Test Devices for the Evaluation of Synthetic Turf Pitches for Field Hockey

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Abstract. Many existing tests for field hockey can be categorized into; how the ball, and how a person interacts with the surface. Interactions during sporting activities can significantly influence how a game is played from both a technical and tactical perspective. Understanding interactions of this nature and identifying factors that can influence and control their performance is essential to comprehend the mechanical behavior of a sports surface. However, synthetic turf pitches are complex structures, comprising several layers, all of which contribute to their composite behavior. Therefore, the mechanical response of the surface to interactions is difficult to measure. It has been argued by many researchers that mechanical tests are inappropriate to simulate in-game conditions and their suitability has been brought into question. Furthermore, there is a lack of good quality peer reviewed data on the mechanical behavior of synthetic turf pitches. Test data are collected by accredited laboratories for the relevant sports governing body, with the data remaining unpublished, thus there is no way to validate or recommend improvements to these standards. Consequently, this paper presents results from a comprehensive program of testing on six world class synthetic turf pitches used for field hockey. Current test equipment and methods employed by the governing body for field hockey (FIH) were validated and recommendations were formulated for their suitability. It was found that impact tests, including the Berlin Artificial Athlete, provided a simple means to classify one pitch against another and gave a significant difference between the six pitches. A review of ball interaction tests, including vertical ball rebound, and ball roll were found to be significantly influenced by environmental factors such as moisture and wind, which highlighted the importance of careful monitoring during testing to ensure pitches were evaluated in approved conditions. In conclusion, current mechanical tests provide a simple and effective way to classify one pitch directly against another. However, their use for determining how the surface behaves in a 'real' game situation and the mechanical information obtained is considered limited

1 Introduction

Synthetic turf pitches are complex structures with several layers, all of which contribute to their composite behavior. Therefore, the mechanical response of the surface to interactions from players, balls and sports equipment are difficult to assess. Impacts involving sports objects, such as a ball or the player and the surface, can

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affect the technique and tactics of a sports performer and the way in which the game is played.

The Federation De Internationale Hockey (FIH) produced a list of requirements to which a playing surface must adhere to in order to be used for sanctioned competitions. These standards are published in the 'handbook of performance requirements and test procedures for synthetic hockey pitches – outdoor' (FIH, 1999). The objectives of the standards are to ensure that field hockey competitions are played on pitches which; provide a proper reflection of team merit, allow players to display and develop their skills, offer comfort and limit risk to players, and extend playability in adverse weather conditions. The handbook has three tiers of standards for different levels of ability/competition: global, standard and starter. The 'global' standard is the most stringent and is compulsory for international competitions and only unfilled (or water based) systems can obtain this standard. However, there is still a large range of acceptability even at this tier and there is a lack of any good quality peer reviewed research on pitch accreditation to validate the approach (Young, 2006).

The most common device for measuring impact behavior on sports surfaces is the Berlin Artificial Athlete. The Berlin is currently used by the FIH as a measure of impact response. The peak impact force is measured, and surface cushioning (F_i) is presented as the percentage reduction compared with a rigid (normally concrete F_c) surface.

$$\text{Force Reduction} = (F_c - F_i)/F_c \tag{1}$$

There are two tests specified by the FIH to measure ball/surface interactions. The first ball rebound (or rebound resilience) is a measure of the energy lost during impact with the surface from a vertical drop. The second is a measure of the frictional resistance of the ball as it rolls across the surface and is called ball roll distance (or ball roll resistance). The roll resistance is defined as the force acting at the point of contact between the ball and surface.

This paper presents results from a comprehensive program of testing on six 'global' standard field hockey pitches. Several of the current tests methods are evaluated for their suitability to measure the behavior of synthetic turf pitches and factors that influence the measurement are also assessed, including the effect of surface water/irrigation and construction specification.

2 Methodology

This section outlines the test methods/equipment used to evaluate the behavior of six 'global' standard water based field hockey pitches. Pitch selection was based on several criteria. Firstly, feedback given by players during interviews and questionnaires (Young, 2006) were analyzed and a shortlist of suitable pitches were identified based on perceived playing characteristics. The shortlist was then reduced to pitches that conformed to FIH 'global' standard accreditation. From the remaining list priority was given to the pitches with available construction specification to facilitate understanding of the effects of different constructions. From the above criteria six pitches were highlighted for field testing, due to data protection the pitches can not be identified and henceforth shall be labeled pitches A to F. Details of the six pitches are illustrated in Table 1.

	Pitch					
	A	B	C	D	E	F
Subbase Thickness	250 mm	450 mm	200 mm	250 mm	200 mm	250 mm
Asphalt Thickness	65 mm	65 mm	70 mm	65 mm	65 mm	65 mm
Shockpad Type	In-situ & Integral	In-situ & Integral	Integral	In-situ	Integral	In-situ
Shockpad Thickness	15 mm[1]	15 mm[1]	8 mm	15 mm	6 mm	15 mm
Pile Material	Nylon	Nylon	Nylon	Polypropylene	Nylon	Polypropylene
Pile Height	12 mm	12 mm	11 mm	15 mm	11 mm	13 mm

Note: [1] combination of 12 mm in-situ and 3 mm integral shockpads

Table 1. Construction details of the six synthetic turf field hockey pitches

Prior to testing each pitch was applied with a full irrigation cycle to ensure it was tested under similar conditions to what players experience during a game. This was repeated every 40 minutes as would be standard during a game of field hockey. To ensure that a good global coverage of the pitch was achieved during testing a grid system was produced with 25 test locations evenly spread across the entire playing area, this provided comprehensive coverage of each pitch.

The FIH outlines many tests for the accreditation of field hockey pitches, however, given this size and context of this paper three test methods are presented within, these are described below.

2.1 Berlin Artificial Athlete

The Berlin Artificial Athlete consists of a falling mass of 20 kg that is electronically released from a height of 55 mm onto a spring with a stiffness of 2000 kN/m^{-1} that is connected to a test foot of 70 mm diameter. The peak impact force is measured three times, and surface cushioning is presented as the average percentage reduction of the second and third drops compared with a rigid (normally concrete) surface, as described in the FIH handbook (1999). The requirement for 'global' standard pitches is between 40 – 65 % force reduction.

2.2 Ball Roll Distance

Ball roll distance, was measured by rolling a ball down a standard inclined plane or ramp. The ball (approved by the FIH) should roll a prescribed distance within a maximum deviation of 3° from the straight line. The test was repeated in the opposite direction and results were averaged, thus reducing the possible effects of wind, slope, wear, pile bias and smoothness. The test follows the procedure outlined in the FIH handbook of performance requirements (1999). The requirements outlined by the FIH for 'global' standard pitches is between 9 m – 15 m ± 10 % of the mean.

2.3 Ball Rebound Height

To determine the ball rebound resilience a vertical drop test was used. The test followed the procedure of the FIH standard (1999). It consisted of releasing a ball from a height of 1.5 m (surface to underside of ball) on to the test surface. The height of rebound for 'global' standard pitches should be between 100 mm and 250 mm with a maximum deviation of 20 % from the mean. The FIH specify that the test should be 'wet' and an approved hockey ball be used.

		Pitch					
Test Device		**A**	**B**	**C**	**D**	**E**	**F**
Berlin Artificial Athlete (%)	Mean	60.4	61.8	43.6	55.5	45.4	52.7
	SD	3.0	3.8	1.7	3.5	2.1	4.2
	COV	5.0	6.1	4.0	6.3	4.6	7.9
Ball Rebound Height (cm)	Mean	32.8	36.8	20.7	41.1	26.2	32.2
	SD	2.4	3.2	5.2	1.0	0.7	2.2
	COV	7.2	8.6	25.0	2.5	2.8	6.8
Ball Roll Distance (m)	Mean	14.5	13.6	15.4	15.1	14.0	15.5
	SD	1.0	2.1	1.8	1.6	1.1	3.1
	COV	7.2	15.6	11.8	10.3	8.1	20.0

Note: SD = standard deviation, COV = coefficient of variance

Table 2. An overview of the results from six synthetic turf field hockey pitches

3 Results

The following section presents the results from the data collection on six 'global' standard synthetic turf field hockey pitches. An overview of the results is presented in Table 2.

3.1 Berlin Artificial Athlete

Measurements with the Berlin identified pitch C as the hardest pitch with a force reduction of 43.6 %. Pitch B was measured as the softest pitch with a force reduction of 61.8 %. Table 2 illustrates the force reduction for all six pitches. From the 25 test locations it was found that pitch C had the least variability with a COV (coefficient of variance, standard deviation / mean) of 4.0 % compared with pitch F which had the most at 7.9 %.

3.2 Ball Roll Distance

A small difference was measured between the six pitches with the ball roll test. Pitch B had the shortest measured distance of 13.6 m and Pitch F had the longest with 15.5 m. Three of the pitches (C, E & F) fell narrowly outside the FIH 'global' specification. A large directional difference was noticed during testing, on pitch B there was a difference from 11.84 m (north to south) to 18.12 m (south to north). This difference was attributed to the influence of the wind.

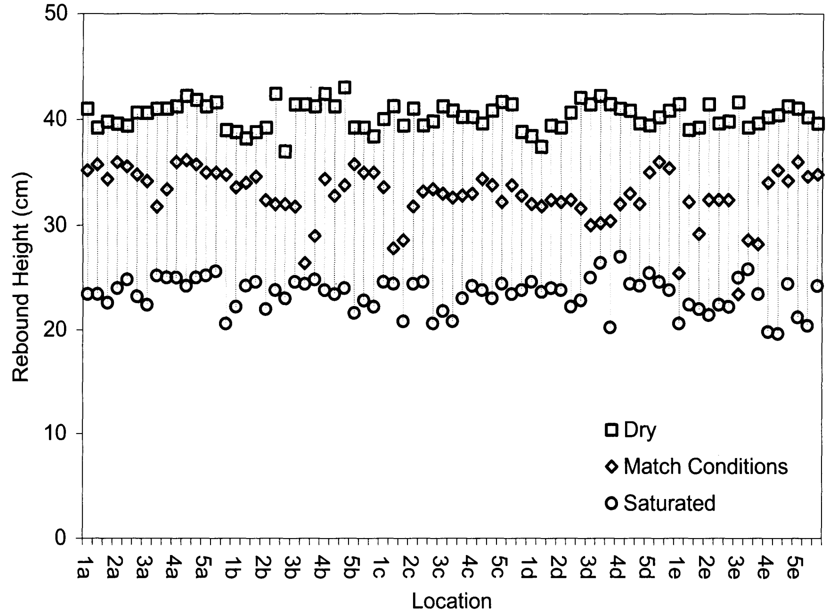

Fig 1. The influence of moisture of ball rebound height on pitch A

3.3 Ball Rebound Height

A large spread of measurements were taken from the ball rebound height tests. Pitch C had the lowest mean rebound height of 20.7 cm compared with pitch D 41.1 cm which was the highest. Five of the six pitches rebound height fell outside the FIH guidelines for rebound height. It was noticed whilst testing that the degree of water on the surface significantly influence the rebound behavior of the ball. Hence, pitch A was tested under three different levels of saturation (dry, match and saturated). Figure 1 illustrates the magnitude of difference for each of these conditions.

4 Discussion

The amount of water on the pitch was shown to significantly influence the behavior of the ball during impact. Thus the uniformity of the watering system to apply a even application of water to the whole playing area is vital to ensure the behavior of the pitch is consistent. The surface water appears to dissipate the impact energy of the ball resulting in less energy being returned to the ball and hence a lower rebound height. The Berlin and ball roll tests did not measure a difference for each moisture level.

The impact behavior of the surface measured with the Berlin was most dependent on the shockpad and carpet layers. It was found that the pitches evaluated with a relatively thin integral system (C & E) had a much higher stiffness than the pitches with an in-situ shockpad system. From these data there was no obvious link between subbase and asphalt layers and pitch behavior, it can therefore be assumed that the carpet/shockpad combination are more influential to pitch performance.

The six pitches fell within the FIH specifications for impact behavior. However, for ball behavior three pitches failed roll distance and five pitches failed the ball rebound test. This suggests that the pitches are outside the requirements of the FIH and hence not suitable for 'elite' field hockey. However, all of the six pitches initially passed the accreditation process. It is unclear if the pitches behavior have changed over time (between the accreditation testing and this testing) or if the equipment/methodology used was different. This raises the issue of regular re-accreditation to ensure pitches remain within the required standards.

In the past it has been argued that these mechanical tests do not fully represent what a player or ball experiences during a game situation and that to fully understand the complex mechanism of pitch behavior test methods are required that more closely simulate these conditions. However, given that the existing test methods are a suitable way to index/classify pitches, for the purpose of surface accreditation, they are considered appropriate.

5 Conclusions

Measurements from these test devices have established that large differences exist between pitches. These differences can be attributed to their construction specifications and environmental influences.

Future measurements are required to determine the influence of 'ageing' and how the pitches performance changes over time. This can also be linked to the maintenance of the pitch which should be investigated.

A more fundamental study into the precise influence of water is required to better understand its effects. Similarly, the rate of drainage/evaporation of water from the surface can influence the pitches behavior during the course of a game, especially in warm weather conditions and this problem needs to be evaluated.

References

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