Third generation artificial pitch quality in commercial football centers

EMERY, Jim <http://orcid.org/0000-0002-4272-1610>, DRISCOLL, Heather F, BARNES, Andrew <http://orcid.org/0000-0001-8262-5132> and JAMES, David <http://orcid.org/0000-0002-1135-626X>

Published version

EMERY, Jim, DRISCOLL, Heather F, BARNES, Andrew and JAMES, David (2016). Third generation artificial pitch quality in commercial football centers. Procedia Engineering, 147, 860-865.

Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 147 (2016) 860 – 865

Procedia Engineering

www.elsevier.com/locate/procedia

11th conference of the International Sports Engineering Association, ISEA 2016

Third generation artificial pitch quality in commercial football centers

Jim Emery[a*], Heather F. Driscoll[b], Andrew Barnes[c], David M. James[a]

[a]*Centre for Sports Engineering Research, Sheffield Hallam University, Sheffield, S10 2BP, UK*
[b]*School of Engineering, Manchester Metropolitan University, Manchester, M1 5GD, UK*
[c] *Academy of Sport and Physical Activity, Sheffield Hallam University, Sheffield, S10 2BP, UK*

Abstract

Small sided football is the most popular and fastest growing area of adult football in the UK with an estimated 1.5m adults playing every week. The sport's popularity has led to an influx of commercial football centers offering organized 5, 6 and 7-a-side leagues on third generation artificial pitches.

The range of quality and maintenance of these pitches is not fully understood despite the established links between surface quality, player performance and injury. Currently researchers and manufacturers use national governing body standards as guidelines for quality; however, many commercial centers are not approved by governing bodies and therefore are not obliged to meet these criteria.

In this paper we characterize the quality of 23 pitches at five, UK based, commercial football centers using portable, low cost methods including; the FIFA rotational resistance test, the Clegg Impact Hammer and an infill depth probe. This paper describes the range of qualities observed, alongside maintenance procedures and usage statistics.

To the authors knowledge this is the first study that characterizes commercial football center pitches. Twenty-two of the 23 pitches met the FIFA 1 star guidelines for rotational resistance (25 - 50 Nm), however, mean Clegg Impact Hammer readings are high (208 G), suggesting surface compliance in commercial centers falls outside FIFA standards. Within pitch variance was common at all centers and was an order of magnitude higher in some pitch comparisons. These findings have two practical implications; 1) pitch quality and maintenance at commercial centers is highly variable across and within pitches, 2) the harder surfaces and the high levels of variability found in commercial football centers suggests that players require footwear researched and designed specifically for these conditions.

Peer-review under responsibility of the organizing committee of ISEA 2016

Keywords: Surfaces; Clegg Hammer; traction; footwear

1. Introduction

According to Sport England's Active People Survey [1] approximately 58% of adult players take part in small sided games compared to 34% playing it's more traditional 11-a-side equivalent. Small sided games include 5, 6 and 7-a-side matches played on smaller artificial pitches with varying rules. There has been an influx of commercial, rather than municipal or institutional, football centers catering for this more popular game. These centers are often, but not exclusively, franchises offering; organized leagues at a variety of ability levels, changing facilities, televised matches and bars for refreshments after the match. Little is known about the characteristics of these pitches when compared to their elite or institutional counterparts despite the games popularity [2].

The absence of standards for commercial football pitches compounds the problem of unknown surface quality. The recently developed Football Association (FA) accreditation scheme requires pitches to be 'suitable and safe for small sided football' yet provides no surface testing or maintenance guidelines. Fédération Internationale de Football Association (FIFA) offers quality guidelines in the form of one and two star surface accreditation [3]. These FIFA standards are compulsory for match play and training in some professional leagues. The FIFA standards are also often used as a benchmark of pitch quality for research and equipment design purposes even though many commercial pitch providers are not obliged to meet these standards.

---

* Corresponding author:. j.emery@shu.ac.uk

Peer-review under responsibility of the organizing committee of ISEA 2016
doi:10.1016/j.proeng.2016.06.289

Epidemiological studies linking surface characteristics with injury risk are often conflicting with no conclusive evidence to suggest that artificial surfaces are more or less likely to cause injury than natural grass surfaces [4,5]. It has been suggested that inconsistencies across a pitch could pose a greater injury risk than homogeneous 'good' or 'bad' pitch quality due to their unpredictability [6]. The same authors suggested that the degradation of rotational traction throughout a season may be the mechanism for lower injury prevalence later on in a football season [6]. Similarly, the variance of floor response within a spring dance floor has been found to have a stronger association with injury risk than mean floor force reduction magnitude [7], suggesting that variance in pitch hardness may have similar injury risk associations.

Surface quality is widely researched and includes investigations into fibers, infill materials, shock pads, wear and degradation [2,8–10]; however, the number of studies including player testing is limited [11–13]. There is a growing body of work suggesting that optimal levels of traction may exist for individuals in other sports [13,14] which is inextricably linked to the surface because it is the interaction between the shoe and surface which generates traction forces [2]. Current evidence suggests that this 'optimal' traction level would be unique to movement, player physiology, footwear and surface.

The growing popularity of small sided football and the current lack of pitch regulations at commercial football centers provide the motivation for this research. This paper presents the current state of commercial small sided football pitches in northern England alongside usage data and anecdotal maintenance reports. This information offers researchers and developers 'real world' information to re-align their products and practices to this more popular game.

2. Method

Data were collected on 23 pitches at five commercial football centers in northern England. All pitches were surfaced with third generation artificial turf; to maintain anonymity centers did not release the physical make-up of each pitch. In general pitches were made up of four constituent parts, a sand and rubber infill material, a carpet surface, a shock-pad and a sub-base. All pitches were outdoor so suffered environmental degradation from sunlight, organic matter and temperature fluctuation (-10 to +30 °C) as well as litter and mechanical wear from use. Testing took place on dry days at temperatures between 3.5 and 11.7°C.

Measures of hardness, traction, infill depth, moisture and environmental conditions were collected using a FIFA rotational traction test device, Clegg Impact Hammer, infill depth probe, soil moisture probe and thermometer respectively. Moisture results are not presented here. Figure 1a shows the FIFA standard rotational traction test. It consists of a rigid disc with six equally spaced studs, a standard total mass of 46 kg (450 N), and is rotated manually with a calibrated torque wrench. The weighted disc is initially dropped on to the test surface from a height of 60 +/25 mm to aid penetration of the studs into the surface. Rotational torque is then applied by the operator (a rate of 12 revolutions per minute is specified or 72 rad.s^{-1}) and the maximum torque value recorded. Tests were performed in new locations to avoid previous tests affecting the outcome.

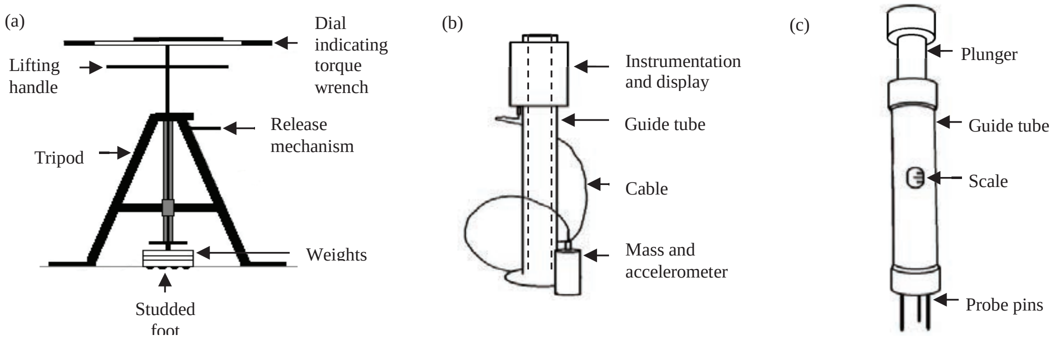

Fig. 1. (a) FIFA rotational traction test device; (b) 0.5 kg Clegg Impact Hammer; (c) infill depth probe.

A Clegg impact hammer (Fig. 1b) was used with a 0.5 kg cylindrical, flat faced mass attached to an accelerometer [15] as recommended for the assessment of natural grass pitches by the FA [16]. Normal impacts were carried out from a 0.55 m drop height. The device's instrumentation samples the accelerometer signal and displays the peak deceleration after each drop in gravities (g). Drops were always performed at new locations to avoid surface compaction from previous tests affecting the outcome. Although not currently a FIFA method for assessing sports surfaces, the Clegg impact hammer has been used in the past to measure sports surfaces as a comparison to the artificial athlete [2]. The test devices availability and portability justified its use in this project.

The infill depth probe (Fig. 1c) consists of three pins fixed to a plunger handle, when these pins slide through their guide tube the extension distance can be read from the scale. In use, the guide tube is placed flat on the pitch and the plunger handle pressed, the pins extend through the infill until they meet the rubber backing of the fiber carpet. The distance of penetration is a proxy for the infill depth.

Test procedures at each football center followed FIFAs protocol for rotational resistance testing [3]. Figure 2a shows the test locations used. The pitches tested varied in size so exact locations are given in terms of percentage of width (w) and length (l); 1

(10% l, 10% w), 2 (10% l, 50% w), 3 (25% l, 50% w), 4 (50% l, 50% w), 5 (75% l, 85% w), 6 (85% l, 50% w). Five repeats of rotational traction and Clegg Hammer tests were carried out at each of the six locations. An undisturbed area of pitch was used for each as shown in Figure 2b. This minimized the influence of previous tests [17]. The mean of the five rotational traction and Clegg Hammer tests was used to represent surface traction and hardness respectively. Infill depth was measured once at each of the six locations.

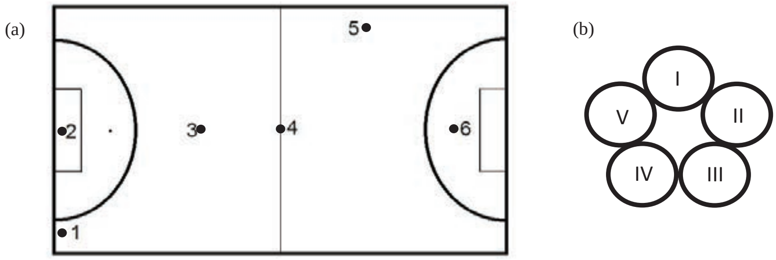

Fig. 2. (a) test locations on the pitch, (b) pattern of measures used to avoid influence of previous tests

Non-parametric statistical tests were used due to the lack of homogeneity in variance between groups. Kruskal-Wallis and post hoc Mann-Whitney tests were used to compare rotational traction, hardness or infill depth within centers or within pitch locations. Bonferroni adjusted levels of significance within football center were $P < 0.005$ and within pitch location were $P < 0.0033$. Spearman's correlation coefficient was used to compare hardness and infill depth.

3. Results

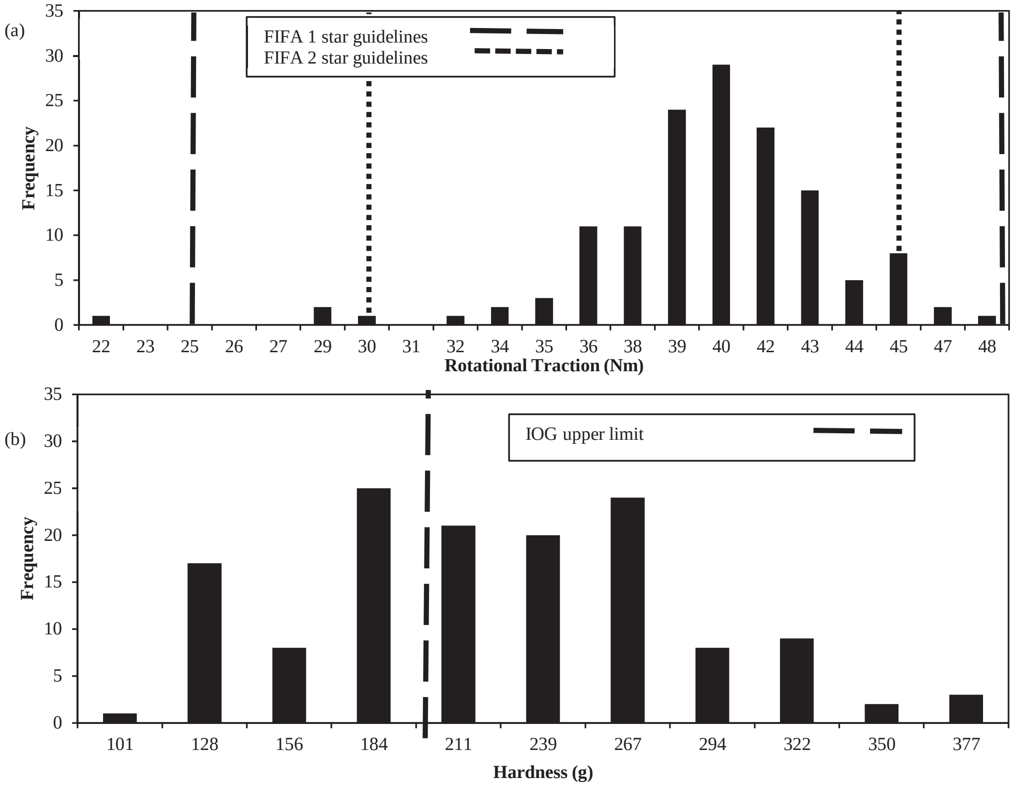

Fig. 3. The distribution profiles all pitch measures of; (a) rotational traction results with respect to the FIFA 1 & 2 star guidelines (25 to 50 & 2 30 to 45 Nm respectively); (b) surface hardness results with respect to the Institute of Groundmanship's (IOG) maintenance upper limit

Figure 3a shows the distribution of 138 rotational traction tests across all centers, pitches and pitch locations with respect to FIFA 1 & 2 star guidelines [3]. Twenty-two of the 23 pitches tested met the FIFA 1 star guidelines for rotational traction (25 to 50 Nm), 15 of which also met the FIFA 2 star guidelines (30 to 45 Nm). The limiting factor for 1 star quality was low traction, though this result seems to be an outlier (fig 3a). The eight pitches that failed to meet FIFA 2 star guidelines were excluded due to low (six pitches) or high traction (two pitches) results.

Figure 3b shows the distribution of 138 surface hardness tests across all centers, pitches and pitch locations with respect to the upper bounds of; the FA's natural grass recommendations to the Institute of Groundsmansip [16]. Sixty two tests (45%) fell within the FA's standards (5 - 200 g).

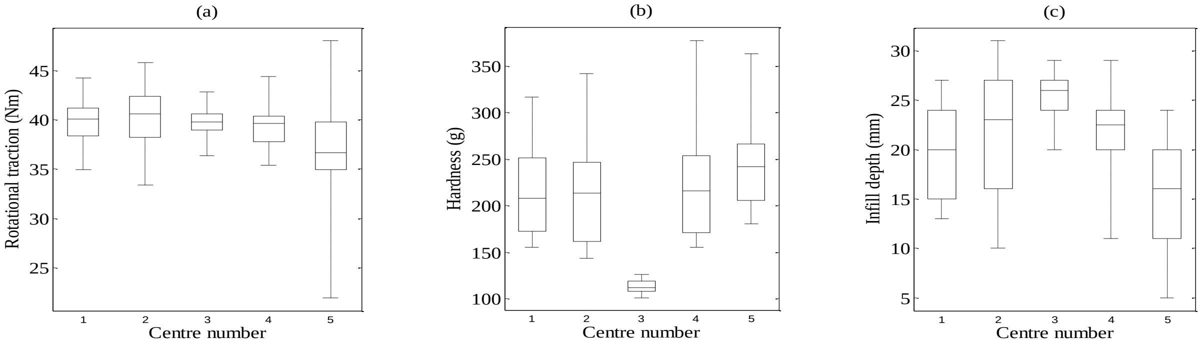

Fig. 4. Surface measures with respect to commercial football center number; (a) rotational traction, (b) hardness, (c) infill depth.

Figure 4 shows the median (horizontal black line), interquartile range (white box) and lower and upper quartile (whiskers) of the three quality measures grouped by football center. Statistically, the rotational traction at center 5 was significantly different to centers 1 and 2 (Fig 4a). In figure 4b, the surface hardness at center three was found to be significantly different to all other centers. Figure 4c shows infill depth, center five was significantly different to center 2, 3 & 4, and center three was significantly different to centers 1, 4 & 5.

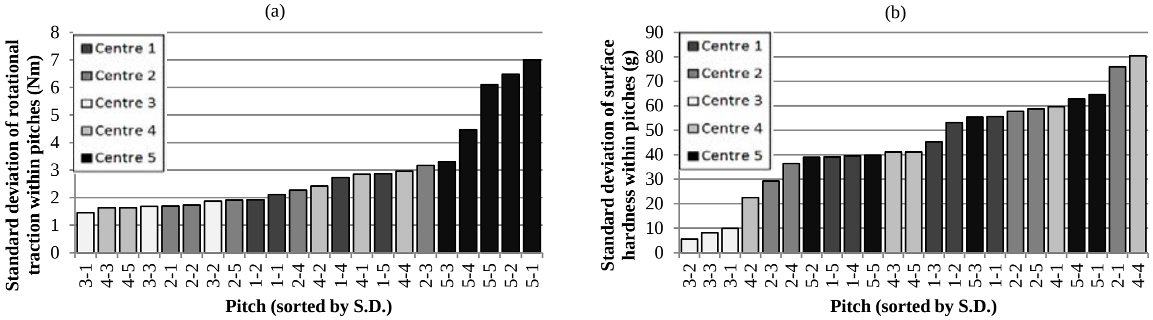

Fig. 5. Standard deviation of measures of each pitch (football center - pitch) sorted from smallest to largest; (a) rotational traction, (b) hardness.

Figure 5 shows the magnitude of variance in rotational traction within pitches. Centre 5's pitches have the five highest rotational traction variance, whereas, center 3's pitches have the three lowest surface hardness variation.

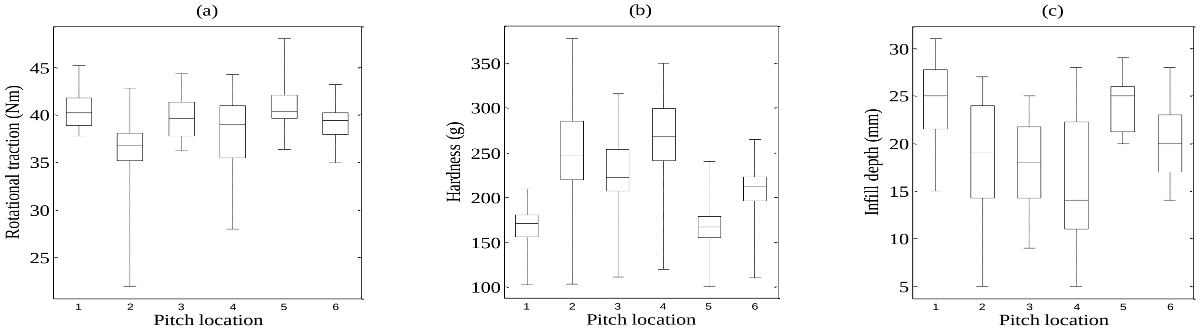

Fig. 6. Surface measures with respect to pitch location; (a) rotational traction, (b) hardness, (c) infill depth.

Figure 6 shows the median (horizontal black line), interquartile range (white box) and lower and upper quartile (whiskers) of the three quality measures grouped by pitch location (Fig. 2a). Statistically, the rotational traction at location 2 was significantly different to location 1 and 6 (Fig. 6a). In figure 6b, no significant differences were identified between locations (1 & 5) or (2, 3 & 4). Figure 6c shows infill depth, locations 1 & 5 were significantly different to locations 2, 3, & 4.

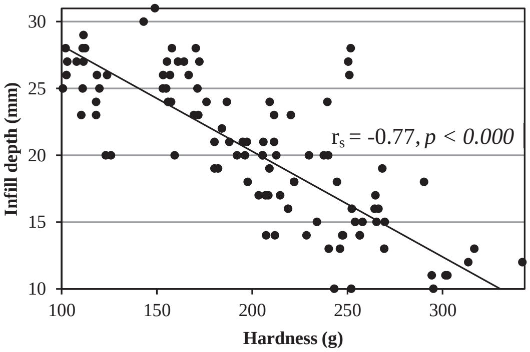

Fig. 7. Bivariate plot of infill depth and hardness with Spearman's rank coefficient.

Figure 7 shows the linear correlation between infill depth and surface hardness. The Spearman's rank correlation revealed that surface hardness is negatively related to infill depth, $r_s = -0.77$, $p < 0.000$.

Full usage profiles cannot be disclosed for reasons of confidentiality but there were three general patterns as shown in Table 1.

Table 1. Football center usage models.

Usage model	Centre numbers	Approximate weekday occupancy (%)			Approximate weekend occupancy (%)			Hours of play per pitch per week
		Morning	Afternoon	Evening	Morning	Afternoon	Evening	
1	1 & 5	25	50	75	10	50	50	12
2	4	0	10	75	10	50	75	10
3	2 & 3	10	10	50	10	25	50	7

The groundskeepers at each center would not reveal full maintenance schedules, however, anecdotal evidence suggests that centers one to four carried out very thorough pitch reconditioning including rubber crumb replacement and redistribution within one month of testing. Centre five's pitches had not been maintained for at least two years.

4. Discussion

All pitches with the exception of one fall within the FIFA 1 star standard for rotational traction, however, if the FIFA standards are considered as upper and lower safety bounds then almost all of these results fall within the upper two-thirds of this range. This suggests that, in general, the rotational traction of recreational small sided pitches errs on the higher side of governing bodies' recommendations. Higher rotational traction has often been associated with greater injury risk [2] due to potential foot fixation and resulting higher joint moments [6], however, recent findings suggest that the utilized traction forces measured during player testing are similar across a range of surfaces and therefore might be player, rather than surface, driven [12].

Hardness results were generally high (mean 209 g), 18 of the 23 pitches tested were above the FA's recommended upper limit. This could be attributed to several factors; 1) compaction, 2) infill removal through play, 3) deterioration over time [18]. Twomey et al.'s [19] findings suggest that unacceptably hard pitches were not the cause of acute injuries but it is possible that repeated play on hard surfaces may be a chronic injury risk factor [20]. In performance terms, softer surfaces have been found to decrease performance in sprints and have no effect on cutting maneuvers [11].

The inter-center comparison identified clear differences in rotational traction and infill at centers five and three respectively. Centre five stands out due to the large variance of traction values and center three for the low variance and mean value of hardness. Whilst there was no evidence to suggest that center five had dangerously low mean traction or high mean hardness values, the variance of traction and hardness was very high which may increase injury risk due to the unpredictable and inconsistent surface response [6,7]. Conversely, center three had the most homogenous hardness readings within pitches and low mean hardness. There are two identifiable factors which suggest why pitches three and five might have such vastly differing variances; 1) maintenance, 2) average weekly playing time. Centre five had performed no maintenance in two years despite having one of the highest average playing times, center three had performed very thorough pitch re-conditioning prior to testing and had one of the lowest average playing times.

The differences identified between within pitch test locations reflect previously reported pitch wear models [21] and present a compelling argument for groundskeepers to maintain rubber crumb levels across the entire pitch and pay particular attention to the more central high wear areas. Furthermore, the correlation between infill levels and surface hardness provide evidence that a cheaper, more portable and easy to use infill depth probe could be used as a proxy for hardness for centers that do not have access to a Clegg hammer or Berlin Artificial Athlete.

The scope of this study was limited due to the commercial sensitivity of comprehensive surface data. The following information is required to deliver more detailed recommendations for the upkeep of commercial pitches; original product specifications, full maintenance history, full usage history. Despite the absence of this information, this paper offers valuable insight into the current state of commercial football center's pitch qualities in the UK and provides researchers and footwear developers with data to realign their current practices from the 'ideal' pitch to these more common and popular examples.

Future work aims to establish better links with commercial providers and gain access to more detailed installation and maintenance information as well as conduct more thorough pitch evaluations including tests which represent the boundary conditions thought to precede injury.

5. Conclusion

To the authors knowledge this is the first study that characterizes commercial football center pitches. Twenty-two of the 23 pitches met the FIFA 1 star guidelines for rotational resistance (25 - 50 Nm), however, mean Clegg Impact Hammer readings are high (208 G), suggesting surface compliance in commercial centers falls outside FIFA standards. Within pitch variance was common at all centers and was an order of magnitude higher in some pitch comparisons. These findings have two practical implications; 1) pitch quality and maintenance at commercial centers is highly variable across and within pitches, 2) the harder surfaces and the high levels of variability found in commercial football centers suggests that players require footwear researched and designed specifically for these conditions.

6. References

[1] Sport England. Active People Survey 2015.

[2] Fleming P. Artificial Turf Systems for Sport Surfaces: Current Knowledge and Research Needs. Proc Inst Mech Eng Part P J Sport Eng Technol 2011;225:43–63.

[3] Fédération Internationale de Football Association. Handbook of Test Methods. Zurich: 2012.

[4] Ekstrand J, Timpka T, Hagglund M, Karlsson J. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study * Commentary. Br J Sports Med 2006;40:975–80.

[5] Meyers MC. Incidence, Causes, and Severity of High School Football Injuries on FieldTurf Versus Natural Grass: A 5-Year Prospective Study. Am J Sports Med 2004;32:1626–38.

[6] Wannop J, Luo G, Stefanyshyn D. Footwear traction at different areas on artificial and natural grass fields. Sport Eng 2012;15:111–6.

[7] Hopper LS, Allen N, Wyon M, Alderson J a., Elliott BC, Ackland TR. Dance floor mechanical properties and dancer injuries in a touring professional ballet company. J Sci Med Sport 2014;17:29–33.

[8] Severn K., Fleming P, Clarke JD, Carre MJ. Science of synthetic turf surfaces: investigating traction behaviour. Proc Inst Mech Eng Part P J Sport Eng Technol 2011;225:147–58.

[9] Clarke JD, Severn KA, Fleming PR, Carré MJ. The effect of physical make-up on the traction performance of third- generation artificial turf surfaces. In: Fleming PR, Forrester SE, editors. 2nd Int. Conf. Sport. Netw., Loughborough: 2010, p. 1–10.

[10] Forrester SE, Tsui F. Spatial and temporal analysis of surface hardness across a third-generation artificial turf pitch over a year. Proc Inst Mech Eng Part P J Sport Eng Technol 2014;228:213–20.

[11] Schrier NM, Wannop JW, Lewinson RT, Worobets J, Stefanyshyn D. Shoe traction and surface compliance affect performance of soccer-related movements. Footwear Sci 2014;6:69–80.

[12] McGhie D, Ettema G. Biomechanical analysis of traction at the shoe-surface interface on third-generation artificial turf. Sport Eng 2013;16:71–80.

[13] Sterzing T, Müller C, Hennig EM, Milani TL. Actual and perceived running performance in soccer shoes: A series of eight studies. Footwear Sci 2009;1:5–17.

[14] Luo G, Stefanyshyn D. Identification of critical traction values for maximum athletic performance. Footwear Sci 2011:37–41.

[15] Clegg B. An impact testing device for in situ base course evaluation. Aust. Road Res. Bur. Proc., 1976, p. 1–6.

[16] Football Association, Institute of Groundmanship. Guidelines for the preperation & mainenance of football pitches. 2009.

[17] Twomey DM, Ullah S, Petrass LA. One, two, three or four: Does the number of Clegg hammer drops alter ground hardness readings on natural grass? Proc. Inst. Mech. Eng. Part P J. Sport. Eng. Technol., 2014, p. 33–9.

[18] Jan-Kieft G. Quality Monitoring of 50 Artificial Turf Fields. Sport 7th Work "Maintaining Perform Synth Surfaces" 2009.

[19] Twomey DM. Is there a link between Injury and Ground Conditions? A Case Study in Australian Football. Proc. Second Inter-national Conf. Sci. Technol. Res. Sport Surfaces, Loughborough: 2010.

[20] Wong P, Hong Y. Soccer injury in the lower extremities. Br J Sports Med 2005;39:473–82.

[21] McLaren NJ, Fleming PR, Forrester S. Artificial grass: A longitudinal study on ball roll and free pile height. Procedia Eng., Sheffield: 2014, p. 871–6.