3 ¹⁵ ± 0.9	5.0 ¹² ± 1.9	4.7 ¹²³ ± 1.4
	Loading	1.7 ²³⁴⁵ ± 0.9	4.6 ¹ ± 1.5	5.5 ¹⁴⁵ ± 1.7	3.6 ¹³ ± 1.5	5.7 ¹³ ± 1.5
Chase	Frequency	1.1 ²³⁴⁵ ± 0.4	5.6 ¹ ± 1.3	5.8 ¹⁴ ± 1.1	4.7 ¹³ ± 1.3	5.0 ¹ ± 1.4
	Loading	1.9 ²³⁴⁵ ± 1.2	5.5 ¹ ± 1.1	6.0 ¹⁴ ± 1.0	4.9 ¹³ ± 1.3	5.2 ¹ ± 1.6
Get Away	Frequency	1.1 ²³⁴⁵ ± 0.4	4.2 ¹⁴⁵ ± 1.7	4.9 ¹⁴⁵ ± 1.4	6.3 ¹²³ ± 0.7	6.3 ¹²³ ± 0.8
	Loading	2.0 ²³⁴⁵ ± 0.4	5.2 ¹ ± 1.5	5.5 ¹ ± 1.2	5.4 ¹ ± 1.1	5.5 ¹ ± 1.4
Get Past	Frequency	1.1 ²³⁴⁵ ± 0.4	3.6 ¹⁴⁵ ± 1.5	5.0 ¹ ± 1.4	5.9 ¹² ± 1.2	5.8 ¹² ± 1.2
	Loading	1.7 ²³⁴⁵ ± 1.0	5.1 ¹ ± 1.3	5.4 ¹ ± 0.8	5.5 ¹ ± 1.0	6.0 ¹ ± 1.3
Avoid Tackle	Frequency	1.3 ²³⁴⁵ ± 0.5	3.6 ¹⁴⁵ ± 1.7	4.2 ¹ ± 2.0	5.6 ¹² ± 1.8	5.8 ¹² ± 1.0
	Loading	2.3 ²⁴⁵ ± 1.6	4.4 ¹ ± 1.5	3.9 ± 2.0	4.8 ¹ ± 1.3	5.7 ¹ ± 1.5
Heading Duel	Frequency	1.6 ²³⁴⁵ ± 1.1	6.3 ¹⁴ ± 0.9	5.2 ¹ ± 1.9	4.9 ¹² ± 1.6	6.2 ¹ ± 0.4
	Loading	2.3 ²³⁴⁵ ± 1.9	5.9 ¹ ± 1.1	5.1 ¹ ± 1.3	4.7 ¹ ± 1.5	5.8 ¹ ± 0.8

significant difference with 1: Goal keepers 2: Defenders 3: Defending Midfielders 4: Attacking Midfielders 5: Forwards

Between the two playing levels there were no significant differences in how the players rated both the frequency and the loading of the one-on-one situations. Between playing positions again most of the differences existed between the goal keepers and all other playing positions with significant differences in almost all cases, both in the rating of frequency and loading (Table 7). Differences in rating between other positions mainly involved the frequency of the one-on-one situations.

Section 3. Surface preferences

Overall a flat/even surface, a smooth ball roll, and a predictable ball bounce were rated to be the most important (Fig. 3). A good stud penetration and uniformity of the pitch were still rated to be important, though less important than the other characteristics. From the other characteristics the respondents preferred an intermediate height of the ball bounce, amount of giving in by the pitch and hardness (Fig. 3). A slightly higher than intermediate traction and shock absorption were preferred and the grass/fibre length of the pitch was preferred short.

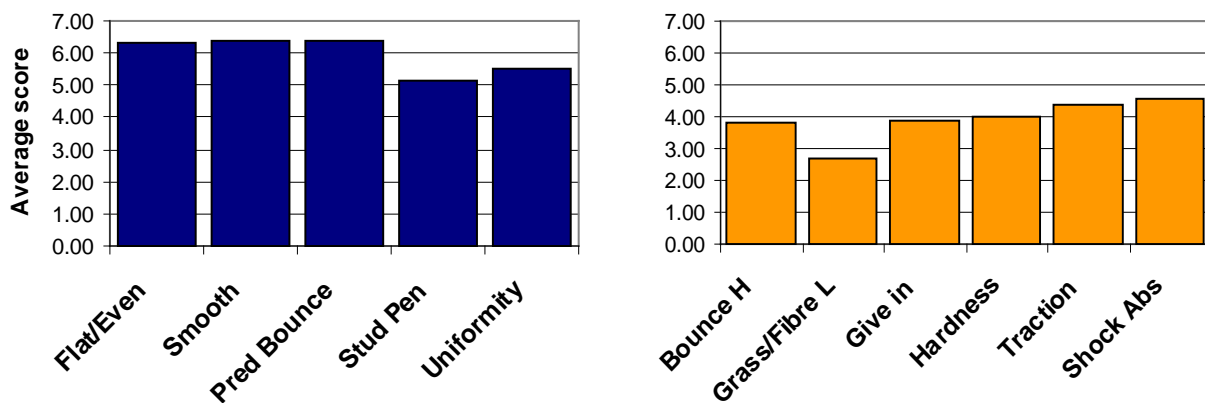


Figure 3. Overall rated importance (left) and preferences (right) of different surface characteristics

Between both playing levels and between the playing positions there were no significant differences in the ratings of the players.

Section 4. Player rating of the university pitches

Comparing the artificial turf pitches, the PEC pitch was rated above average for the flatness/evenness, smoothness of the ball roll, predictability of the ball bounce, stud penetration and the uniformity of the pitch (Fig. 4). The EHB pitch ratings showed only stud penetration as just below average, but the other characteristics were rated as above average. Comparing the rating of both pitches the PEC scored significantly higher on the stud penetration.

From the other characteristics the ball bounce was rated slightly higher than intermediate for both pitches. The fibre length and the amount of give were both rated as lower than intermediate. Whereas hardness, traction and shock absorption were rated to be around intermediate.

Comparing both pitches the traction was rated to be significantly higher on the PEC pitch. Apart from this the hardness of the PEC pitch was rated lower and the shock absorption higher, though these differences were not significant.

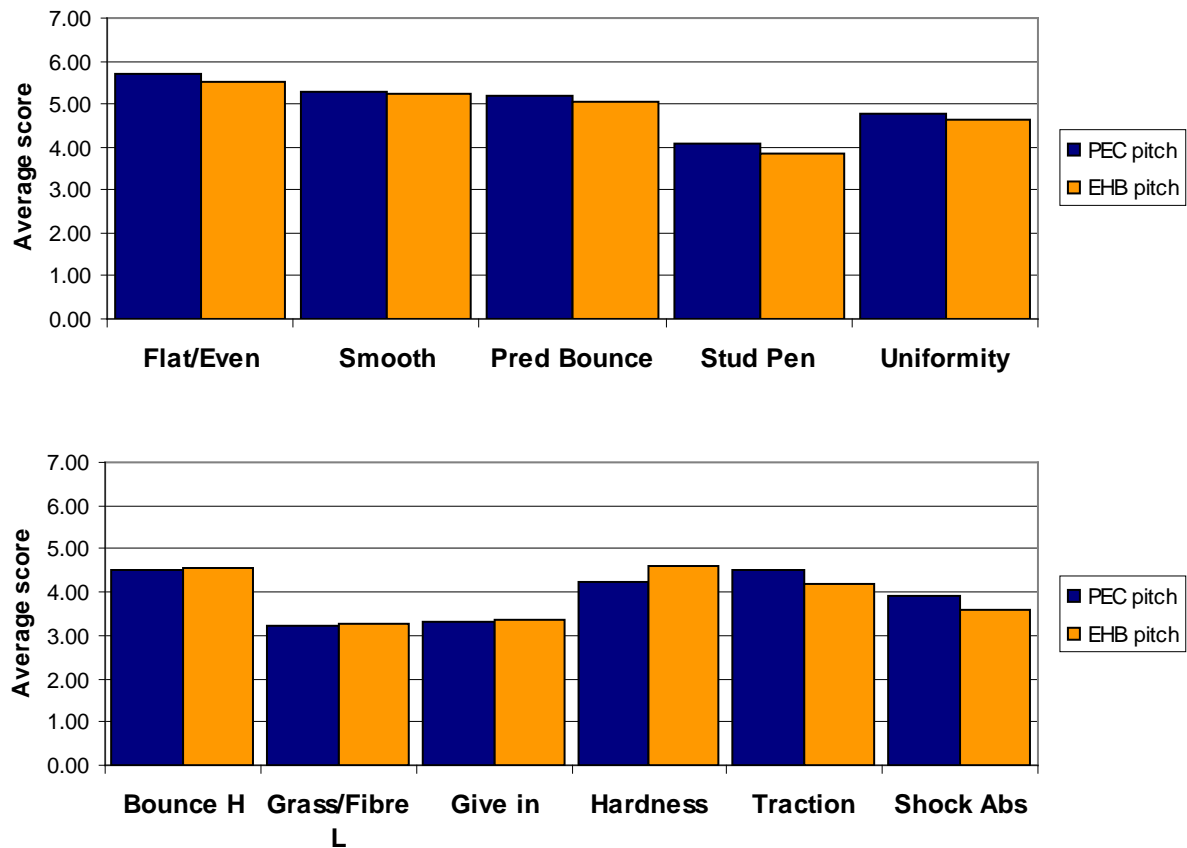


Figure 4. Comparison of the overall average ratings of both artificial pitches

Between both playing levels the players in the lower playing level group rated the smoothness and stud penetration of the PEC pitch significantly higher than the players in the upper playing level group (Table 8). For the EHB pitch no significant differences were found between playing levels.

Table 8. Significant differences in rating of the PEC pitch between playing levels (mean±SD)

Playing level	Lower	Upper
Smooth	5.7 ± 1.6	4.9 ± 1.5
Stud Penetration	4.7 ± 1.3	3.5 ± 1.6

The questions about the mindset of the players show that overall the players rated the EHB pitch the worst and their match pitch (natural grass) the best of the three pitches (Fig. 5). The EHB pitch was rated to have the highest loading and the players worried relatively more about getting injuries when playing on this pitch. In their opinion they are significantly more likely to get injured when playing on the EHB pitch compared to both other pitches. Plus they indicated they moved significantly more cautiously on this pitch and judged they cannot move as freely on this pitch as they can on the other pitches.

Between the two playing levels the players in the upper playing level group rated the loading and the injury chance on their match pitch significantly lower than the players in the lower playing level group (Table 9).

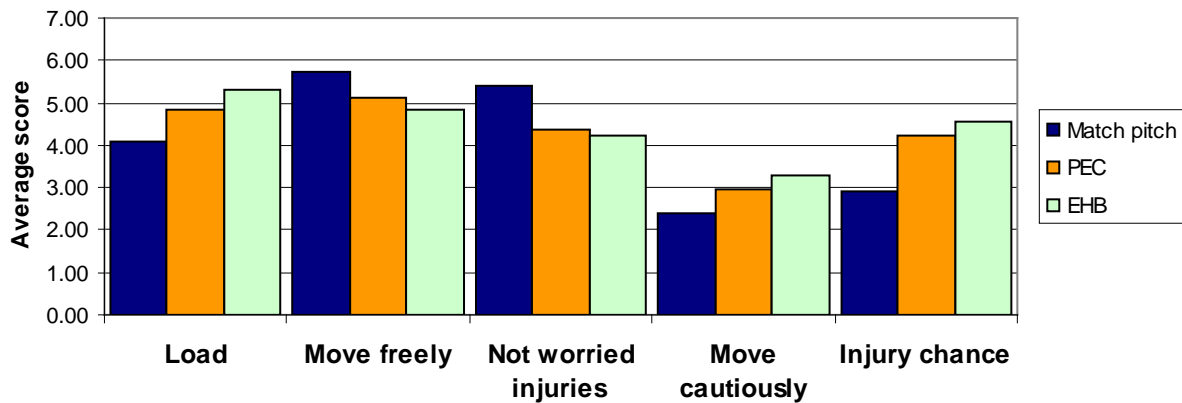


Figure 5. Comparison of average rating on the mindset of players on different pitches

Table 9. Significant differences on surface rating between playing levels (mean+SD)

Playing level	Lower	Upper
Load Match Pitch	4.6 ± 1.3	3.6 ± 1.3
Injury chance Match pitch	3.3 ± 1.4	2.6 ± 1.4

DISCUSSION

The results of the questionnaire show that overall some movements are considered to be more important than others. But it is also clear that this partially depends on both the playing level and position of the players. That the playing position is an important factor is also shown by the different ratings of the one-on-one situations.

The rating of the different pitches seems partially dependent on the playing level, which might be related to the exposure of the players to each particular pitch. However, the match pitch (natural grass) of the players was rated the best on all points.

Movements

Of the listed movement types 'sprinting', 'a general change of direction' and 'stop & turn' were considered the most important from all the players, whereas 'walking' and 'diving' were clearly considered the least important. On aspects of how frequently movements were performed 'running', 'planting non-kicking foot' and 'a general change of direction' were rated the highest, whereas 'sprinting', 'stopping', jump/land and 'stop & turn' were the rated the highest for loading on the player. Comparing the three categories to each other shows that 'sprinting', 'a general change of direction' and 'stop & turn' were rated high in two of the three categories. As they were all rated the highest in the importance category there appears to be a relationship between the frequency or amount of loading of the movement and the importance of the movement.

The overall results of the questionnaire also show that changing direction is an important part in soccer. This agreed with the focus group outcome as 'change of direction' was rated the highest by all the players. Looking in more detail shows that 'stop & turn' was rated the highest in each category. This indicates that it might be important to look at the 'stop & turn', as this would enhance 'sidestep cuts' and 'crossover cuts' on which previous studies have focused (Kaila, 2007, McLean et al., 2004, Queen et al. 2008).

There were only a few significant differences found between the two different playing levels. Though two of the three differences involved 'a general change of direction' for which both the importance and frequency was rated higher by the players in the lower playing level group. However, on the specific changes of direction like 'stop & turn' and 'arc run' no differences were found between the two playing levels. Also on the rated loading of the different movements no significant differences were found suggesting that the playing level has no influence on this.

Of the different playing positions the goal keepers showed the largest difference with all the different playing positions in all the different categories. This is no surprise as the role of the goal keepers is very different to that of the other players.

The offensive positions (attacking midfielders and forwards) rated both the frequency and importance of the 'arc run' higher than the defensive positions (defenders and defending midfielders). Even though this was not always a significant this shows a clear difference between the offensive and defensive positions. This agreed with the statement during the focus group that the importance of a movement is dependent of the position of a player. Other differences found between playing positions for 'sidestep cut', 'dribbling', 'tackle' and 'heading' clearly show that the playing position is something that needs to be considered carefully in future studies.

One-on-one situations

For the one-on-one situations 'marking an opponent' and 'heading duel' were rated to be the most frequent. The category 'heading duel' was also rated to have the highest loading, followed by 'chasing an opponent', 'getting away from an opponent' and 'getting past an opponent'.

No significant differences were found between responses from the two playing levels. Between positions the goal keepers again showed the most differences. Between the other positions a 'heading duel' was rated higher by the defenders and forwards than both midfield positions in terms of how frequently they encounter this and the experienced loading. Similar to the rating for heading these differences were not significant, but it seems apparent that heading and heading duels are more relevant for defenders and forwards than midfield players. 'Marking an opponent' is performed more often by the defensive positions than the offensive positions. Whereas the frequency rating for 'getting away from an opponent', 'getting past an opponent' and 'avoiding a tackle' increased from defenders through to forwards.

These results again show that according to their field position players, will encounter some one-on-one situations more than others. There also seems to be a relation with the rating of movements. The positions that rated heading high in the movements section also rated a heading duel high. But there are also other connections. For example, the more offensive players rated arc run, sidestep cut and crossover cut higher than the defensive players. These are typically movements which help to get past an opponent, which was also rated higher by the offensive players. Similarly, tackling was rated higher by defensive players in terms of importance and frequency, while avoiding a tackle was rated higher by offensive players.

Surfaces

For the 'importance' of the surface characteristics, all categories were rated highly, though uniformity and stud penetration were rated less important than a smooth ball roll, predictable ball bounce and a flat/even surface. For the preferences of surface characteristics most were rated around intermediate. Only the length of the grass/fibres

was clearly preferred short. Neither playing level or playing position had a significant effect on the rating of the surface preferences.

Between the two university artificial pitches the PEC pitch was rated to exhibit significantly higher traction than the EHB pitch. It was also rated to be softer and to have higher shock absorption, though this was not statistically significant. The playing level of the players had a significant effect on the rating of the smoothness and stud penetration as this was rated better by the players in the lower playing level group.

For the questions about the mindset of the players, their match pitch (natural grass) scored the best on all questions, whereas the EHB pitch (artificial turf) scored the worst. This demonstrates that the players rated their match pitch to have the lowest loading during their movements, the lowest chance of injuries, and that they are the least worried about injuries while playing on their match pitch. This is also supported by their scores on their perception that they can move more freely on their match pitch in contrast to the two artificial pitches.

The higher loading, and the view of the players was that they are more likely to get injured on the EHB pitch than on the PEC pitch might be caused by the differences in the individual characteristic ratings. The EHB pitch was rated to have significantly less traction than the PEC pitch, but overall also to be harder and have less shock absorption, though not significant. However, while previous mechanical measurements on these pitches showed that the PEC pitch had a higher rotational traction than the EHB pitch (34 – 41Nm vs. 29 – 35Nm), measurements with a Clegg hammer showed the PEC pitch was similar or harder than the EHB pitch. The differences between the measurements and the opinions of the players might also be caused by several other factors. How the players rate their experience on a surface may vary between players, be based on their overall experience of the pitch or they may mainly consider their last experience or two on the pitch. It is also likely that, due to the time difference between testing and the questionnaires, the conditions of the pitches may have changed. Furthermore, it might be that the differences are caused by the limitations of the test equipment, or their design not replicating the players actions in terms of load, duration etc.

Between the different playing levels, the players in the upper playing level group rated their match pitch significantly better on loading and injury chance than the players in the lower playing level group. As there were no significant difference between the groups for the other pitches it seems that the opinion of the players about their own match pitch does not have a direct effect on how they rate the other pitches. On the other hand, players do compare natural grass with artificial turf as during the focus group the players stated that they wanted an artificial turf to replicate natural turf. They also stated that the current artificial turfs they are exposed to do not replicate the playing quality of the natural grass they compete on regularly, and that natural turf is their benchmark.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study show that multiple movements are rated highly for importance, frequency, and loading. For most surface characteristics the players preferred intermediate values. Playing position and level can have a significant effect on how a player rates each movement and one-on-one situation, but had no effect on their surface preferences. Differences between the two artificial turf pitches indicated that surface traction, hardness and shock absorption are responsible for differences in the ratings for musculoskeletal loading.

For future studies on player-surface interaction different types of movements should be used along with different one-on-one situations to replicate in-game scenarios. Furthermore, different surfaces with a varying range of surface traction, hardness, and

shock absorption should be used to increase the understanding of how these properties affect musculoskeletal loading.

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