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Pablo Burillo ^a, Leonor Gallardo ^b, Jose Luis Felipe ^c & Ana Maria Gallardo ^d

^a Sport Science Institute, Camilo Jose Cela University, Madrid, Spain

^b Faculty of Sport Science, University of Castilla-La Mancha, Toledo, Spain

^c Faculty of Sport Sciences, European University of Madrid, Madrid, Spain

^d Faculty of Health, Physical Activity and Sport, Catholic University of San Antonio, Murcia, Spain

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ORIGINAL ARTICLE

Artificial turf surfaces: Perception of safety, sporting feature, satisfaction and preference of football users

PABLO BURILLO¹, LEONOR GALLARDO², JOSE LUIS FELIPE³, & ANA MARIA GALLARDO⁴

¹*Sport Science Institute, Camilo José Cela University, Madrid, Spain,* ²*Faculty of Sport Science, University of Castilla-La Mancha, Toledo, Spain,* ³*Faculty of Sport Sciences, European University of Madrid, Madrid, Spain,* and ⁴*Faculty of Health, Physical Activity and Sport, Catholic University of San Antonio, Murcia, Spain*

Abstract

The aim of this research is to understand the experience of the football sector on the use of artificial turf (satisfaction, safety, sporting feature, or the advantages and disadvantages). The study was conducted on a random selection of 627 male participants (404 amateur/semi-professional footballers, 101 coaches and 122 referees) that regularly train/compete on artificial turf in Spanish football leagues. The results of the skin abrasion, muscle strain and the possibility of sustaining an injury, on a Likert-type 10-point interval scale, gave a perception of 'somewhat dissatisfied' for the participants. The main advantages of artificial turf were their sports features, the evenness of the surface and the good state of conservation. Participants were satisfied with the artificial turf surface. Approximately three out of four participants gave an overall ranking of highly satisfied. The players were significantly less satisfied than the coaches and referees. The overall satisfaction with artificial turf fields was strongly influenced by previous experience, particularly those who had previously played on dirt pitches. These results highlight the versatility of artificial turf to adapt to any circumstance or requirement for local sport and top-level professional competitions alike.

Keywords: *Artificial turf, football, perception, safety, user satisfaction, preference*

Introduction

Football has experienced wide change over the last 40 years as far as playing surfaces are concerned. Football has traditionally been played on natural grass pitches. However, in large areas of southern Europe, Africa and Asia, dirt pitches have often been the surface for locations with more limited economic resources and for lower leagues (FIFA, 2007a). In fact, only professional clubs and wealthier suburban areas have been able to build, and particularly maintain, their grounds with natural turf (ESTO, 2008). In recent years, there has been a marked introduction of artificial turf. This playing surface can be attractive for amateur footballers of all ages who were formerly used to dirt pitches and natural surfaces in a poor state (Burillo, 2009).

The number of natural turf pitches has reduced dramatically in favour of artificial turf. McNitt (2005) forecasted a 20% increase in artificial turf football grounds per year in the United States, mainly because of the potential for exploitation of this surface. Furthermore, artificial turf is considered to be an ideal surface for the training of young footballers (Stiles, James, Dixon, & Guisasaola, 2009). However, this increase is also due to the fact that dirt pitches are a poor 'advertising' for the sport, particularly in today's global context. In addition, investment in natural turf fields is very expensive to maintain for most local organisations, particularly where there are high temperatures and low annual rainfall (Orchard, 2002). Furthermore, their restricted periods of use are not consistent with current strategies for promoting the sport. Thus, sports

Correspondence: L. Gallardo, University of Castilla-La Mancha, Avda. Carlos III, s/n. Edificio Sabatini 1.52. 47051, Toledo, Spain.
E-mail: leonor.gallardo@uclm.es

organisations are asking themselves which type of playing surface offers the best response to their needs (Gallardo, Burillo, García-Tascón, & Salinero, 2009).

It was not until 2003 that International Federation of Association Football (FIFA) accepted artificial turf for official competitions (Burillo, 2009). The arrival of third-generation artificial turf (with rubber and sand infills) in the 1990s saw the disappearance of most of the problems attached to previous generations, such as high stiffness, friction, degree of skin abrasion, or distorted bounce and roll of the ball (Ekstrand, Timpka, & Hägglund, 2006; McNitt, 2005; Steffen, Andersen, & Bahr, 2007), and was welcomed by a large proportion of the sporting, political and social sectors (Ekstrand et al., 2006).

At first, artificial turf received a lukewarm reception because of the higher number of injuries when compared with other surfaces, particularly natural turf (Schmidt-Oltsen, Jörgensen, Kaalund, & Sørensen, 1991). However, the various studies carried out comparing third-generation artificial turf with all the other natural surfaces have redressed this imbalance in injury numbers (Ekstrand et al., 2006; Foster, 2007; Meyers, 2010; Meyers & Barnhill, 2004; Naunheim, Parrott, & Standeven, 2004; Steffen et al., 2007). Since then, FIFA has acknowledged artificial turf as an alternative, not a substitute (FIFA, 2007a). Nevertheless, the professional sector, in general, remains unconvinced, and artificial turf is still used in a very limited manner.

Artificial turf has also led to the spread of seven-a-side football as an amateur sport; a great advance for community football. The increase in the number of users has led to a major increase in active sports participation by the public, and various pitches are needed to meet this demand (Gallardo et al., 2009; Whitlock, 2008).

Several researchers have documented user satisfaction on other football playing surfaces as compared with natural turf (Andersson, Ekblom, & Krustup, 2008; Ford et al., 2006; Foster, 2007; Zanetti, 2009). However, there has been limited research done on the perception of artificial turf in particular; for instance, the actual degree of satisfaction. Understanding user satisfaction is imperative in developing artificial turf facilities and improving the service (Burillo, 2009). The success of sporting organisations lies in the awareness they have of the needs, expectations, attitudes and nature of their potential users. Users may initially be largely influenced by the appearance of the sports facility (Zanetti, 2009). The first impression is usually visual, and so the overall image is very important. However, subsequent experience defines a user's satisfaction in the final analysis. The aim of this research is to document the experience of the sporting sector (i.e., football players, coaches and

referees) on the use of artificial football turf and its sociodemographic profile (age, levels, years of experience and previous playing surface), perception of safety, sports feature, advantages and disadvantages, preferences regarding type of playing surface and overall satisfaction.

Methods

Participants

The study was conducted on a random selection of 627 male subjects (mean 28.4 years; $s = 7.7$), of whom, 404 were amateur/semi-professional footballers (mean 26.2 years; $s = 6.4$), 101 coaches (mean 43.1 years; $s = 10.8$) and 122 referees (mean 24.7 years; $s = 5.9$) from the Royal Spanish Football Federation database. Each group was composed of participants who regularly train and compete on artificial turf pitches in amateur football competitions in Castilla-La Mancha (Spain). The sample size was defined with a 95% confidence level, the standard error being 3% for the players, 5% for the coaches and 4% for the referees.

There was a homogenous distribution of participants in terms of age, level and years of experience of artificial turf (Table I). Previously, most of the participants had trained/played either on dirt pitches (66% of the total), while the rest had trained on natural turf (34%).

None of the artificial turf pitches on which the participants have trained or competed had been previously certified by any federation (FIFA or the Spanish Federation). There were a total of 79 pitches (87% of the whole sample in Castilla-La Mancha). The artificial turf was third generation [monofilament or fibrillated fibres of 50–60 mm, with sand and Styrene Butadiene Rubber (SBR) infills], with an average age of 3.9 years ($s = 2.4$). Ninety per cent of the fields do not have shock pad. It is not known how many of these fields are regularly maintained.

Data compilation was conducted *in situ* before daily training sessions, and in the case of the referees, at their technical meetings, during the final part of the 2008 to 2009 season (February–April). The participants were informed (both oral and written) about the study and were given instructions for filling in the questionnaire, the ethical approval (previously reviewed by an institutional ethics panel) and the informed consent.

Design of the study

A questionnaire was designed specifically for this survey to study user satisfaction with artificial turf. The following phases of research were followed in

Table I. Summary of categorical variables of participants

Categorical variables	Players (N,%)	Coaches (N, %)	Referees (N, %)	Total (N, %)
Age				
16–19 years	97 (24, 0)	0 (0, 0)	33 (27, 0)	130 (20, 74)
20–25 years	129 (31, 9)	15 (14, 9)	45 (36, 9)	189 (30, 14)
26–35 years	105 (26, 0)	37 (36, 6)	26 (21, 3)	168 (26, 79)
> 36 years	73 (18, 1)	49 (48, 5)	18 (14, 8)	140 (22, 32)
Level				
Youth sport	82 (20, 3)	54 (53, 5)	22 (18, 0)	158 (30, 60)
Regional	212 (52, 5)	39 (38, 6)	56 (45, 9)	307 (45, 67)
National	110 (27, 2)	8 (7, 9)	44 (36, 1)	162 (23, 73)
Previous experience with artificial turf				
1–3 years	176 (43, 6)	42 (41, 6)	48 (39, 3)	266 (41, 50)
> 3 years	228 (56, 4)	59 (58, 4)	74 (60, 7)	361 (58, 50)
Previous playing surface				
Natural turf	162 (40, 1)	38 (37, 6)	28 (23, 0)	228 (33, 57)
Dirt pitches	242 (59, 9)	63 (62, 4)	94 (77, 0)	399 (66, 43)
Total	404 (100%)	101 (100%)	122 (100%)	627 (100%)

order to check the questionnaire's validity and reliability (Thomas, Nelson, & Silverman, 2005).

The first phase consisted of proposing a set of variables (55 items) regarding perception of satisfaction based on previous questionnaires and studies. A number of factors were defined based on other questionnaires about satisfaction with artificial turf (Andersson et al., 2008; Ekstrand et al., 2006; Meyers & Barnhill, 2004; UEFA, 2004).

In the second phase, content and criterion validity was assessed by 14 experts, who were asked to select the most important variables in the artificial turf study. These experts are recognized in their respective fields (university lecturers, such as a Ph.D. in Sport Management and Facilities, a Ph.D. in Biomechanics, and a Ph.D. in Sport Medicine; two sports managers; three football players; two coaches; two referees; and two artificial turf manufacturers). The Group Discussion technique was used to identify the most suitable variables to explain and determine the perception of the football sector on the use of artificial turf. The experts presented and discussed the factors and variables in previous studies and changes most requested by those engaging in artificial turf fields.

The result was a questionnaire adapted to the characteristics pertaining to each group of participants: 45 items for players, 51 for coaches and 45 for referees, with the following measures: sociodemographic profile (such as age, level, years of experiences and previous playing surfaces), safety, sports feature, advantages and disadvantages, preferences regarding type of playing surface and overall perception of satisfaction. Almost all the items of the questionnaires were constructed by Closed Questions. The sociodemographic factor has made by Categorical responses. The sections of Safety (6 questions), Sports feature (14 questions for players

and referees, 17 questions for coaches), Preferences regarding type of playing surface (4 questions) and Overall perception of satisfaction (12 questions) were built by Scaled items. These variables were graduated on a Likert-type 10-point interval scale, following the recommendations of Hill, Brierley, and MacDougall (2003) and Thomas et al. (2005), with a minimum value (1), which denoted 'Extremely Dissatisfied' and a maximum value (10), denoting 'Extremely Satisfied'. Finally, the section of 'Advantages and disadvantages' was built with two Open-Ended questions: discuss the main advantage/disadvantage of the artificial turf surface on the others surfaces on which you trained/competed, such as natural turf. The responses were synthesized and grouped into categories for interpretation (percentage of response).

In the third phase, a pilot study was conducted on the questionnaire, in which 23 players, 10 coaches and 11 referees from different levels and age groups took part. The fourth phase checked the questionnaire's construct reliability and validity. Responses were always examined to determine whether the items seem clear and appropriate. No substantial changes were mandated by the results of the pilot study (only some changes of format and layout of the survey). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's Sphericity Test and Cronbach's Alpha coefficient were used here. The KMO test gave a satisfactory result of 0.724 for players, 0.763 for coaches and 0.834 for referees, all with a significance of $p < 0.01$ in Bartlett's Sphericity Test. The questionnaires obtained excellent results in Cronbach's Alpha coefficient (0.888 players, 0.864 coaches and 0.846 referees, on a scale of 0 to 1), to quantify the level of reliability of the measurement scales.

Statistical analysis

The statistical analysis was based on the subjective form of satisfaction perception measurement, as had been done previously in similar studies (Andersson et al., 2008; Meyers & Barnhill, 2004; Steffen et al., 2007; Zanetti, 2009). The SPSS 15.0 statistics programme for Windows was employed. Various statistical tests were applied: a descriptive variable analysis (including mean, standard deviation, percentage); the Kolmogorov–Smirnov test ($p < 0.05$), to check normality and compare non-normal distributions; the Chi-squared (χ^2) statistic ($p < 0.05$) for contingency tables and contrast of observed and expected values; the Kruskal–Wallis test ($p < 0.05$) comparing distributions applying a non-parametric method; and the Spearman Rho correlation ($p < 0.05$) in non-normal distributions. A confidence level of 95% was established.

Results

The participants gave low ratings to artificial turf safety aspects (Table II). Skin abrasion (in sliding tackles) (2.90, $s = 1.61$), muscle strain (4.86, $s = 1.69$) and the risk of sustaining an injury (4.29, $s = 1.99$) gave a perception of ‘somewhat dissatisfaction’ for the group. In general, players were more dissatisfied, returning values that were lower than those of coaches and referees.

As far as sports feature was concerned, the overall evaluation obtained from the participants was positive. The highest-scoring aspects were the perception of pitch markings (7.84, $s = 1.67$), the evenness of the surface (7.47, $s = 1.61$) and the state of conservation of the pitch (7.25, $s = 1.79$). The rest of the variables also received satisfactory scores, particularly those connected with the interaction between the surface and the ball and movement on the pitch. The lowest-scoring variables were playing at high temperatures (5.10, $s = 1.86$) and with a snow-covered or frozen surface (5.13, $s = 1.87$).

One particular group, the coaches were asked about the suitability of artificial turf for youth football, amateur regional leagues, or for top-level players. The coaches gave a high ranking for this surface, both for teaching football and for regional leagues.

In the comparison between groups, the players were significantly less satisfied than the coaches and referees when it came to safety aspects ($p < 0.01$), except for muscle strain, for which we only found differences between players and referees, with a confidence level of 95% (Table II). The players were significantly less satisfied than the referees in all sporting aspects ($p < 0.01$), and less satisfied than the coaches except for the state of conservation of the pitch and its evenness which received similar

scores. Coaches and referees did not differ significantly in most variables analysed, giving similar scores, except in two safety variables ($p < 0.01$) (skin abrasion and possibility of sustaining an injury) and two of sports feature (speed movements, $p < 0.05$, and behaviour of the ball, $p < 0.01$). Also, significant differences ($p < 0.01$) were detected in the overall satisfaction of players as against coaches and referees.

One of the foremost aspects for the coaches was the suspension of the activity or training session due to the pitch conditions. Altogether, 84% of the coaches had never had to cancel any training session because of the condition of the artificial turf. Other coaches (16%) have cancelled only 1–3 training sessions. Nobody has cancelled 4 sessions or more in artificial turf.

The main advantages of artificial turf for the football users were its sports feature (23.4% of whole group), the evenness of the surface (20.3%) and the good state of conservation of the pitch (13.6%) (Table III). Advantages of artificial turf identified by the players were its sporting feature and improved performance (29.7%), as well as the evenness of the surface (17.6%). Meanwhile, advantages recognised by the coaches and referees for this surface were its good state of conservation (24.8% and 13.9%, respectively) and the evenness of the surface (18.8% and 30.3%). On the other hand, all agreed that skin abrasion, especially in sliding tackles, was the biggest disadvantage of artificial turf, with a mean percentage of 33.2%.

As far as perception of overall satisfaction with artificial turf (Table II) was concerned, the participants were satisfied with the current artificial turf surfaces which they usually use, with a mean score of 7.29 ($s = 1.89$). Coaches and referees displayed significantly greater satisfaction with artificial turf than the players did. As for the preferred surface (Table III), participants could choose between three possibilities as favourite surface: artificial turf, natural turf, or both surfaces. Approximately 39% of participants preferred natural turf as a training/competition surface, while 32% preferred artificial turf and the remaining 29% preferred both surfaces.

The ‘competition level’ was an influence factor for the satisfaction of the football users ($p < 0.01$ for players and coaches; $p < 0.05$ for referees). Generally, participants expressed a perception of overall satisfaction with artificial turf that was significantly lower as the playing level increased (Table IV). There were also significant differences with regard to age for players ($p < 0.01$) and coaches ($p < 0.05$). Similarly, participants whose previous playing surface was dirt pitches were significantly more satisfied than those who had played/trained on a natural turf surface ($p < 0.01$ for players and referees; $p < 0.05$ for coaches).

Table II. Assessment and Kruskal–Wallis tests of safety, sporting feature and perception of satisfaction with artificial turf

Variable	Players, P 1–10	Coaches, C 1–10	Referees, R 1–10	Whole group	Contrast	K–W test	Significance
	$\bar{X}(s)$	$\bar{X}(s)$	$\bar{X}(s)$	$\bar{X}(s)$			
Safety							
Muscle strain	4.73 (1.59)	5.00 (1.46)	5.20 (2.10)	4.86 (1.69)	P–C	0.5789	0.4467
					P–R	4.9655	0.026*
					C–R	0.8306	0.3620
Skin abrasion	2.71 (1.41)	2.75 (1.27)	3.66 (2.19)	2.90 (1.61)	P–C	220.00	0.000**
					P–R	16.938	0.000**
					C–R	8.4115	0.003**
Possibility of sustaining an injury	3.82 (1.80)	4.42 (1.86)	5.71 (2.02)	4.29 (1.99)	P–C	8.1746	0.004**
					P–R	76.550	0.000**
					C–R	22.603	0.000**
Sports feature							
State of conservation of the pitch	7.05 (1.86)	7.56 (1.11)	7.64 (1.93)	7.25 (1.79)	P–C	2.1423	0.1432
					P–R	9.4021	0.002**
					C–R	1.6532	0.1985
Evenness of the surface	7.32 (1.64)	7.69 (1.30)	7.75 (1.69)	7.47 (1.61)	P–C	1.9242	0.1653
					P–R	7.0197	0.008**
					C–R	0.7983	0.3715
Speed movements	5.69 (1.98)	7.52 (1.21)	7.84 (1.48)	6.40 (2.03)	P–C	75.172	0.000**
					P–R	105.59	0.000**
					C–R	4.9059	0.026*
Ball rebound	6.12 (1.88)	7.65 (1.31)	7.20 (1.84)	6.58 (1.77)	P–C	86.29	0.000**
					P–R	50.597	0.000**
					C–R	4.5225	0.033*
Player running	6.34 (1.68)	7.63 (1.27)	7.54 (1.46)	6.78 (1.76)	P–C	44.415	0.000**
					P–R	43.64	0.000**
					C–R	0.000	0.9982
Behaviour of the ball	6.37 (1.64)	8.24 (1.28)	7.66 (1.65)	6.92 (1.81)	P–C	99.848	0.000**
					P–R	51.886	0.000**
					C–R	8.322	0.004**
Playing at flooded surface	6.41 (1.80)	7.56 (1.34)	7.25 (2.04)	6.76 (1.82)	P–C	41.99	0.000**
					P–R	21.99	0.000**
					C–R	0.2698	0.603
Playing at snow-covered or frozen surface	4.77 (1.72)	5.83 (1.44)	5.74 (2.41)	5.13 (1.87)	P–C	42.69	0.000**
					P–R	22.24	0.000**
					C–R	0.066	0.7971
Playing at high temperatures	4.64 (1.77)	5.80 (1.53)	6.02 (2.22)	5.10 (1.86)	P–C	53.38	0.000**
					P–R	45.9	0.000**
					C–R	2.106	0.146
Perception of pitch markings	7.45 (1.68)	8.50 (1.35)	8.61 (1.54)	7.84 (1.67)	P–C	41.513	0.000**
					P–R	51.814	0.000**
					C–R	1.8734	0.171
Suitability for youth competition		8.78 (1.39)		8.78 (1.39)			
Suitability for regional competition		8.35 (1.32)		8.35 (1.32)			
Suitability for professional competition		6.65 (1.69)		6.65 (1.69)			
General satisfaction with artificial turf	7.14 (2.01)	7.61 (1.52)	7.53 (1.69)	7.29 (1.89)	P–C	9.2081	0.009**
					P–R	9.0902	0.009**
					C–R	0.0079	0.929

* $p < 0.05$; ** $p < 0.01$.

Significant differences ($p < 0.01$) were observed with regard to the overall perception of satisfaction with artificial turf displayed by participants and their preference for the type of playing surface (Table IV). Participants who chose artificial turf as their preferred surface were very satisfied (scores of 8, 9 and 10 from nearly 85%). Meanwhile, those who preferred natural turf expressed a greater degree of dissatisfaction with artificial turf, scores given were below 7.

Discussion

Safety

For a long time, artificial turf has been believed to give rise to more sporting injuries than natural turf (Canaway, Bell, Holmes, & Baker, 1990; Schmidt-Olsen et al., 1991). In spite of this, recent epidemiological studies on third-generation artificial turf claim that the risk of injury is no greater on this

Table III. Summary of advantages and disadvantages of artificial turf and preference surface for users

	Players N (%)	Coaches N (%)	Referees N (%)	Whole group N (%)
Advantages of artificial turf				
Sporting practicability and improved performance	120 (29.7)	10 (9.9)	17 (13.9)	147 (23.4)
Evenness of the surface	71 (17.6)	19 (18.8)	37 (30.3)	127 (20.3)
Good state of conservation of the pitch	43 (10.6)	25 (24.8)	17 (13.9)	85 (13.6)
To spend more time on this surface	55 (13.6)	11 (10.9)	3 (2.5)	69 (11.0)
Playing at flooded surface	29 (7.2)	8 (7.9)	17 (13.9)	54 (8.6)
Lower risk of sustaining an injury	20 (5.0)	8 (7.9)	5 (4.1%)	33 (5.3)
Lower physical fatigue	18 (4.5)	0 (0)	0 (0)	18 (2.9)
Suitable for teaching football	0 (0)	11 (10.9)	0 (0)	11 (1.8)
Perception of pitch markings	0 (0)	0 (0)	6 (4.9)	6 (1.0)
<i>Don't know/refusal</i>	48 (11.9)	9 (8.9)	20 (16.4)	77 (12.3)
Disadvantages of artificial turf				
Skin abrasion (sliding tackles)	160 (39.6)	20 (19.8)	28 (23.0)	208 (33.2)
Playing at high temperatures	64 (15.8)	12 (11.9)	10 (8.2)	86 (13.7)
Risk of sustaining an injury	43 (10.6)	18 (17.8)	25 (20.5)	86 (13.7)
Worst sporting performance	36 (8.9)	12 (11.9)	12 (9.8)	60 (9.6)
Dangerous components (Hydrant, artificial turf joints, etc.)	20 (5.0)	5 (5.0)	11 (9.0)	36 (5.7)
Rapid deterioration	19 (4.7)	6 (5.9)	7 (5.7)	32 (5.1)
Better natural turf in good state	9 (2.2)	19 (18.8)	1 (0.8)	29 (4.6)
<i>Don't know/refusal</i>	53 (13.1)	9 (8.9)	28 (23.0)	90 (14.3)
Preferences %				
Artificial turf	25.5	42.6	27.0	31.72
Natural turf	41.3	29.7	46.7	39.23
Both surfaces	33.2	27.7	26.2	29.04

surface (Steffen et al., 2007). Ekstrand et al. (2006) state that in artificial turf, there is significantly greater risk of ankle injury but less risk of muscle injury. Also, other studies (Pasanen, Parkkari, Rossi, & Kannus, 2008) show that there is an increased risk of injury in artificial turf caused by increased friction surface of the footwear. The type of studs and their distribution on the sole modify the resistance to frictional forces (Bentley, Ramanathan, Arnold, Wang, & Abboud, 2011; Kernozek & Zimmer, 2000). By contrast, according to Steffen et al. (2007) and Meyers (2010), the latest generation of artificial turf is safer to play because of the lower frequency and severity of injury. It should be clarified that most of these studies have not specified whether the sample of artificial turf fields (very small in some cases) passed the quality control of international certification services (EN or FIFA Quality Concept) because the percentage of fields certified by FIFA Quality Concept 2009 (1 or 2 stars) did not even reach a trifling 1.5% of the total in Europe.

All the participants displayed a noteworthy degree of dissatisfaction with regard to the three aspects surveyed concerning safety, principally with regard to skin abrasion, with an average mark of 2–3 out of 10, which shows that this aspect is very poor. Skin abrasion was also the biggest disadvantage of artificial turf over other surfaces for most participants, as was the case in other studies (Chivers, 2008; Meyers & Barnhill, 2004; Zanetti, 2009), because it may cause abrasions or friction burns. Although

third-generation artificial turf fields have considerably reduced the incidents of skin abrasion in the interaction between player and surface, the problem has not disappeared (Steffen et al., 2007). Alcántara, Gámez, Rosa, and Sanchís (2009) pointed out that this was the main disadvantage over natural turf for both FIFA and Union of European Football Associations (UEFA). Skin abrasion is one of the main aspects currently being addressed in the improvement of synthetic surfaces (McNitt, 2005). Many laboratories and companies are working on new fibres, such as lineal low-density polyethylene (LLDPE), to reduce skin abrasion in artificial turf (Sandkuehler, Torres, & Allgeuer, 2010; Torres, Sandkuehler, Garcia Muenzer, & Allgeuer, 2010).

Sporting feature

Sports feature is crucial in ultimate sporting performance (Hughes & Franks, 2005). This being so, sporting feature and better performance on artificial turf are two of the main advantages cited by the participants. The parameter of greatest satisfaction was the visibility of pitch markings on artificial turf, together with the evenness of the pitch and the state of conservation (preservation). The treatment against UVA rays has been one of the most improved features of artificial turf fibre (Foster, 2007). This treatment began to be applied in third-generation artificial turf. Since the fibre's resistance against

Table IV. Pearson's test of satisfaction with artificial turf pitches and Satisfaction of users based on the surface preference

Satisfaction with artificial turf pitches		$\bar{X}_{(s)}$	Players			Coaches			Referees		
			Pearson χ^2	Significance	$\bar{X}_{(s)}$	Pearson χ^2	Significance	$\bar{X}_{(s)}$	Pearson χ^2	Significance	
Age	16–19 years	7.93 (1.42)	82.861	0.000**	–	28.018	0.014*	7.70 (1.53)	25.598	0.541	
	20–25 years	7.50 (1.56)			8.53 (0.92)			7.53 (1.66)			
	26–35 years	7.09 (2.04)			7.19 (1.70)			7.38 (1.58)			
	> 36 years	5.53 (2.42)			7.65 (1.42)			7.44 (2.25)			
Level	Youth sport	8.05 (1.33)	90.885	0.000**	8.15 (1.52)	38.222	0.000**	8.05 (1.70)	32.847	0.017*	
	Regional	7.50 (1.60)			6.90 (1.23)			7.38 (1.85)			
	National	5.77 (2.43)			7.50 (1.51)			7.48 (1.44)			
Experience with artificial turf	1–3 years	6.66 (2.21)	25.127	0.003**	7.54 (1.47)	4.538	0.716	7.40 (2.02)	8.943	0.443	
	> 3 years	7.51 (1.75)			7.84 (1.70)			7.62 (1.45)			
Previous playing surface	Natural turf	6.10 (2.21)	90.723	0.000**	7.00 (1.63)	13.284	0.039*	6.18 (1.68)	40.267	0.000**	
	Dirt pitches	7.83 (1.51)			7.98 (1.34)			7.94 (1.48)			
Sport surface preference											
		Sport surface preference									
		Artificial turf $\bar{X}_{(s)}$	Natural turf $\bar{X}_{(s)}$	Both $\bar{X}_{(s)}$	Pearson χ^2	df	Asymptotic significance (two-tailed)				
Satisfaction with artificial turf $\bar{X}_{(SD)}$	Players	8.37 (0.99)	5.70 (2.11)	7.99 (1.19)	169.2	18	0.000**				
	Coaches	8.23 (1.17)	6.50 (1.48)	7.89 (1.43)	32.3	14	0.004**				
	Referees	8.52 (1.00)	6.67 (1.87)	8.06 (1.05)	35.6	18	0.008**				

* $p < 0.05$; ** $p < 0.01$.

direct sunlight is increased, the field has a better appearance (Foster, 2007).

There is another aspect where there are certain differences in users' perception, the ball interaction variables (bounce, movement along the ground, control, among others). In general, moderate satisfaction was displayed for these aspects (with mean scores between 6 and 8). Burillo (2009) stressed that the new generation of artificial turf met needs related to the bounce and roll of the ball, as against previous generations, considered to be less practical and more uncertain for the players. Similarly, FIFA (2007c) conducted various studies analyzing the performance and run of play in competitions on artificial turf, and there were clear similarities with natural turf in most aspects (including ball possession, control, and attacking play). However, these studies were conducted on 2-star (FIFA-certified) artificial turf fields that comprise a trifling proportion of pitches in the world. Similarly, in other studies, in which the quality of artificial turf is not specified, there were significant differences in a better ball roll, ball bounce and player-surface on natural surfaces (Martinez et al., 2004; Stiles et al., 2009).

But we cannot assume that all artificial turf is the same, and that all natural turf is the same. The performance of an artificial turf field depends on the type of components used, the way they are installed on site, the intensity of usage a surface is subjected to and the maintenance carried out (Alcántara et al., 2009; Martinez et al., 2004). There exists huge variability in the products available (fibres and rubber infill) that could change the mechanical properties of the field. For example, the types of infill or the greater density in the infill system clearly affect the maximum traction generated by the surface (Severn, Fleming, Clarke, & Carré, 2011). Similarly, the larger size of the rubber infill increases the impact forces and the ball bounce (Alcántara et al., 2009). To ensure a surface is delivering the anticipated acceptable levels of performance owners should make a good choice of the surface components and it may be tested throughout its life.

The variables relating to play in extreme weather conditions (high temperatures or snow-covered pitch) were the most unfavourable aspects of sporting feature. Zanetti (2009) stated that players usually preferred to play on artificial turf when the weather was mild or cold. Thus, playing in high temperatures was one of the main disadvantages expressed by the participants. Zanetti (2009) noticed this problem; particularly in areas with extreme temperatures (Africa, Asia, southern European countries, etc.). In contrast, natural turf acts as a regulator of both temperature and moisture (Orchard, 2002). For this reason, FIFA (2007b) recommends irrigation for pitches wherever the temperatures are high and

rainfall is scarce. Watering the turf, as well as improving the pitch conditions, lubricates the fibre, thereby helping to minimise potential skin abrasions, cools the surface, and also stabilises the infill, thus preventing any dispersion thereof (FIFA, 2007b; Simon, 2010). Consideration should be given to innovation in fibres and thermoplastic infills, natural materials (including cork and coconut fibre, among others), watering the surface prior to a game and replacing asphalt-type underlays, in order to reduce the surface temperature, as has been shown in other studies (McNitt, Petrunak, & Serensits, 2008; Williams & Pulley, 2002), and thus imitate the surrounding thermoregulation properties of natural turf.

However, the coaches considered that artificial turf was highly suitable for youth or amateur football, and went so far as not to rule out its suitability for professional competitions. Various studies (Burillo, 2009; ESTO, 2008) noted that in its early days artificial turf was not highly thought of by sports federations, but now this perception has changed and this surface is beginning to be positively considered for any type or category of competition.

Satisfaction

Participants (players, coaches and referees) were satisfied with the artificial turf surface they used frequently. In the three groups, approximately three out of four participants gave an overall ranking of highly satisfied for artificial turf (marks between 7 and 10). This may be attributed to the development of football in Spain, where in the last 20 years, the vast majority of amateur and semi-professional pitches were dirt pitches, with very few natural turf grounds (let alone those in perfect condition) (Burillo, 2009). Two out of three participants stated that, looking back on their playing days, most of their games/training sessions were carried out on dirt surface.

The overall satisfaction with artificial turf fields was strongly influenced by previous experience, which represented a major change for most of the participants (particularly those who had previously played on dirt pitches). These participants perceived that their sporting performance had improved, and this has had a positive bearing on their satisfaction. In Zanetti's study (2009), the participants gave a significantly higher ranking to artificial turf surfaces compared to dirt pitches in almost all the factors analysed. In addition, the participants expressed that artificial turf fields have a higher utilisation and hours of use. Time that previously was usually restricted to high-level teams (McNitt, 2005). There is no doubt that the introduction of this third-generation synthetic surface in football has been a

major step forward from dirt pitches. Several authors (Foster, 2007; Martinez et al., 2004; O'Donnell, 2008; Zanetti, 2009) indicate that the artificial turf football fields have over three main advantages over other surfaces: 1. the resistance to adverse weather conditions. The drainage system causes the water is evacuated rapidly and the floods are nearly impossible after abundant rains. Also, it allows that the snow could be removed without damaging the pitch; 2. the behaviour of the ball on the surface. The ball interacts with the field uniformly, without any strange element that impairs its movement; 3. the homogeneity of the properties of the field. It causes that 'player-surface' interaction and 'ball-surface' interaction are safe and reliable.

There was different perception of satisfaction among participants depending on their level within the three groups (players $p < 0.01$; coaches $p < 0.01$; referees $p < 0.05$). Overall satisfaction has increased when the participants' level decreased. Furthermore, the youngest users expressed an overall satisfaction for artificial turf that was significantly higher, and this evaluation became progressively smaller the older the participant. This may be explained by the substantial improvement to be found on artificial turf pitches in the last 10 years, and their incorporation above all into youth football (FIFA, 2007a; McNitt, 2005). For the *Youth Sport* group, it may be possible that artificial turf is the best known sports surface. The youngest users (and thus the ones with the least playing experience) went straight from playing on dirt or natural turf pitches (usually in poor condition) to third-generation artificial turf surfaces, without the negative experience of first- and second-generation surfaces (Burillo, 2009; O'Donnell, 2008).

Similarly, among the coaches, we found it significant that 84% of them had never had to cancel a training session because of the condition of an artificial turf pitch. The training session is a cornerstone criterion as far as coaches are concerned. The chance to improve the team, where the coach has more control and power of decision, comes during a training session on the pitch (Burillo, 2009). Thus, the satisfaction of the coaches rest on the low incidence of training session cancellations due to the state of the artificial turf.

Preference

Artificial turf can be said to be widely accepted, as it was chosen as one of the favourite surfaces for football by 60% of participants in the study of the three possible options (the 31% chose artificial turf and the 29% chose both, artificial and natural surfaces). However, while artificial turf received a joint satisfaction ranking that was moderately high,

natural turf was favoured by 40% of participants (reaching the 69% if we add the 29% of both surfaces). We found significant correlations between the choice of ideal surface for football and the perception of overall satisfaction for artificial turf for the three groups ($p < 0.01$). Participants whose ranking for artificial turf was excellent or very satisfactory opted for this surface. On the other hand, participants whose overall satisfaction ran from moderate to low (scores of 5–8 points on the scale 1–10) expressed a preference for natural turf. This makes us reflect on that artificial turf fields are well perceived by many football users, although some of them, especially players, still prefer to play on natural turf.

Furthermore, participants who had mostly played on natural turf fields still had a certain preference for that surface, even though currently they may have been training/playing on artificial turf. Apparently, the biggest obstacle for acceptance of artificial turf was the user's prior experience. Previous studies (Martinez et al., 2004; Meyers & Barnhill, 2004; Schlegel, 2009) consider that changing natural turf to artificial turf could be negative for football players in the beginning, regardless of the time they have been playing in artificial turf, because their football training has been developed in another kind of surface. In view of the fact that youth football is mainly played on artificial turf fields today, it seems fair to predict that future discrepancies between artificial and natural surfaces will progressively decrease, and the introduction of artificial turf in first-class football will be less traumatic. As Stiles et al. (2009) state, artificial turf is gradually removing natural turf from its leadership in many sports. However, it is worth noting that the results of this study come from 'user group' who compete and train in Mediterranean climate regions or South Europe. It is possible that in other regions such as Central and North Europe, where the state of natural turf fields is often excellent due to a higher average rainfall and lower average temperature, the perceptions are different.

Conclusion

Artificial turf has been gradually meeting a large proportion of footballers' demands, especially in non-federated leagues (youth football, local leagues, seven-a-side, veterans and so on). Football stakeholders, the coaches and referees in particular, are extremely satisfied with artificial turf football fields. Approximately three out of four participants gave an overall ranking of highly satisfied. The overall satisfaction with artificial turf fields was strongly influenced by previous experience, particularly those who had previously played on dirt pitches. Although

majority of the participants who were used to natural turf pitches still prefer that surface, there is a noticeable trend of appreciation for artificial turf. The perception of artificial turf was positive in most of the variables analysed, especially among the younger participants. Furthermore, artificial turf had a 60% acceptance rate as the ideal surface for football (particularly among coaches) and it is very close to the level of natural turf (69% acceptance).

The main advantages of artificial turf were its sporting feature and the fact that it made for improved performance, its good state of conservation and the visibility of pitch markings. The vast majority of coaches had never had to cancel a training session because of the condition of an artificial turf pitch. On the other hand, the main disadvantages were skin abrasions and playing in high temperatures. These results highlight the versatility of artificial turf to adapt to any circumstance or requirement for local sport and top-level professional competitions alike. However, the future success of artificial turf pitches will be also linked to a regular maintenance and a supervision of the technical, biomechanics and security properties that can improve the fields' quality and user satisfaction.

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