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Research and Consultancy in Equine Surfaces

NTU Nottingham Trent University

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Ground and Going Study

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In collaboration with

University of Central Lancashire UCLan

Nottingham Trent University

RACES Research and Consultancy in Equine Surfaces

Racing Foundation

Horse Welfare Board

BHA British Horseracing Authority

Contents

Executive Summary

1. Background and context

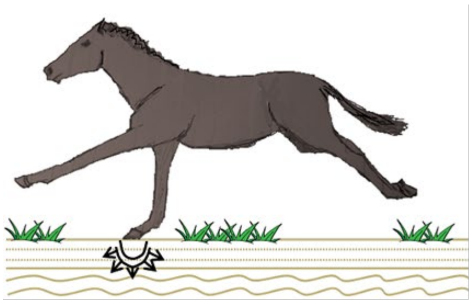
The following report evaluates the use of alternative tools to characterise the ground and going of turf racecourses in Great Britain. These tools (Vienna Surface Tester and moisture meter) provide an objective assessment that describes going on race-day and produces a detailed explanation of ground condition that could support racecourse maintenance and future Performance Quality Standards (PQS). The protocol used for this project, has successfully quantified the functional properties of cross-country ground at national and international eventing competitions previously [1].

Current methods of assessing going are not always consistent and could therefore be improved; this study has been exploring how an alternative protocol could be of benefit to the racing industry. Quantitative racecourse going data and qualitative opinion data given by relevant stakeholders have been important in ensuring a holistic approach to the study.

The findings presented here are the result of assessing turf racecourses in Great Britain over 15 months during 2023-2024. Going data has been analysed against various external factors such as time-based going allowance, region, weather and soil type whilst information from clerks and trainers have helped develop recommendations. The study has highlighted good practice and identified potential steps that could improve methods of classifying going and assessing ground condition of turf racecourses in the future.

Surface measurements that are directly related to horse performance

In 2014, the Fédération Equestre Internationale (FEI) published the Equine Surfaces White Paper where four functional properties of surfaces (and their variability) were identified as independently important in relation to performance [2]. These four functional properties are impact firmness (top-level firmness), cushioning, responsiveness (energy return) and grip. The measurements taken in this current project using the Vienna Surface Tester (VST), relate to all these functional properties except for grip and have been found to influence performance [1]. A tool for grip was trialled at two racecourses as part of this current study, but was too variable between operators to justify its use beyond pilot testing.



The VST measures deeper layers of the ground that may not be picked up by other test devices that penetrate just the top layers of the surface

2. Outcomes

The outcomes presented below were identified in the original proposal and define the primary endpoints of the project. These outcomes were critical in designing and executing the study and have been used as a framework to present the findings.

Recommend tools and protocols suitable for measuring turf: Develop a standard protocol that can reliably and consistently measure racetrack going and that can be used to directly compare different racetracks.

Provide an evidence base for comparative purposes: Develop a database of the functional properties of racing turf surfaces that span a range of going found in each discipline (flat and jump racing) and will provide an initial reference source for comparative and classification purposes.

Provide better opportunities for informed decision-making: Develop a report format that provides a detailed assessment of the ground conditions along with an overall classification of going that will be compared against official going. Greater knowledge of surface function will better equip stakeholders in making decisions on preparation which should ultimately improve horse welfare.

3. Key Findings

3.1 Tools and protocols for measuring turf

The report output produced from the protocol that the team developed using the VST and moisture meter, provide a rich source of information that many clerks described as being useful. Out of responses given by 44 clerks, describing their course when it was tested, 73% (n=32) expressed a positive interest and identified benefits of the VST.

A smaller dataset was compared to normalised winning times, this detailed analysis highlighted that cushioning from the VST corresponded to the performance of horses from their winning times. In this case, cushioning could predict 82% of performance.

Reliability tests demonstrated that the tools and protocol used in this study are robust for between-operator measurements of going on race days.

Cushioning was considered the most promising measurement to quantify race day going

3.2 Development of a reference source for comparative and classification purposes

3.21 Comparing the VST to Timeform performance-based going descriptions

Cushioning data from the VST, as a measure of going, was compared to Timeform performance-based going descriptions. The cushioning data was either categorised as matching the Timeform going descriptions, or it was reported as an outlier.

It was found that 60% of the cushioning measurements were within an acceptable range (76% flat; 58% jumping) and matched the Timeform going descriptions.

Differences in top level firmness were detected between regions which could not be completely explained by other measurements. As horses differ in their movement over the top of the ground, top level firmness may be an important measurement for trainers.

Cushioning data were reported as outliers when it did not sit within an acceptable range of the Timeform going descriptions and on further investigation, these outliers could be explained by energy return, course variability and moisture.

The VST can differentiate between seasonal periods, race type, number of fixtures, soil type and regions.

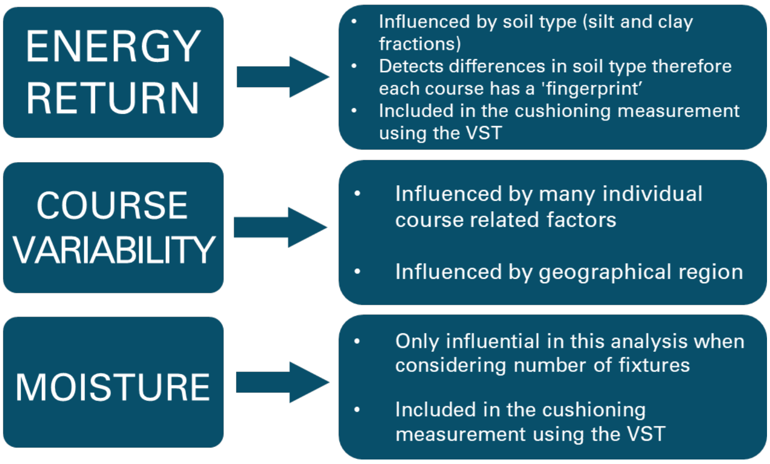


Figure 3.1 *Primary measurements that explained outliers when cushioning data did not sit within an acceptable range of Timeform going descriptions*

3.22 Comparing official going information to Timeform performance-based going descriptions

The agreement between clerk's official going descriptions and Timeform going descriptions was 58% for all race types, with higher agreement in jumping (61%) compared to flat racing (51%).

Based on this analysis the GoingStick® can differentiate between seasonal periods, race type and number of fixtures, but could not identify differences between regions or soil types. This illustrates the limitations in the ability of GoingStick® to provide a holistic measure of race day going that is consistent between racetracks.

Current method of assessing going could be modified to improve suitability for measuring turf and better inform stakeholders

3.23 Notable measurements calculated from the VST

Cushioning indicates how much support the horse gets from the ground and in this study, cushioning more consistently identified differences in going that related to horse performance than any other measurements. Our protocol uses lower-level firmness, moisture and energy return to calculate cushioning.

Energy return is a measure of bounce and provides an indication of how springy or dead the ground is for the horse. In this analysis energy return was found to be a course specific measurement because it was strongly related to the percentage of silt and clay in the soil and there was limited variation throughout the year.

Cushioning is derived from more than one measurement and directly relates to horse performance. Energy return is included in the calculation for cushioning because it accounts for course specific differences and could improve comparisons between courses

3.24 Summarising ways to improve current official going information

Either a combination of measurements that define going with a single value (i.e. cushioning), or several measurements that can be published together prior to, or on race days would enhance current official going information.

Routinely reporting variability around each course would help understand the variation in these measurements which cannot currently be accounted for.

Considerations related to use and maintenance should also be noted. In particular, both the VST and GoingStick® found courses with a higher number of fixtures had higher cushioning values and GoingStick® indices, suggesting they were more compacted.

3.3 Understanding challenges to provide opportunities for informed decision-making

Subjectivity in using GoingStick® readings to provide official going descriptions were often seen as challenges by clerks, some of whom noted that different ground staff produced different readings. Because of this, clerks described other assessment methods to make a judgement on race day going descriptions.

Lack of confidence in the GoingStick® readings were expressed by trainers and were described as being "quite subjective". The mistrust in measurements of the GoingStick® has led to trainers using a variety of different methods to obtain the information they feel they need, to make decisions on running horses.

There was a strong feeling from both clerks and trainers that alternative objective measurements are needed to quantify going and remove the subjectivity. Clerks (73% n=32) commented that measurements from the VST appeared informative, particularly from a maintenance perspective, but many were concerned about the time taken to obtain the measurements for race day going.

Trainers expressed a desire for multiple readings leading up to race days, particularly as they must declare 48 hours before the meeting. Clerks also identified a need to obtain more detailed measurements during pre-race preparation. The call for more detailed and reliable information was a strong theme throughout responses from clerks and trainers. The VST was seen by the clerks as a tool that could contribute to pre-race detail and could be particularly useful in the last three to four days before race day.

Maintenance was also raised as a concern by trainers in the context of the management and compaction of over racing certain courses, particularly when the courses are small. There were also comments about root structure in relation to compaction and how higher levels of rainfall influences the ground and therefore racetrack performance.

4. The future: Recommendations

The following recommendations are supported by the work carried out for this project, as summarised above. Please refer to Section 2 for a more detailed explanation of the research evidence.

4.1 Recommend tools and protocols suitable for measuring turf

The Vienna Surface Tester consistently and reliably measures going irrespective of operator and could be considered an alternative method to assess going.

The current project was designed as a first stage to investigate alternative tools and protocols to measure going on race day. The VST has already proved its worth as a tool for successfully measuring eventing cross country ground and for this current project we have demonstrated that it can consistently and reliably measure going and has the benefit of not being influenced by the operator. The research team are currently investigating alternative funding opportunities to develop the VST into a commercially available product.

Current method of assessing going could be modified to improve suitability for measuring turf and better inform stakeholders

Challenges with the current going measurements can be addressed by considering the following recommendations:

Predicted cushioning could be calculated from an annual assessment of energy return using the VST, and routine race day GoingStick® indices with the addition of moisture data. A 12-month trial period would be recommended and would produce a more course-specific measure of going, than current GoingStick® indices alone.

Annual monitoring of course specific energy return quantified using the VST and comparisons of VST measurements against GoingStick® data will help manage consistency of going measurements over time.

Reliability and confidence in GoingStick® indices would be improved by additional support and training and enhanced service agreements with Turftrax.

Publishing pre-race information using the VST would help improve how stakeholders interpret going data on race day.

Note: Any tool or method employed to measure going on race days that supersedes the GoingStick index should be introduced over time and should include ongoing evaluation of the results with key stakeholders to develop confidence in, and understanding of the data reported

4.2 Initial reference source compared against other methods of going classification to support recommendations

A database of the functional properties of racing turf surfaces that span a range of going found in each discipline was developed which allowed us to investigate factors that influence going measurements and compare between subjective and objective going information.

Recommendations related to factors that were found to be influential are as follows:

> **Higher numbers of fixtures** in a year resulted in firmer ground due to compaction, as supported by comments from trainers. It is recommended that when reviewing fixture schedules, these findings are accounted for particularly for smaller racecourses. Building in additional rest periods and/or increasing use of decompaction equipment where possible, for all or parts of courses is expected to be beneficial.
>
> **The complexity of going assessments** was illustrated in our evaluation of factors that influence racing performance. Adding to this current database and evaluating it further would assist in better understanding these complexities, and help answer questions such as what key factors influence course variability, regional differences in top level firmness and why some measurements did not correspond with going descriptions.
>
> **Improvements in stakeholder confidence** and understanding of going assessments could be gained by regular analysis and publication of going data.
>
> **Expansion of the database** to include VST measurements from all-weather racetracks and gallops so comparisons between training and racing surfaces can be made and trainers can develop confidence in these measurements.

Understanding the complexity of racecourse going in Britain and building confidence in stakeholders can only be achieved through continued input and evaluation of objective going measurements

4.3 Provide better opportunities for informed decision-making

The following recommendations have been developed from analysis of the main database and comments from clerks and trainers, to demonstrate how decision-making could be better informed.

Provide detailed mapping and reporting of course going, course variability and weather data for stakeholders in the run up to a race meeting to improve understanding of a particular course.

Establish a standardized database of going and weather information from all racecourses that can be used proactively to model and predict going and changes in going between racecourses. Provide regular updates for stakeholders to improve confidence in going data.

Use the VST to collect more detailed measurements when other tools are not capable of measuring aspects of, or changes in going that negatively influence performance.

Changes that are made to methods of assessing the going must be explained to trainers in addition to working with clerks to help them adjust to the way they interpret racecourse data.

Irrespective of any proposed changes, it is apparent that trainers are aware of the subjectivity and uncertainty in going classifications so developing better guidance for them would be of benefit.

Informed decisions can only be made confidently if they are made using reliable, objective information

RESEARCH EVIDENCE

1. Introduction and aims

The ground and going condition of a racetrack is important for performance, welfare and safety, and in Great Britain, Thoroughbred racecourses are currently measured using the GoingStick®, a tool developed by Turftrax Ltd and Cranfield University [3, 4]. The GoingStick® is used on race-day to provide a going index value alongside a qualitative description of the course that classifies the going between firm and heavy. The GoingStick® is quick and easy to use which is essential for assessment of racecourses on race-day. Despite this there are some challenges with the going index value because it does not consistently match the described classification [5] and anecdotal evidence suggests that the going index from one racecourse is not directly comparable with the next.

A practical method of quantifying functional properties of equestrian turf used for eventing cross-country has been published recently [1]. The aim was to develop a method that was easy for a practitioner to conduct quickly, prior to competition but that was sensitive enough to provide meaningful data that related to the horse's performance. Several tools were investigated in this previous study including the GoingStick®, the Vienna Surface Tester (VST) and the Lang penetrometer. Data were compared to a more sophisticated test device that simulates the forces experienced by the horse's forelimb landing on a surface in gallop, the Orono Biomechanical Surface Tester (OBST) [6]. A strong correlation was found between the OBST and the VST and moisture but other handheld devices were did not correlate well [1]. The VST and moisture meter calculate a series of values including cushioning, which is a measure of how much the surface will support the horse during limb loading and is therefore relevant to both performance and safety. More recently we have demonstrated how cushioning derived from the VST is a strong predictor of jump and flat racehorse performance [7]. The findings presented in [7] suggest it is possible to use simple and practical test devices to reliably classify racetrack going; and it provides a strong justification for further investigation of this method of assessing racetrack ground and going.

> The VST correlates well to the forces **actually** experienced by a horse. Other test devices do not show similar patterns

The aim of this project was to evaluate ground and going data from turf racetracks in Great Britain that span the range of soil, sward and grass types over 15 months, thereby characterising going accounted for by different soil type, geographical regions, venues and seasonal weather conditions. These data were compared to official going, time based going, and opinions of going from stakeholders (e.g. clerks of the course, ground staff and trainers) to help propose a protocol that consistently, reliably and efficiently quantifies racetrack going.

Expected outcomes for this study were:

Recommend tools and protocols suitable for measuring turf: Develop a standard protocol that can reliably and consistently measure racetrack going and that can be used to directly compare different racetracks.

Provide an evidence base for comparative purposes: Develop a database of the functional properties of racing turf surfaces that span a range of going found in each discipline (flat and jump racing) and will provide an initial reference source for comparative and classification purposes.

Provide better opportunities for informed decision-making: Develop a report format that provides a detailed assessment of the ground conditions along with an overall classification of going that will be compared against official going. Greater knowledge of surface function will better equip stakeholders in making decisions on preparation which should ultimately improve horse welfare.

2. Tools and protocols for measuring turf

Introduction

The use of the VST and moisture meters have been successfully used in equestrian eventing for cross-country ground and going, however this is the first project using such equipment for turf racecourses.

Objectives

1. Develop a standard protocol for measuring racetrack going.
2. Assess reliability between and within equipment and operator to recommend tools and protocols suitable for consistently measuring turf.
3. Analyse VST data against race time data as a proof-of-concept to help design analysis for the main study and demonstrate how surface measurements from the VST relate to horse performance.

Objective 1. Standard protocol

Data were collected using a device called the Vienna Surface Tester (VST) and a moisture meter (ThetaProbe®) at locations every 250 m around the course. The data provides information about the ground characteristics that are directly relevant to the horse and for this reason, these variables are described as functional properties [1, 2]. Data was collected at the same time as when the clerk assessed the course using the GoingStick® and wooden stick, on race day. The VST is a ball weighing just under 7 kg, containing two accelerometers (Figure 2.1). The ball is dropped between heights of 0.05 m and 0.85 m to collect data at different impact velocities that is then used to provide information about surface hardness, penetration depth, energy return and stiffness. VST and moisture data can be used to calculate cushioning, course variability and a Research Going Value. An example of the report that a clerk receives is illustrated in Figure 2.3. In addition, data points are added to Google Earth, thus helping identify exact locations where data has been collected (Figure 2.2).

Figure 2.1. *The Vienna Surface Tester (instrumented ball) and a ThetaProbe (three-pronged moisture meter used to measure volumetric moisture content) are used to assess surface functional properties.*

Figure 2.2 *Example of a course map using Google Earth to identify exact locations where data was collected (Note: this map is an example only and not connected to the example course report in Figure 2.2 above).*

Jump Racecourse Ground Measurement Data

Course:			Date and time:						
Jumps Measure no:	Soil moisture	Cushion-ing	Firmness	Depth	Energy return	Stiffness (top ground layer)	Stiffness (lower ground layer)	Measurement site description: Location	
1	39	8.10	61	31	9	118	138	See map below for location of measure	Chase
2	44	8.27	66	28	8	124	167	points used for data collection	Hurdle
3	41	8.08	62	32	8	127	145		Chase
4	41	8.71	69	29	9	128	181		Hurdle
5	43	7.74	57	31	9	107	122		Chase
6	42	7.97	62	29	8	113	140		Hurdle
7	44	8.06	62	29	9	143	145		Chase
8	44	7.25	53	33	8	81	106		Hurdle
9	39	8.51	67	28	8	119	169		Chase
10	34	8.50	66	29	7	104	165		Hurdle
11	42	7.78	60	31	7	114	133		Chase
12	42	7.70	58	31	8	105	122		Hurdle
13	37	8.69	69	27	8	148	179		Chase
14	42	8.81	70	28	9	119	183		Hurdle
15	39	7.66	58	32	7	136	124		Chase
16	39	8.92	71	27	9	128	191		Hurdle
17	41	8.87	69	28	10	161	180		Chase
18	37	8.79	70	29	8	164	182		Hurdle
19	41	8.42	66	28	8	130	163		Chase
20	37	8.04	61	31	7	130	138		Hurdle
21									Chase
22									Hurdle
23									Chase
24									Hurdle
25									Chase
26									Hurdle
27									Chase
28									Hurdle
29									Chase
30									Hurdle
Average	40	8.2	64	29	8	125	154	Course variability value	Going value (0-10)
SD	2.6	0.5	5.2	1.8	0.8	19.6	25.2	10.1	5.9
SD%	6.4%	5.8%	8.2%	6.1%	9.4%	15.7%	16.4%		

Notes on measurements
(amended some ranges 10/01/2023)

Soil moisture		
<15 very dry	15-25 dry	25-50 good
50-65 wet	>65 very wet	
Cushioning = how much a surface is supportive compared to how much it gives when ridden on it		
		<7 heavy
7-7.5 soft	7.5-8 good/soft	8-9 good
9-9.75 good/firm	9.75-10.5 firm	>10.5 hard
VST measurements at either 2m/s or 4m/s impact velocity depending on measurement		
Firmness = peak deacceleration at impact		
Range @ 4m/s		<45 heavy
45-55 soft	55-62 good/soft	62-70 good
70-75 good/firm	75-80 firm	>80 hard
Depth = penetration depth in mm @4m/s		
Range @ 4m/s		>35 heavy
32.5-35 soft	30-32.5 good/soft	26-30 good
23.5-26 good/firm	22-23.5 firm	<22 hard
Energy return = % recoil energy from the surface @ 4m/s. A higher figure = more energy return.		
<7 low	7-10 average	>10 good
Stiffness = surface stiffness. A higher figure indicates a stiffer surface.		
Top (0-10cm) layer range		<90 heavy
90-100 soft	100-110 good/soft	110-130 good
130-150 good/firm	150-180 firm	>180 hard
Lower (10-25cm) layers range		<115 heavy
115-125 soft	125-140 good/soft	140-195 good
195-230 good/firm	230-270 firm	>270 hard
Course variability value		
<10 consistent	10-20 average	>20 variable
Approx Going value (0-10 scale) range		
0-2 heavy	**2-3.5 soft**	**3.5-4.6 good/soft**
4.6-6.3 good	**6.3-8 good/firm**	**8-10 firm**

Clerk of the course raceday going report

Going description	Goingstick
Good	

Figure 2.3 *Example of a course report using colour to assist in presenting functional properties at locations every 250 m from one racecourse. The Going Value reported adjacent to the course variability value is the Research Going Value and is still in development*

Objective 2. Reliability assessment of Vienna Surface Testers

Inter-reliability and intra-reliability of equipment and operators under controlled conditions

Tests were carried out early in the project (May-June 2023) between the three VSTs used for the project, with the same operator and the same ground condition (concrete with a rubber mat, 5 cm thickness) to quantify inter-reliability between operators and between test devices. No significant differences between operators or VSTs were identified for all surface parameters (impact firmness, depth, energy return and stiffness) as described in Table 2.1 and 2.2.

Calibration tests by each operator were being conducted every 1-2 weeks to check there was no drift in the data produced within each VST. Calibration tests were being carried out under the same conditions using concrete and a rubber mat. Whilst temperature cannot be controlled, mat temperature was recorded during testing to detect any effects that temperature may have on the results.

Table 2.1. *Comparison between operator (n=4) for key variables collected from the Vienna Surface Tester using a rubber mat*

Measurements taken from the VST*	F(test statistic)	R^2	P Value (significance)	Differences between users?
Firmness (GMax)	0.17	0.00%	0.997	No
Depth (mm)	0.06	0.00%	1.00	No
Stiffness (KN/m)	0.66	0.00%	0.725	No

*VST Vienna Surface Tester

Table 2.2. *Comparison between Vienna Surface Testers (n=3) for key functional properties using a rubber mat*

Measurements taken from the VST*	F(test statistic)	R^2	P Value (significance)	Differences between VSTs?
Firmness (GMax)	0.44	0.00%	0.645	No
Depth (mm)	0.03	0.00%	0.972	No
Stiffness (KN/m)	1.39	0.25%	0.252	No

*VST Vienna Surface Tester

Inter-reliability of equipment in the field

Comparison between users, VSTs and moisture meters in the field (Table 2.3) were the second step in assessing the reliability of the test protocol. Seven comparisons between operators and VSTs in the field were carried out at six racecourses (one course was measured twice) between November 2023 and February 2024. No significant differences ($P<0.05$) were found between devices; however, a small bias in the accelerometery signal was evident between VSTs which could not be explained by course variability alone. Following conversations with the manufacturer of the VST, further interrogation of the response curves was carried out (velocity-firmness curves from each of the 14 drops at each location) to determine a calibration value for each VST. The results following calibration are shown in Table 2.3. The difference between VSTs following calibration can be explained by course variability, as the location of each drop will influence the resulting measurement. Course variability was 14.4 ± 10.9 % between measurement locations, indicating that some variation at each drop location is expected.

Table 2.3. *Percentage difference between Vienna Surface Testers following calibration of devices. Note: REF is the Reference VST that was the first one being used for the project and recognised as the one that other VSTs would be compared to*

	Vienna Surface Tester 1	Vienna Surface Tester 2	Vienna Surface Tester 3
VST1	REF		
VST2	0.53%	*	
VST3	-2.99%	1.55%	*

*VST Vienna Surface Tester

Objective 3. Proof of concept analysis: race times against Vienna Surface Tester measurements

Any tool that is designed to measure surface functionality should be able to produce results that have relevance to the activity that occurs on that surface. For example, measurements of athletics tracks must have relevance to human running and sprinting mechanics and are therefore the tracks are tested with artificial athletes. The VST has previously been assessed for its suitability to provide meaningful results on eventing cross country ground and was considered as a useful tool [1]. This current proof-of-concept study was designed to assess the VST's suitability to provide meaningful results for horseracing.

Currently the only measure of galloping mechanics available to the team that equates to racing performance are winning race times. Consequently, VST measurements were compared to normalized winning race times (time-based going allowance) using single course and multi-course models. From this analysis, the VST could predict up to 82% of the time-based going allowance (adjusted $r^2=0.819$, $P<0.001$), indicating that it can produce meaningful results for horseracing [7].

A graph of the final models (grey=piecewise polynomial model, light blue=quadratic model) are shown in Figure 2.4, which includes data from 25 flat (red dots) and 25 jump (dark blue dots) meetings. This graph illustrates the relationship between winning times and a VST measurement of going (cushioning). There is some scatter in the data, suggesting some variation between race meetings, but a clear pattern is evident. On the left-hand side of Figure 2.4, the dots depict softer jump ground, but as cushioning increases (meaning that the ground absorbs less force), the winning times reduce so the horses are galloping faster because they are getting more support from the ground. The model is curved, showing progressively less of an increase in galloping speed as the cushioning forces continue to increase towards firm ground, to the point where maximal speeds are very similar even though the cushioning forces are still increasing. The graph suggests that there is no real performance advantage in having firmer ground above about 10 kN of cushioning force measured with the VST. This study was important as it informed the design of the analysis for the main study; the primary surface measurement from the VST that we focus on is cushioning, based on the findings above.

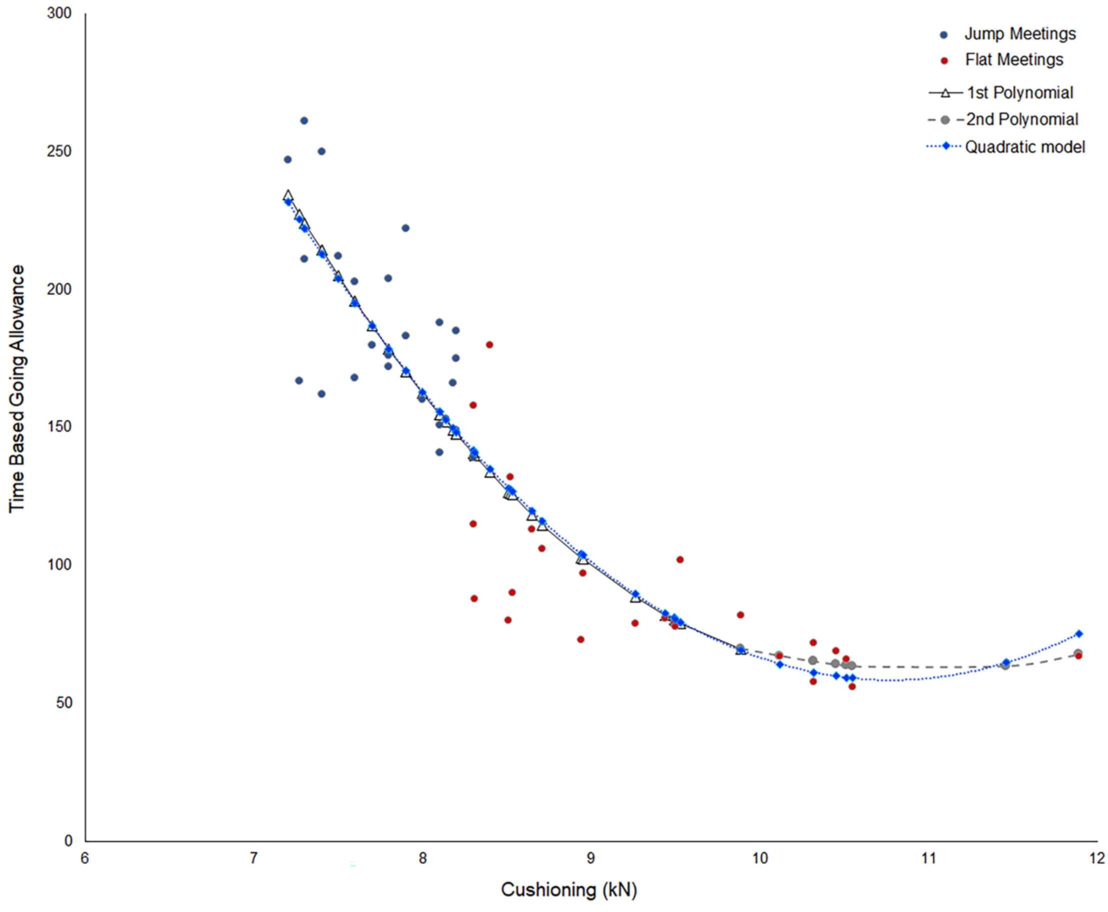


Figure 2.4: *The relationship between surface measurements taken on race day mornings (cushioning (kN)) and performance measurements from normalized winning times (time-based going allowance) from the races on the card at each of the 50 meetings included in the analysis.*

3. Development of an evidence base for comparative purposes

Survey of racecourses using Vienna Surface Tester and moisture meter

Introduction

In order evaluate the usefulness of a tool for a specific application it is necessary to test it in a realistic situation and then evaluate its performance.

Objectives

1. Develop a database of surface measurements (VST, GoingStick® and official going) and external factors that include race type, geographical region, number of fixtures, soil type and month for reference and analysis purposes.
2. Analyse the complete dataset to investigate strengths and limitations of current and potential methods of measuring going and to support recommendations for future assessment of racetracks on race day and routine preparation.

Method

A reference database of surface measurements from racecourses in Britain, were compiled between 1st January 2023 and 6th June 2024 and included VST, moisture measurements and official going. Figure 3.1 provides an overview of the official descriptive assessments of going from the clerk of the course and GoingStick® indices against the descriptive assessment of Timeform's first race.

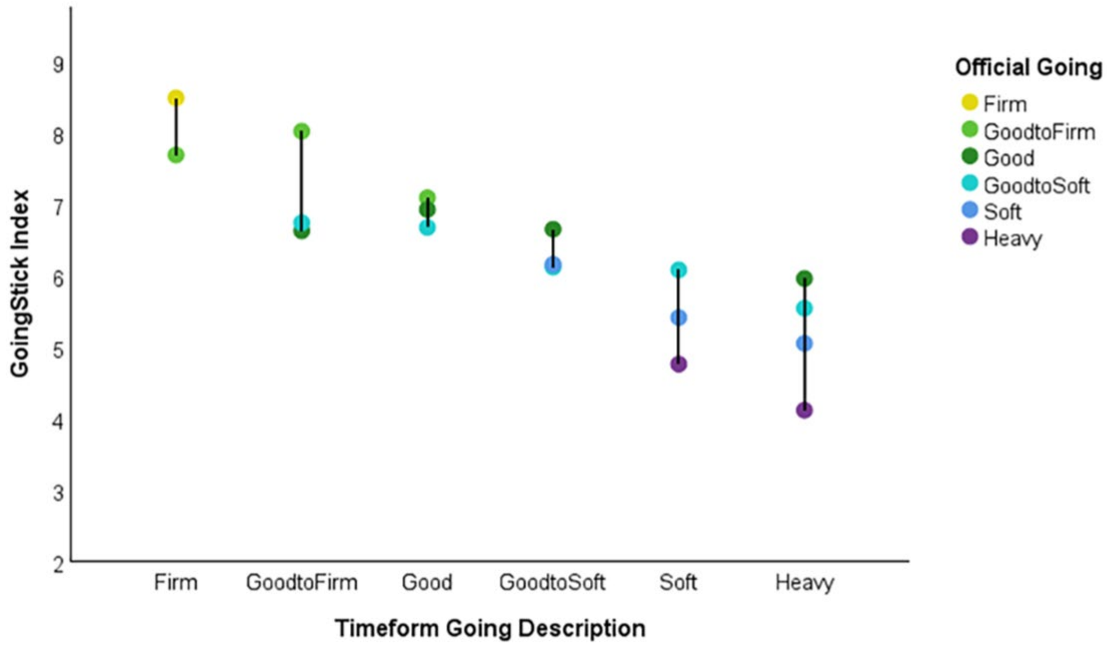


Figure 3.1: *Summary of the official data from all race meetings that has been included in the reference database*

Additional factors were included in the analysis to help determine their influence on surface measurements. Additional factors focused on race type, geographical region of the racecourse, number of fixtures at the course in 2023, general soil type, and month of the year. The temperature at 12 noon on the day of the meeting from the local area was also added (Met Office WOW - Home Page). This included n=283 separate entries in the database.

Initial exploration of the surface data was carried out to identify outliers where cushioning from the VST was either much lower or higher than the rest of the data. An outlier was defined as when cushioning was lower than 25% or higher than 75% of the range within each Timeform descriptive assessment of going (Figure 3.2). Data was separated by race type and data from each meeting were then classified as either low, high or no outlier.

Identifying outliers allowed us to investigate whether any specific factors added to the database, were influential in producing either low or high cushioning values that did not match the performance related going description given by Timeform. Table 3.1 provides a breakdown of factors used in the analysis. Exploration of GoingStick® indices were then investigated in a similar manner and could help identify differences between the use of the VST and GoingStick® to support recommendations. Detail of the statistical analysis has been presented below.

__Table 3.1:__ Factors included in the analysis

Factor	*Levels*		*n*	*Source*
Outliers	3	Low (Lower than	58	Initial analysis of confidence intervals for cushioning against Timeform descriptions
		25%)	171	
		No (25 to 75 %)	54	
		High (higher than 75%)		
Race type	3	Flat	87	Race meeting information
		Hurdle	94	
		Chase	102	
Region	7	East Midlands & EA	36	UK regional map
		London & SE	53	
		NE, York & Humber	29	
		NW	39	
		Scotland	29	
		SW & Wales	66	
		W Midlands	31	
Number of fixtures	4	10 or less	25	BHA Fixtures list 2023
		11 to 15	94	
		16 to 20	121	
		21 or more	43	
Main soil type	6	Clay	80	University of Georgia
		Clay silt/silty clay	9	
		Clay loam/clayey loam/loam/loamy	66	
		clay	46	
		Loamy sand/sand	61	
		Sandy clay loam/sandy loam	21	
		Silty clay loam		
Month	12	January	23	Race meeting date
		February	26	
		March	24	
		April	18	
		May	33	
		June	20	
		July	31	
		August	23	
		September	24	
		October	12	
		November	29	
		December	20	

Statistical analysis

A multivariable analysis of variance was conducted using a General Linear Model to investigate the main effect of outliers and factors influencing them. The VST variables were moisture (%), cushioning (kN), top and lower-level firmness (g), energy return (%), course variability (%COV) and temperature (°C). Each factor was tested (together with outliers) in separate models. Where main effects were found, Bonferroni post-hoc tests were used to identify pairwise differences between levels. The method was repeated using a univariate analysis of variance to investigate whether the published GoingStick® indices produced equivalent results to the VST. Stratified bootstrapping was used for all variables as the data were not normally distributed. Significance was set at $P<0.05$.

Results and discussion:

Outliers

As the outliers were separated into high, no and low groups using the cushioning values, it was not surprising that there was a significant difference ($P<0.001$) between outlier groups for all VST variables, except for course variability ($P=0.068$). Temperature ($P=0.458$) and moisture ($P=0.252$) were also not significantly different. This indicates that when all race meetings are included together, outliers could not be easily explained by climatic conditions such as temperature and moisture as measured in this study, or the variation in measurements found around the course. Moisture will be dependent on irrigation as well as rainfall and is therefore difficult to investigate further, without more detailed records of irrigation levels per course. These findings suggest factors other than those investigated here, account for cushioning data that is either much lower or higher than expected, when compared to performance based going descriptions.

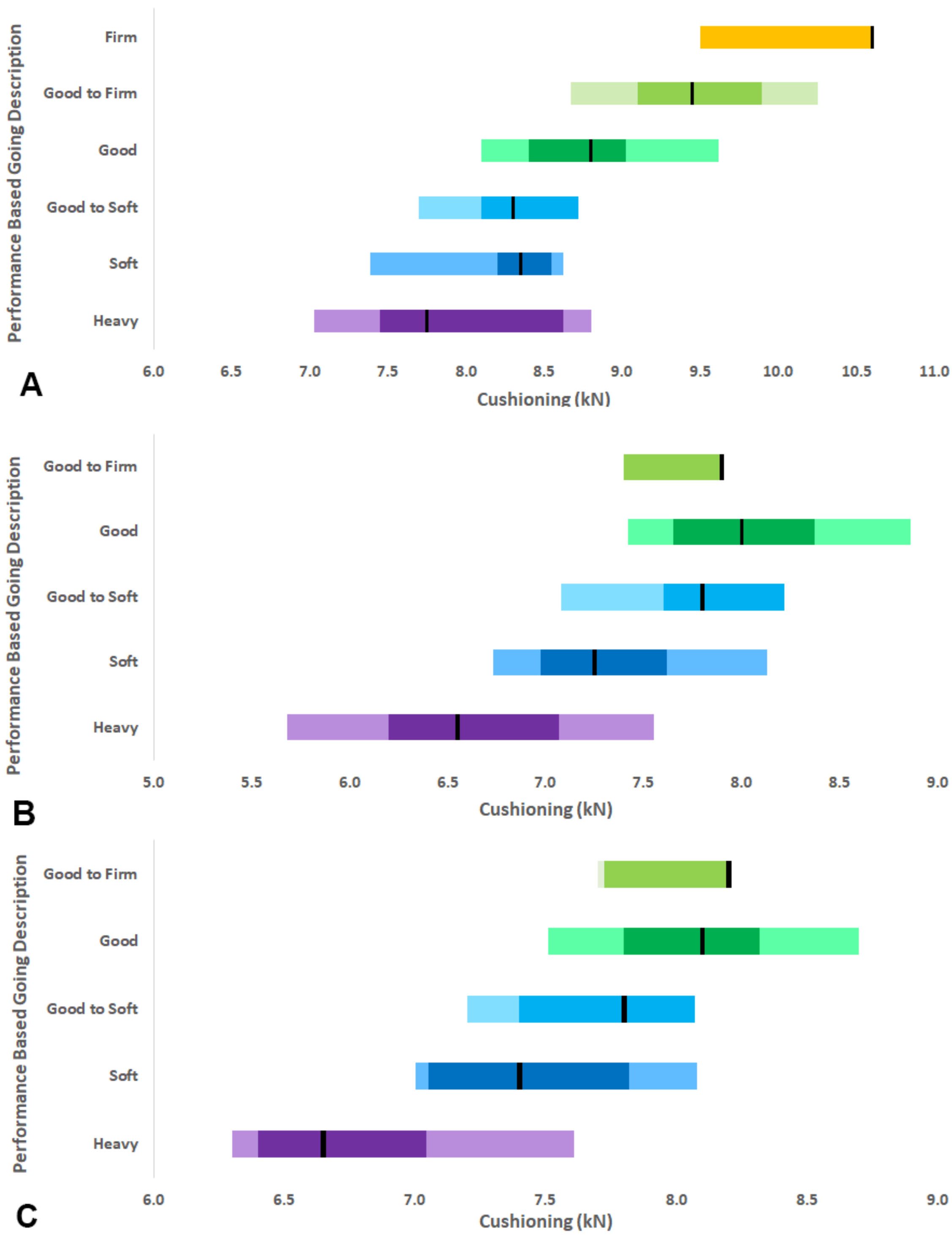


Figure 3.2: *Results for cushioning separated by Timeform performance based going descriptions for the complete dataset separated by* ***A)*** *Flat,* ***B)*** *Chase and* ***C)*** *Hurdle disciplines. Colours denote confidence intervals; black vertical line = 50%, darker colours = 25-75% range, lighter colours = outliers.*

Race type

Unsurprisingly there was a difference between flat and jump (chase/hurdle) race types (P<0.001) for most variables (temperature, moisture, cushioning, top and lower-level firmness and energy return). The effect of outlier was not significant (P=0.054), but it was close to significance, so the post hoc tests were explored to assess which variables were different. Interestingly both energy return (P=0.002) and course variability (P=0.039) were different between outliers when considering race type. The pattern of higher energy return with high outliers and lower energy return with low outliers is very clear in this graph (Figure 3.3). Course variability is greater for low outliers for flat and chase races. This provides additional evidence to suggest that course related factors contribute to outlier measurements.

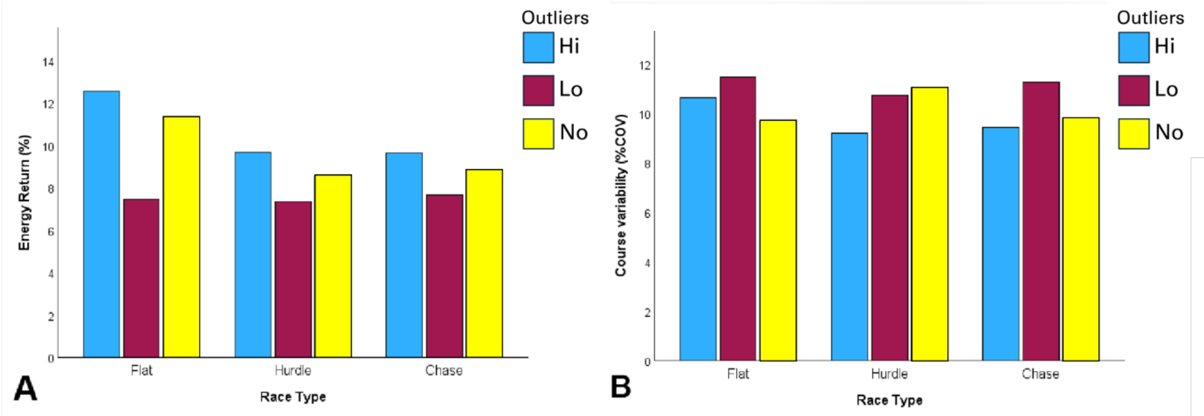


Figure 3.3: A) the difference in energy return (%) for race type by outliers, and B) the difference in course variability (%COV) for race type by outliers. For energy return, there is a pattern, which is most obvious when comparing outliers where higher energy return was recorded for high outliers (blue columns) and lower energy return was recorded for low outliers (red column). For flat and chase race types, an increase in course variability was found for low outliers.

Geographical region

There were differences (P<0.001) between regions, but region did not explain the outliers. The differences between regions were evident for top level firmness (P=0.003) and course variability (P<0.001). Specifically, the North East, York, Humber and London and the South East had a higher top level firmness compared to the North West. Courses appeared to be more variable in the North East, York and Humber and the North West and Scotland than other regions. The differences could not be explained by the climatic conditions included in the analysis, as temperature (P=0.334) and moisture (P=0.282) were not different between regions. As stated previously, rainfall and irrigation patterns would enhance this analysis.

Number of fixtures

The number of fixtures was significantly different (P<0.001) between fixture categories for all VST variables except for course variability. Generally, temperature was higher

(P<0.001) and moisture was lower (P<0.001) for courses with a higher number of fixtures. The VST variable that was most significantly different was cushioning (P=0.001), where cushioning forces increased with the increasing number of fixtures. Figure 3.4 shows that the differences were found between lower number of fixtures (low/11 to 15) and higher number of fixtures (16 to 20/high). A similar pattern was found for top and lower-level firmness with a difference between low and 16 to 20/high fixtures. This indicates that there is an increase in compaction of the surface with higher use, which is also influenced by the climatic conditions tested (temperature and moisture).

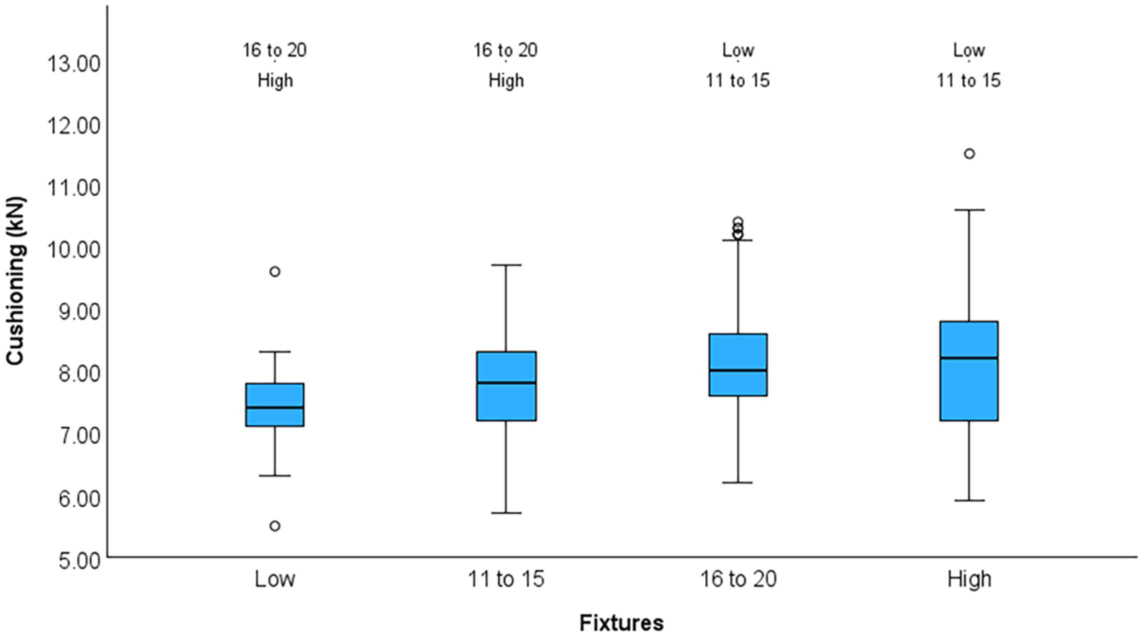


Figure 3.4: *Cushioning (kN) where the mean (black line), 25 to 75% confidence intervals (blue box) and error variance (black T bars) are separated by number of fixtures. Pairwise significant differences (P<0.05) are indicated above each fixture category. For example, significantly lower cushioning forces were found for courses with a low number of fixtures compared to those with 16 to 20 fixtures and a high number of fixtures.*

The number of fixtures had an influence on outliers for two variables, moisture (P=0.041) and energy return (P=0.021). The graphs below describe the data (Figure 3.5). For moisture, high outliers can partly be explained by a lower moisture content, except for courses with a low number of fixtures, where higher moisture content is evident. For courses with 11 to 15 fixtures, low outliers can partly be explained by a higher moisture content. Energy return is sometimes considered to be a fingerprint of the course and is related to soil type (as seen later in the analysis). Energy return for all but courses with 11 to 15 fixtures can partly explain the outliers, which to some extent could be a course related factor.

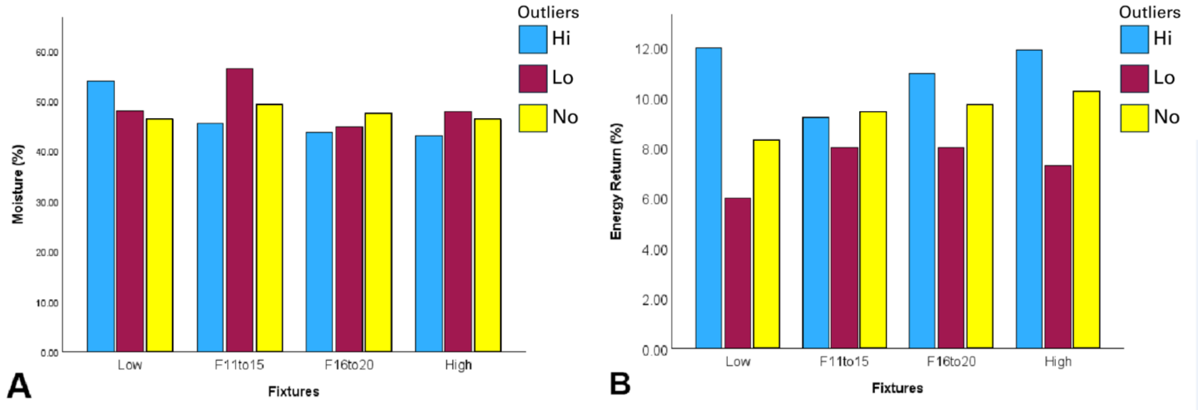


Figure 3.5: A) *the difference in moisture content (%) for number of fixtures by outliers, and* ***B)*** *the difference in energy return (%) for number of fixtures by outliers. Although significantly different, there is no obvious pattern for moisture content. For energy return, there is a pattern, but this is most obvious when comparing outliers where higher energy return was recorded for high outliers (blue columns) and lower energy return was recorded for low outliers (red column).*

Soil type

A difference between soil types (P=0.023) was found, but soil type did not explain the outliers. As indicated above, the difference related to the course fingerprint of energy return (P=0.010). Clay loam/clayey loam/loam/loamy clay had a higher energy return than loamy sand/sand. Silty clay loam had a higher energy return than clay, clay loam/clayey loam/loam/loamy clay, loamy sand/sand and sandy clay loam/sandy loam. The differences are illustrated in Figure 3.6.

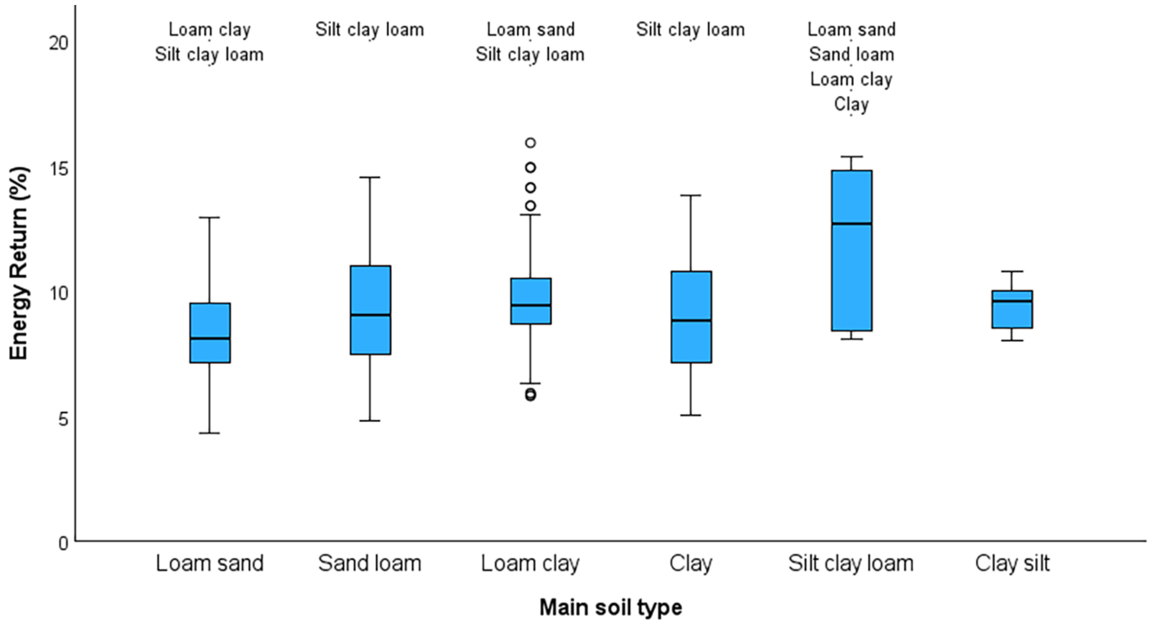


Figure 3.6: *Energy return (%) where the mean (black line), 25 to 75% confidence intervals (blue box) and error variance (black T bars) are separated by soil type. Pairwise significant differences (P<0.05) are indicated above each soil type category. For example, significantly lower energy return was found for courses with a main soil type of clay compared to silty clay loam.*

Month

Differences between months were found ($P<0.001$), but not in relation to outliers. The variables that differ include temperature, cushioning, top and lower-level firmness and energy return. The differences between months are complex, so the results are displayed in Table 3.2, where differences are illustrated by letters for each variable. The greater the number of letters between months, the more different they are, so the table illustrates many of the seasonal differences that might be expected.

Table 3.2: *Significant differences ($P<0.05$) between months for temperature (T), cushioning (C), top (F_T) and lower-level firmness (F_L) and energy return (E). Colour code: Green; temperature and surface measurements were found to be different, Yellow; only temperature was different, Blue; only surface measurements were different, White; no differences were found.*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan												
Feb												
Mar												
Apr	E	E										
May	$TCF_{L}E$	$TCF_{L}E$	$TCF_{L}E$	T								
Jun	$TCF_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}$	TCF_{L}	T							
Jul	$TCF_{L}E$	$TCF_{L}E$	TCE	T	T	T						
Aug	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{L}E$	T	TE						
Sep	TE	TCE	T	T	T	T		$CF_{L}E$				
Oct	T	TE	T	T		T	T	$TCF_{L}E$	T			
Nov					$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	TE	T		
Dec				E	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{T}F_{L}E$	$TCF_{L}E$	TE		

Efficiency of VST data collection methods to measure cushioning

Throughout the analysis, cushioning has consistently been identified as a potential variable that could be used to quantify going on race days. Cushioning is a combination of lower-level firmness (which relates to the upper and lower ground conditions on the day), energy return (which provides a measure that is course specific and improves the ability to compare between courses) and moisture (which provides an indication of the top-level ground conditions). Cushioning is also a useful measurement, as it can be directly related to horse performance.

Despite this, feedback throughout the project has included concerns that the time taken to collect the data is too long (due to using 14 drops and also measuring moisture at each location). Three options could be employed to reduce the time taken to collect the data on race days, which are: 1) only collect VST data and calculate cushioning without moisture, 2) collect data from locations at 500 m intervals instead of every 250 m, and 3) collect data from the top two drop heights only (four measurements).A randomly chosen sample of data from 50 meetings was used to assess the effect of these three options on the resulting cushioning measurements.

Data was included from 15 flat races, 18 chases and 17 hurdle races. For option 1) a cushioning equation without moisture was recalculated using original data that compared Orono Biomechanical Surface measurements to VST measurements [1]. For option 2), individual meeting reports were accessed, the number of locations was reduced systematically to every 500 m within the report and average cushioning values were recalculated for the meeting. For option 3) individual meeting reports were accessed, the final 4 drops from the raw VST data were identified for each location and average cushioning values were recalculated for the meeting.

Bland Altman plots were used to compare cushioning measurements to recalculated cushioning measurements by plotting the average against the difference between the two measurements. For each comparison, the standard deviation of the difference between measurements was also determined. The three plots were then combined to illustrate the effect of changing the protocol (see Figure 3.7). Differences between protocols (mean and standard deviation) were as follows: 1) No moisture, 0.22±0.27 kN, 2) 500 m, 0.04±0.15 kN, and 3) 4 drops 0.004±0.09 kN.

From the plots either reducing the number of locations or reducing the number of drops to the top two drop heights provided acceptable data to the original cushioning measurements. As such, on race days to reduce data collection time the protocol could be modified to taking fewer measurements from key locations on the course or taking 4 drops from the highest heights and moisture at each 250 m location.

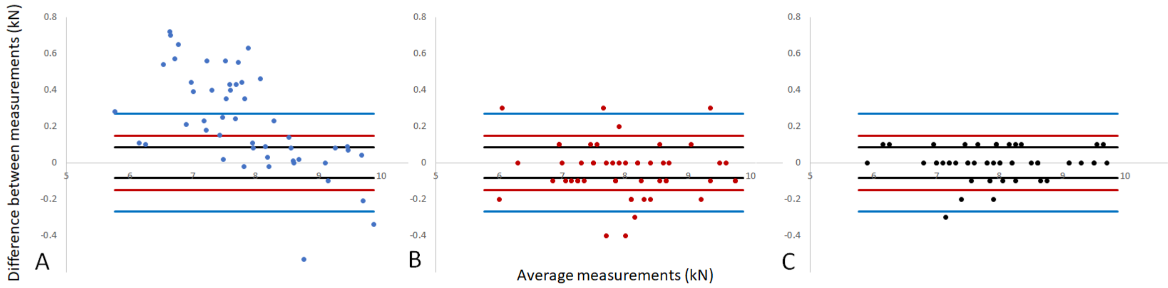


Figure 3.7: *Bland Altman plots of cushioning (kN) using three revised protocols. A) No moisture (blue), B) 500 m (red), C) 4 drops (black). One standard deviation of the difference between measurements is highlighted on each graph showing the spread of data between protocols.*

3.1 Comparing to official going measurements and descriptions

GoingStick® Analysis

Outliers

No significant differences were found between outlier groups (P=0.229).

Race type

A difference was found for race type (P<0.001) where GoingStick® indices were different between flat and jump (chase/hurdle) racing. However, differences between race type were not evident when outliers were considered (P=0.658).

Geographical region

There were no significant differences between regions (P=0.338) or between regions when outliers were taken into account (P=0.886).

Number of fixtures

A difference between fixtures was evident (P<0.001), where a lower index was associated with a lower number of fixtures (see Figure 3.8). There was no difference when considering fixtures with respect to outliers. From the evidence, the GoingStick® produced a lower index, indicating softer, less compacted ground for courses with a low number of fixtures.

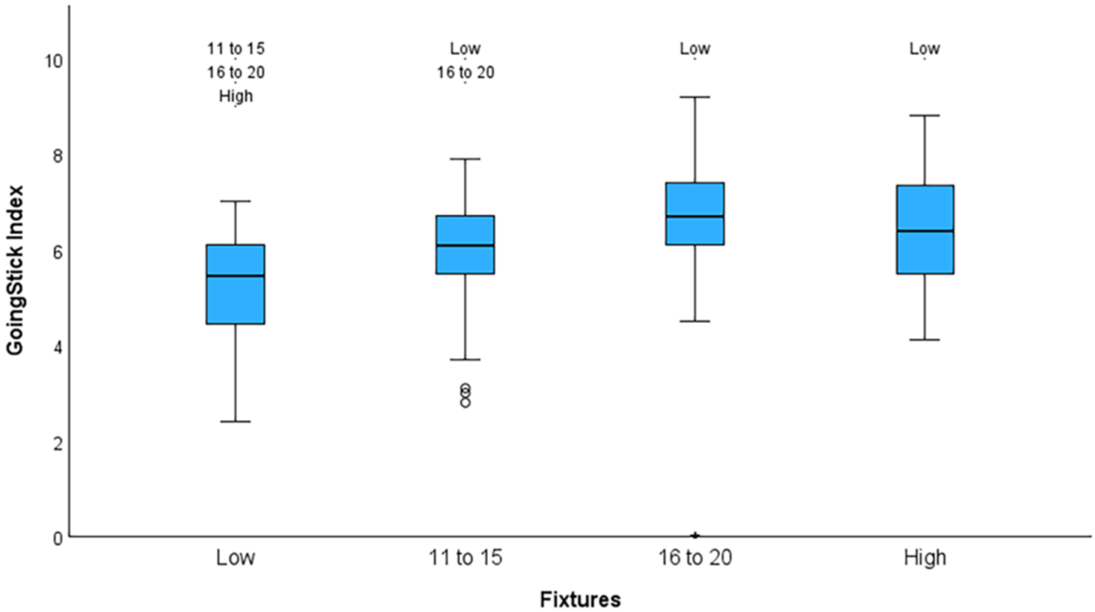


Figure 3.8: *Mean (black line), 25 to 75% confidence intervals (blue box) and error variance (black T bars) for GoingStick® Index when separated by number of fixtures. Pairwise significant differences (P<0.05) are indicated above each fixture category. For example, significantly lower GoingStick® Indices were found for courses with a low number of fixtures compared to those with 11 to 15, 16 to 20 and a high number of fixtures.*

Soil type

There were no significant differences between soil type (P=0.280) or soil type when outliers were taken into account (P=0.816).

Month

There was a significant difference between months (P<0.001). Table 3.3 illustrates where differences were found. No differences were found when considering month with respect to outliers. The GoingStick® could differentiate going between two periods (April to September) and (November to March).

Table 3.3: *Significant differences (P<0.05) between months for GoingStick® Index (G). The colour code from the VST analysis is repeated to illustrate the differences between GoingStick® measures and VST measures: Green; temperature and surface measurements were found to be different, Yellow; only temperature was different, Blue; only surface measurements were different, White; no differences were found.*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan												
Feb												
Mar												
Apr		G										
May	G	G	G									
Jun	G	G	G									
Jul	G	G	G									
Aug	G	G	G									
Sep	G	G	G									
Oct												
Nov					G	G						
Dec				G	G	G	G	G	G			

Developing cushioning measurements with continued use of the GoingStick®

An alternative to using the VST for measuring cushioning on race days was to develop a prediction of cushioning using the GoingStick® index combined with variables that were identified as important components of cushioning (moisture and energy return). Moisture can be measured quickly and easily on race days using commercially available devices. Energy return is a VST measurement, but as each course has its own fingerprint related to energy return that does not vary too greatly annually, an average value for each course could be used to reduce course related variability in GoingStick® indices. As such, GoingStick® indices, moisture and course averages for energy return were evaluated in a regression equation against cushioning for the complete dataset.

Exploration of the results was carried out to assess the range of predicted cushioning values within each Timeform descriptive assessment of going (separated by race type). The results are shown in Figure 3.9.

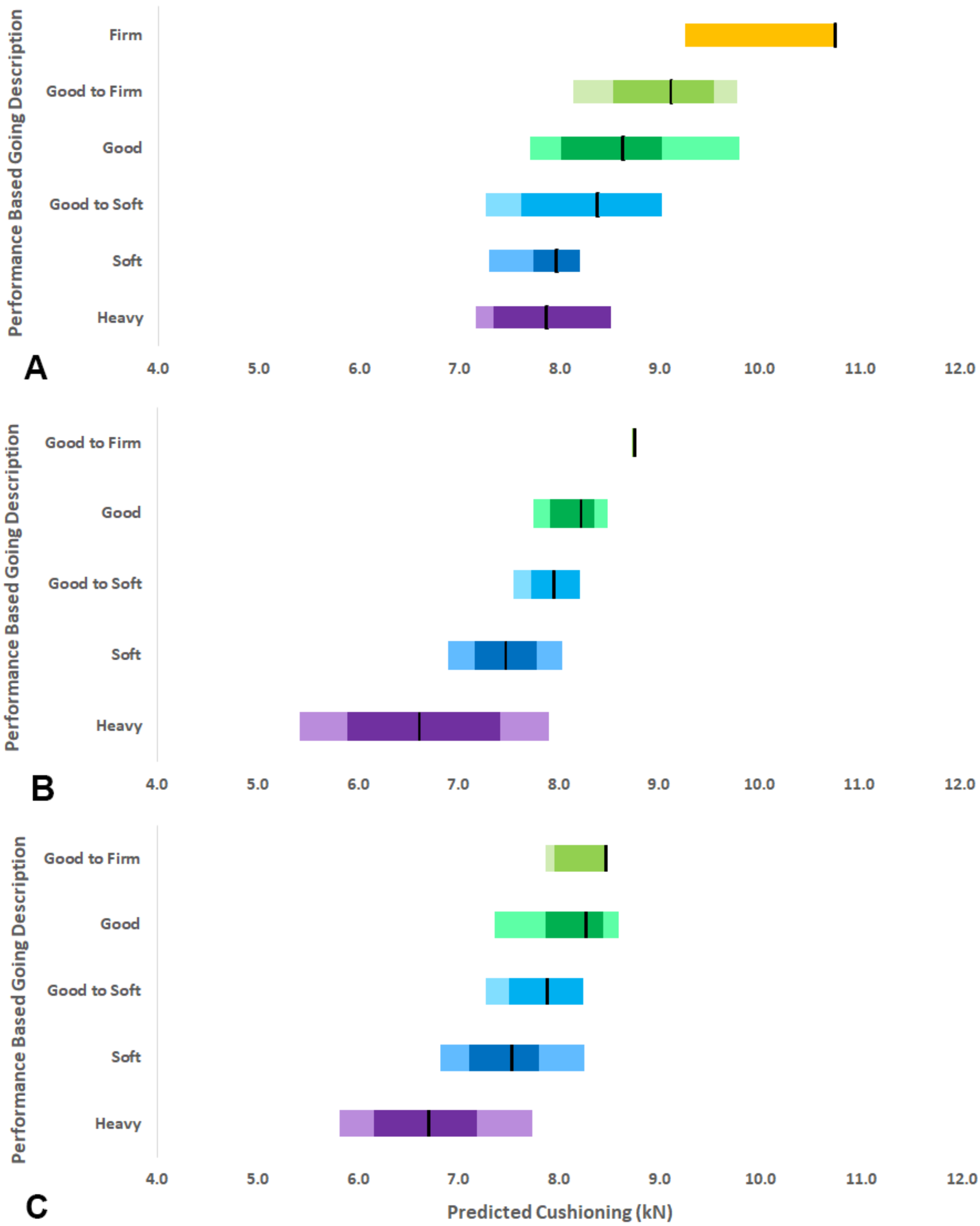


Figure 3.9: *Results for predicted cushioning (calculated using GoingStick Indices, energy return and moisture) separated by Timeform performance based going descriptions for the complete dataset separated by A) Flat, B) Chase and C) Hurdle disciplines. Colours denote confidence intervals; black = 50%, darker colours = 25-75%, lighter colours = outliers.*

Comparing back to official going descriptions

For the final analysis we have included a comparison of official going descriptions and performance based going descriptions for GoingStick® indices, predicted cushioning using GoingStick® indices, moisture and course-based energy return and cushioning. Huber's maximum likelihood estimation was used to compare the sample averages for going descriptions for flat and jump going separately. This information is provided in Table 3.4.

Table 3.4: *Maximum likelihood estimations for official (O) and performance based (P) going descriptions and the difference between them (D) for GoingStick® indices, predicted cushioning (kN) and cushioning (kN) for jump and flat races.*

Flat	GoingStick® indices			Predicted cushioning (kN)			Cushioning (kN)		
	O	P	D	O	P	D	O	P	D
Firm	8.5	8.2	0.3	10.7	10.7	0.0	11.1	10.5	0.5
Good to Firm	7.8	7.4	0.4	9.4	9.1	0.3	9.7	9.4	0.2
Good	7.1	7.3	-0.2	8.7	8.6	0.1	9.0	8.8	0.2
Good to Soft	6.8	6.4	0.4	8.2	8.4	-0.2	8.5	8.4	0.1
Soft	5.7	6.4	-0.7	7.8	8.0	-0.2	8.0	8.3	-0.3
Heavy		5.5			7.8			7.9	

Jump	GoingStick® indices			Predicted cushioning (kN)			Cushioning (kN)		
	O	P	D	O	P	D	O	P	D
Good to Firm		6.3			8.7			7.9	
Good	6.6	6.8	-0.2	8.2	8.2	0.0	8.1	8.1	0.0
Good to Soft	6.1	6.3	-0.2	7.8	7.9	-0.1	7.7	7.8	-0.1
Soft	5.4	5.4	0.0	7.4	7.5	-0.1	7.2	7.4	-0.2
Heavy	4.2	4.3	-0.1	6.6	6.7	0.0	6.6	6.6	0.0

The data presented in Table 3.4 provides a basis from which a numeric value of going could be used for flat and jump racing that does not need adjustment between racecourses. The values would indicate the mid-point of each description, so agreement between official and performance-based descriptions would be essential prior to use of the method.

Outliers will need further monitoring to understand why the measurements do not follow expected opinions and/or performance.

Additional information that was not included in the analysis was a value for VST cushioning from two racecourses when flat racing was subsequently abandoned (6.2 kN and 6.3 kN), which could be used as a low threshold for abandoning flat race meetings in the future, when the ground is very wet. A high flat racing threshold, where racing was abandoned was not measured however currently the highest recorded VST cushioning value in this dataset was 11.5 kN. For jump racing, the highest and lowest recorded VST cushioning values were 9.1 kN and 5.5 kN (chase) and 8.9 kN and 6.2 kN (hurdle).

3.2 Conclusions

A database of surface measurements (VST, GoingStick® and official going) and external factors that include race type, geographical region, number of fixtures, soil type and month for reference and analysis purposes was developed in line with the objectives of the study.

The complete dataset was analysed to investigate strengths and limitations of current and potential methods of measuring going and to support recommendations for future assessment of racetracks on race day and routine preparation.

Key results from this analysis were that:

- Courses that have a higher number of fixtures are likely to be more compacted.
- Regional differences in top level firmness were evident, which could not be completely explained by the measurements.
- Energy return provides a course related fingerprint that influences performance.
- The GoingStick® can differentiate between seasonal periods, race type and number of fixtures based on this analysis.
- Regional variation in course variability was evident and course variability is also likely to impact performance.

Any tool and/or method that is employed to measure going on race days that would supersede reporting the GoingStick® index should be introduced over time and should include ongoing evaluation of the results with key stakeholders to develop confidence in and understanding of the data reported.

4 Soil analysis to identify soil texture using a sample of seven racecourses

Introduction

Whilst the primary focus of this project has been to evaluate the reliability and consistency of a mechanical test device, soil type cannot be overlooked. Natural turf is a granular material made up of soil particles, air and water, with grass sward and roots. Of particular interest is soil texture because this will affect the ground's architecture, porosity and water holding capacity which in turn, will influence how mechanical test devices respond.

Originally classification of soil texture was expected to be collated from information provided by clerks, which did occur, however it was evident that many racetracks have distinctly different soil types that could not be reported consistently. Additionally, the soil descriptions that some clerks have on record were only taken from one location and may have been assessed a year or more ago meaning modifications may have occurred through routine maintenance such as filling divots. Soil used to fill divots does not always match the original soil texture in which case changes in soil type may occur. These inconsistencies meant that although clerk's information about soil texture was recorded, there was a need to explore the type of soil more thoroughly, but on a smaller scale. To support this part of the project, the aim was to investigate the influence that soil texture had on ground and going data by analysing soil profiles from seven racetracks in more detail.

Objectives

1. Explore effects of soil texture on mechanical properties measured using the Vienna Surface Tester
2. Report variability of soil texture from seven racetracks using data collected every 500m

Method

Soil samples were collected using a soil corer every 500 m at seven racetracks (Figure 4.1) and measurements were taken using the VST and moisture meter at every location to produce matched data. Soil samples were processed using dry sieving to calculate percentage sand and organic matter and laser diffraction was used to quantify percentage silt and clay, providing an accurate measure of soil texture [8].

Figure 4.1: *Example of soil core taken from seven racecourses out of season to analyse the influence soil texture has on surface functional properties*

4.1 Results and discussion

Objective 1: Explore effects of soil texture on mechanical properties measured using the Vienna Surface Tester

VST-generated variables such as energy return, stiffness, firmness (GMax) and depth show a range of strong relationships with soil composition. Figure 4.2 highlights that energy return (2m/s and 4 m/s) were strongly correlated with that of the percentage of both silt and clay. Conversely, the percentage sand content of a racecourse surface was correlated with that of stiffness, firmness and cushioning.

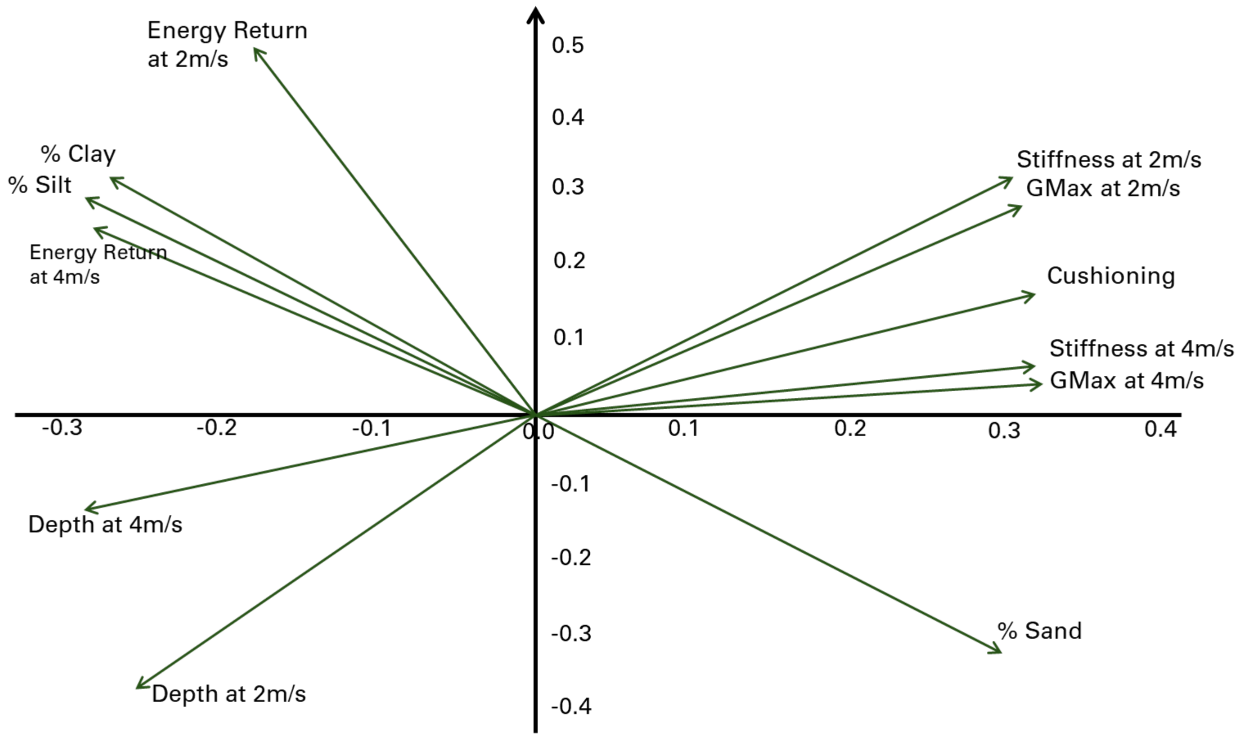


Figure 4.2: *Loading plot demonstrating the interactions between key soil properties and the variables assessed by the Vienna Surface Tester*

This is a 'Loading Plot'. When trying to describe all the competing variables which interact on a racecourse, we often use a 'Loading Plot'.
Much like a tug-of-war, if two variables are on opposite sides, they are negatively related; if they are close together, they are likely to be positively related.
A loading plot helps you see which variables are most important and how they relate. It's a visual guide to understanding the underlying structure of your data.

Objective 2: Variability of soil texture from seven racetracks using data collected every 500m

Coefficient of variation (CV) was calculated to produce a measure of variation within each racecourse. Number of samples taken around the entire racecourse was dependent on length of course and samples were taken every 500 m. Variation was considered to be low if the CV was below 10%. Silt and clay fractions that were most variable appeared to be identified by energy return (4 m/s), which supported the findings above and are presented in Table 4.1.

Table 4.1: *Coefficients of variation (CV) of soil texture and physical properties across seven racecourses of varying soil type. Figures in red denote elements which exceed 10% variability*

	Racecourse 1	Racecourse 2	Racecourse 3	Racecourse 4	Racecourse 5	Racecourse 6	Racecourse 7
% of Sand	7.76	6.09	10.03	6.9	6.66	2.63	5.97
% of Silt	33.81	23.7	61.93	25.08	27.43	27.1	61.25
% of Clay	29.9	34.4	53.68	34.21	28.35	30.98	64.41
Cushioning	9.87	3.06	5.83	3.23	4.47	2.51	7.19
Energy Return at 2m/s	6.23	6.69	16.24	7.55	10.43	7.29	11.73
Energy Return at 4m/s	15.34	5.9	20.46	4.49	5.83	8.9	16.17

?

The coefficient of variation (CV) is a measure of how much something varies in relation to its average. It's often used to show how spread out or inconsistent a set of data is.
If you have a CV of 10, it means that you can get values 10% either side of the of the average value. In other words, the values are showing some inconsistency.

4.2 Conclusions

The percentage of clay and silt in each course is notably variable whereas the percentage of sand remains more consistent in the courses that were sampled (n=7). Sand can be beneficial to help with drainage however the silt and clay fractions are more likely to be related to the native soil found at each specific racecourse.

Analysis performed in Section 3 identified that energy return using the VST was a course specific measurement and could detect differences in soil type. The soil analysis here, demonstrates that energy return is most strongly related the silt and clay fractions of soil, suggesting that it is the percentage of silt and clay that energy return can detect.

5 Understanding the challenges of going information

Introduction

An outcome of this project has been to better understand how to equip stakeholders in quantifying going on race day and making decisions on racetrack preparation and maintenance. Clerks are responsible for assessing and managing the racetrack, reporting the going on race day morning, and predicting how the course will perform during racing, whilst trainers must have a thorough understanding of each racecourse, including its nuances and be capable of interpreting the going index and going classifications. Therefore, exploring clerk and trainer opinion of how the ground is measured and described, is important. Direct questions through communication with clerks and interviews with trainers have been used to identify key opportunities and challenges that will inform recommendations and support how the project's overall findings are applied to the industry.

Objectives

1. Identify opinions of current methods of measuring and reporting racetrack going on British racecourses on race day
2. Describe track characteristics that are deemed to be the most important on race day
3. Identify factors that contribute to differences in opinion between stakeholders on methods of measuring and reporting racetrack going
4. Propose strategies that may support future methods of measuring and reporting going classification

5.1 Communication with clerks

Method

Opinion data from clerks of the course were used to develop greater understanding of the key issues in measuring and assessing racecourse going on race day and during routine maintenance. Clerks were asked to comment on the following three points, during racecourse visits and additionally contacted via email as a follow-up:

i) efficiency and consistency of current measuring techniques carried out with the GoingStick® and walking stick

ii) the going index and description as a method of measuring relevant characteristics of the track

iii) the use of the VST and moisture meter to assess going and racecourse condition

Thematic analysis was carried out to detect patterns that were categorised as themes and then interpreted and evaluated with reference to opportunities and challenges.

There was a good response rate from clerks (88% n=44), some responded more than once. Data was received from a variety of racecourses and clerks meaning there was a good cross-section of experience and type of racecourse. Positive responses related to the VST were tabulated (Table 5.1). Responses were coded and grouped into themes prior to analysis (interpretation and evaluation), (Figure 5.1).

Results and discussion

Clerks were asked to comment on the use of the VST and moisture meter to assess going and racecourse condition and from the comments that were given through email or verbally, there were a high number of clerks that responded positively to the VST, the comments of which have been tabulated in Table 5.1. The clerks had not experienced using the VST themselves which was a limitation of this study although they all had an opportunity to observe the VST being used and the chance to scrutinise its data output.

***Table 5.1** Overview of positive responses to the use of the Vienna Surface Tester given by clerks and grounds people (88% n=44) at* many *racecourses that were visited*

Comments about the VST that were given by clerks / grounds team and were unprompted
"I endorse the use of the VST"
"You are correct, there is varied soil and I concur with your findings. Race times are invariably a good guide and these are demonstrated here."
Stated the results were interesting and support their prediction of the going
Found the VST findings useful in general, the number of high fixtures at this racecourse meant that the clerk was not surprised that the VST detected higher stiffness in the lower levels of the soil. Clerk wanted us back again soon.
"I agree with your comments, please come back and assess it again"
"Please come as often as you would like, I would love to use these findings"
"Please come back, these findings you have with the VST would be very useful for this course because it is steep and uneven and difficult to assess and it would help get the uneven part of the course ready for race day"
Great to have something that is comparable between courses
Impressed with measurements, that are very similar to their opinion, especially the softer areas of the course which were picked up, they want us to come back
Broadly concur with the grounds team, moisture from natural rain seemed to be distinguished from irrigation due to difference in quantity and rate
Clerk said they would be very happy to use the results as part of the official description
Expressed pleasure in a less subjective tool that could be helpful especially with climate change and smarter watering / preparation.
"At times it can be difficult to get the stick into the ground and therefore the VST could be a better tool"
Happy with the findings which matched their opinion and showed the differences between the chase and hurdle courses
"The data really makes sense"
The grounds team asked if we could go more often, the VST identified the area that was needed to be improved through better drainage
"Good to have similar results to what we have predicted, we take going readings seven days prior to racing and this tool could be beneficial for this too"
Clerk wanted to use the VST prior to race day to help see what needs doing. The clerk talked about wanting to measure going related to energy return and for this reason was very interested in the VST.
Comment on the importance of consistent measurements and the use of moisture data, not directly related to VST but suggesting these factors are crucial
Very impressed that we got the same results as the grounds team
The VST identified a water blockage and a burst pipe
Good because it can pick up lower and top levels, it backs up what we find – provides evidence to support us
Horse feels the deeper layers of surface and traditional tools cannot pick this up, the clerk suggested that it could be that what the ball tells us is right
"We agree with your results, the wetter parts are exactly where we expected them"
"Again, excellent data that is really building a model for our course. Energy return data was certainly applicable."
"You have shown the subtle differences in the course"
"You have picked up the wetter areas exactly where we have them, it is also very useful to see the deeper levels"
Clerk stated that the data is very helpful
Clerk stated that they agree with our data

5.2 Confidence in GoingStick® values: opportunities and challenges

Several clerks have stated that they lack confidence in the GoingStick readings. There are likely to be multiple reasons for this, some of which have been noted by clerks and are highlighted below:

- The GoingStick® is operator dependent, for instance the clerk and head grounds-person can take measurements at the same time but get different average readings. Individual operators will produce differences in applied force when the probe penetrates the ground whilst the angle and rate of pull back can alter measured shear properties [4]. One clerk mentioned possible inconsistency or malfunction in their device, but this was not commonly identified. The protocol used by clerks or grounds-people at different courses can vary, for instance some will push the GoingStick® into the ground using their foot whereas it is meant to be pushed in by just holding the handle.

- Course specific differences in physical properties such as soil type, particle size difference, depth and moisture will influence the response. To our knowledge the GoingStick® does not currently account for soil type or moisture. Moisture is measured at some but not all courses.

Despite a significant number of comments that identified challenges with the GoingStick®, some clerks gave positive feedback, illustrating that this is not a universal opinion. Three clerks commented on how the GoingStick® was useful. One clerk described how the GoingStick® supported the going they published on race day and was important in providing more than just a subjective classification. Two clerks described the benefits of the GoingStick® during course maintenance such as irrigating the course and decompaction. An additional point made by one of these clerks was that the GoingStick was useful in summer when deciding on irrigation schedules but that it was not necessarily a reliable tool for explaining going on race day.

5.3 Using the Vienna Surface Tester to assess track going: opportunities and challenges

The deeper layers of the track are significant to the performance and safety of the horse and some clerks commented on how the use of the VST could enhance the going classification because of this. There were significant numbers of comments by clerks about how trainers and jockeys had little confidence in the published going. Some clerks felt that if they had a greater level of detail of the ground then they could better explain and justify the published going value and description. Interestingly there were examples of where clerks described jockeys and trainers as immediately assuming that if the grass was wet then the going would be soft and if it was dry or slightly discoloured the going had to be good / good to firm. It is unclear whether this type of assumption occurred regularly and it may be more directly related to an individual horse rather than the trainer's opinion more generally.

Despite high numbers of comments supporting the use of the VST, there were concerns with how long it would take to get round the course on a race day. None of the clerks have used the device themselves at this stage but this comment deserves further investigation. Analysis of the complete data set for this current project has included exploring the effect that reduced sampling has on surface characterisation.

5.4 Using the Vienna Surface Tester in decision making prior to maintenance: opportunities and challenges

Many clerks expressed an interest in how the VST provides a more detailed level of understanding of the track, beneficial for track management. It was suggested that it could support decisions on maintenance for decompaction work and irrigation, and that more VST data would be welcomed in the preparatory work before fixtures. One of the clerks reported that the VST identified specific areas of drainage and irrigation that had been carried out the day before, indicating sensitivity of the tool as well as the level of detail that was given. Another clerk commented on how a tool that only measured top layers of the surface (for example the GoingStick®), failed to include important information about the deeper layers. The deep layers of the soil are directly relevant to how the more superficial layers will behave and are therefore important for making decisions about maintenance [1,2,6].

5.5 Clerk opinion: conclusions

In summary there were mixed opinions of both the GoingStick® and the VST. There appears to be a lack of confidence in the GoingStick® by clerks which means that the going assessment becomes subjective and the clerk makes their own decision using other tools. There is an interest in measuring the deeper layers, to help support the clerk's decisions for course maintenance in between race fixtures, as well as in predicting the going on the morning of race day. The primary challenge in using the VST on race days would be the length of time taken to measure it. The use of a reduced number of drops per location or reduced test locations were possible and are presented in section 3.

The description of going should ideally reflect how the surface will perform. If it is possible to measure a surface objectively, that is consistently comparable to horse performance, then it is hypothesised that clerks, jockeys, and trainers will gain more confidence in how it is measured.

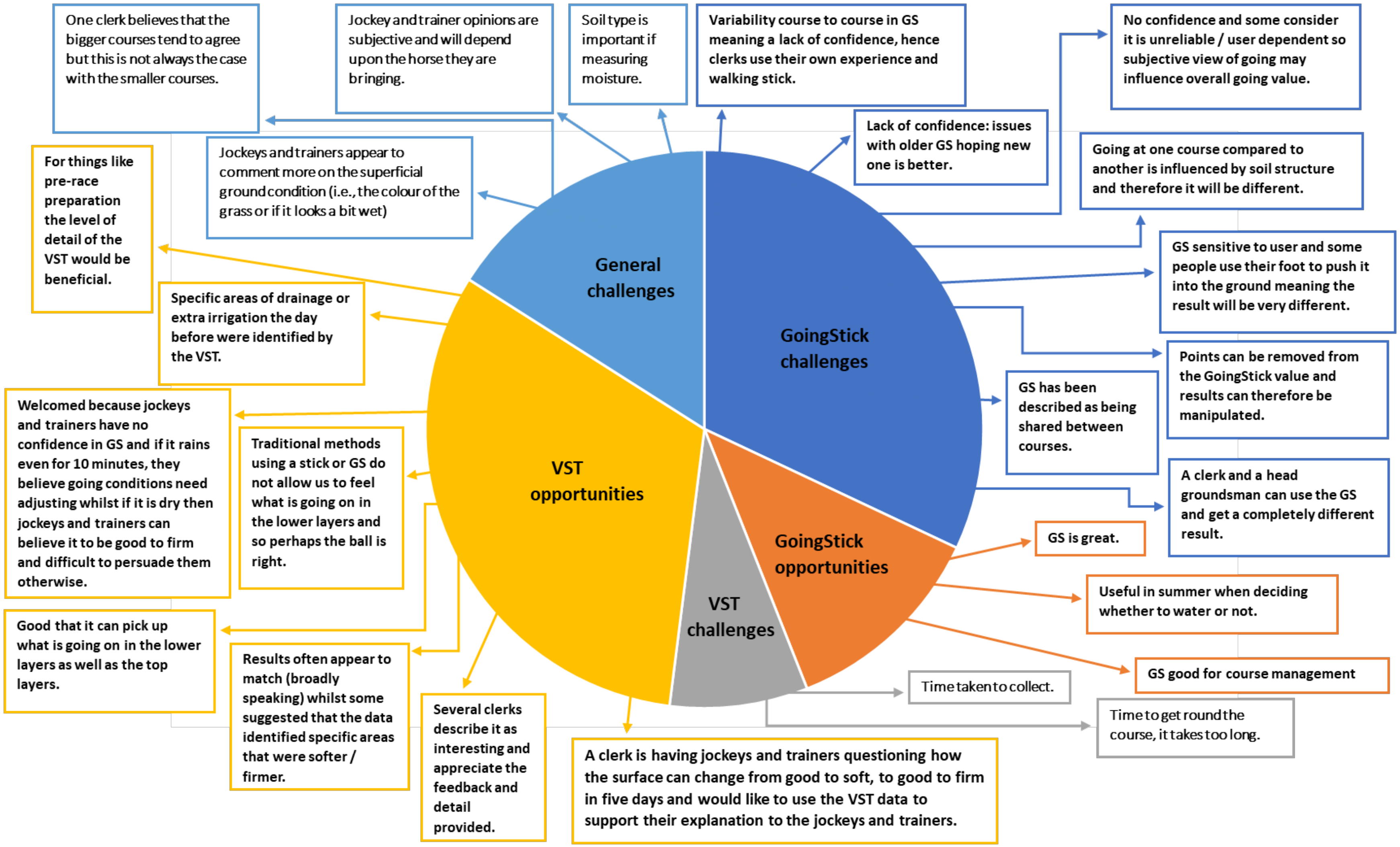


Figure 5.1: Clerk responses, coded and analysed by exploring various themes and supporting comments or points raised by clerks

5.6 Communication with trainers

Method

Trainer opinion was extracted through direct enquiry using semi-structured interviews by telephone to help understand individual trainer perception (Appendix I). The approach was idiographic, meaning that rather than aiming to identify opinion of trainers more generally, there was a focus on individual perceptions and the lived experience. Interviews were audio-recorded and later transcribed verbatim, as a word document and securely stored. Analysis was carried out using interpretative phenomenological analysis (IPA) that allowed a flexible approach, appropriate for semi-structured interview methods. IPA aims to allow the researcher to immerse themselves in the data so that they can develop an in-depth understanding of the topic in question (assessing racecourses), from the perspective of the interviewee (the trainer) whilst considering the research question and relevant theory [9]. The audio and text were carefully scrutinised multiple times by two researchers who came from different experiential backgrounds to provide a more thorough interpretation. Scrutiny of the interview data enabled the development of exploratory comments and from this, emergent themes were produced. The themes were further investigated to identify connections between the experience of different participants and where appropriate, themes were clustered and used to produce conclusions. Final themes were derived according to frequency, quantity and depth of responses; experiential assertions from trainers were balanced against the researcher's interpretation through contextualisation to support a transparent and detailed analysis.

Results and discussion

The interviews lasted between approximately 15-30 minutes and allowed three key themes, there were no areas of non-disclosure. All data was pseudonymised and includes trainers from different geographical locations in Great Britain and those from large and small training establishments. Questions did not specifically refer to maintenance practices however this was a topic that was often referred too (Table 5.1).

Table 5.1 *Themes derived from interviews with trainers (n=6) on opinions of assessing the ground and going at racetracks*

Confidence in the official going description and GoingStick® index	Validity and reliability of equipment	-reliance on clerk and own assessment (varied methods of assessment) -track conditions not comparable across courses -difficult to resolve these issues -subjectivity of the going description and official going index (not always comparable to description) -clerks do not always rely on / trust GoingStick® readings
	Motives of the racecourse	-concern that clerks / racecourse owners may have a vested interest to attract more runners -call for independent going assessors for impartial assessment of going
	Subjective nature of going classification results in disagreements	-clerks are variable in their reporting and this has to be accounted for -everybody has different experience and opinions (subjective)
Level of detail of the course	More detailed report of the racecourse	-multiple readings leading up to the race -like to see more detail for instance difference in the back straight to the rest
Course maintenance	Watering and root growth of racecourse	-watering appears to be inconsistent (i.e. over watering or just watering the racing line or watering when high levels of solar radiation) -divot filling can mean that root growth is poor
	International practices	-Canada suggested that races are altered to dirt tracks when turf is too soft whereas in France, the ground tends to be softer than here (GB), suggested that watering practices are better in France

The following is a short exploration of the main emerging themes from the thematic analysis. The quotes used are a small sample and are the ones that best summarised each emergent theme.

Confidence in the official going

Validity and reliability of equipment

In order to assess the course on race day all of the trainers (n=6, 100%) said they would check the official GoingStick® index and description of the course however each trainer expressed differing levels of value placed on these metrics as suggested by Trainer 1 who said "You take into account the figures, but often I'll ask them how far they can get their stick in to the ground because I personally would still use a pointed stick." Whilst Trainer 2 said "Obviously if the GoingStick® numbers are completely different (to the going description), I would question this with the clerk of the course, but I'm not as hung up as most trainers are about going…"
Trainer 5 described the going assessment as being "quite subjective" and that they would use "…badgering questions…. to get the clerk's opinion of the ground" to help with their decision making, because of the subjectivity of the assessment. From analysing the data of all trainers, understandably there appear to be a variety of techniques used to get the information they need.

Some trainers emphasised the importance of walking the track prior to racing to get a better sense of the ground conditions themselves but that footwear would influence how well they could evaluate the going. Several trainers demonstrated a preference of using a stick to push into the ground to make their own assessments such as Trainer 1 (see above) and Trainer 5 who said, 'If I was at the racecourse, I always walk it myself with a stick and use the point of the wooden stick…."

Preference of a walking stick was found by some clerks and head grounds people with similar comments to trainers as to how this is more familiar to them and that they have more confidence in this. It is apparent that most trainers formulate their opinion of the ground using a mix of different measures or observations but that each has their own formula. There appears to be a lack of trust in the accuracy and reliability of the official going as expressed by Trainer 2:

"I tend to weigh up both (going index and description), but knowing the clerks of the courses I trust, I will take their description as 80% of it."

Some trainers suggested that the clerk tells them the GoingStick® does not work but when it is working, they may also lack confidence in the values as described by Trainer 3:

"I'm not convinced that they (the clerks) have great faith in the GoingStick® when you speak to these guys…"

Despite most trainers expressing some level of mistrust or lack of confidence in the official going (n=4, 67%), Trainer 6 seemed to be less concerned and provided the following view on the assessment of course going: "I think the GoingStick® is, of use.

You know, I don't think it's the be all and end all, to be honest. You know, I'd prefer the overall description and what I saw when I got to the racecourse…."

Motives of racecourses

Overall, trainers relied on the description of the course from the clerks and most agreed that the clerk's opinion played a large part in their decision-making process. However, there were several expressions of distrust of the official going and course description published by some racecourses as explained by Trainer 5:

"It depends on the clerk of the course. It depends on the owner of the racecourse because quite often, particular racecourse ownership groups will tell their clerks to not publish that the ground there, is any quicker than good ground. So, you just get to know which ones you don't trust."

It is evident that trainers believe some racecourses attempt to attract as many runners as possible, even if this means that they are not as transparent about the going as they should for example a comment by Trainer 1 stated that "some clerks are over optimistic to make you run". It seems that trainers are aware of differences in clerks and courses, for example Trainer 2 said "You have to know your courses and you have to know your clerk as well. So, the accuracy tends to be good on the whole… accurate of the going description. But going back to your previous question, some of them get it very, very wrong."

This has led to questions being raised around the ethics of having the ground tested by the venue's staff and suggestions of the need for an impartial group to assess going. Several of the trainers emphasised the need to reconsider who assessed and published the course going on race day, as highlighted by Trainer 4:

"I honestly believe we should have independent going describers…. You know, it shouldn't be down to the clerk of the course, who is employed by people who have vested interests in getting full fields for their races. So, they want them to describe the going as good to get as many runners as possible."

And Trainer 5 stated "I think you just have to have a completely independent person doing it. And you know, just saying that's what it is …. Sometimes it will be the same as a clerk and quite often it will be different."

Subjective nature of going classification

Many of the trainers talked about the subjective nature of going and how this leads to disagreements in classifying the ground. The subjectiveness raises questions of the accuracy of reporting the ground between courses with good in one place being different to good in another. These comments support the evidence provided from the main data analysis where there is quite a bit of crossover between descriptions classified under each GoingStick value. Trainer 2 explains this clearly by saying "Calling going by one descriptive word, good, good to soft, firm, good [to] firm. It depends on who is giving that description. So, it's not scientific, it's a man's opinion." Trainer 6 talked about subjectivity by explaining that the going description is an opinion and is therefore personal, "… Some people might say it's good ground and some people might say it's good to soft or good to firm." Trainer 4 stated that courses cannot be easily compared because of soil texture and other such factors.

There is always going to be an element of the trainer having to interpret the going classification and it is clear from these interviews that each trainer has their own strategy. Trainer 3 explained how the responsibility of understanding the going on any given race day is down to them as the trainer:

"I think all going is open to interpretation. You know, we have an official description/reading. But I think ultimately, it's up to us to decide if we think it's accurate or not."

Without the use of a more objective measure that is not influenced by operator or affected by factors specifically related to a course, then it is difficult to remove the subjectivity.

Detail of the course prior to race day

A less prominent theme but one that many of the trainers touched upon (n=5, 83%) was the need for multiple readings leading up to the race day that should be taken and published. More detailed reports of the track which better defines the variability in going (i.e. places to look out for), would be desirable. Trainer 3 stated "I think they need to let us put a little bit more meat on the bones. Yeah. You know, for example, if the ground is good to firm on the easy side, is it on the firmer side." Trainer 4 explained how some clerks provide a little more information but only one or two clerks do this, "...one or two clerks … If it's a mixture of ground, for example, it's good and good to firm. They put it's 60% good and 40% good to firm…" Trainer 5 supported these comments by highlighting a more detailed report as favourable by saying that it was "…quite sensible when they report it as certain parts of the track [are different], you know, when they refer to as the back straight or this, that and the other." Trainer 6 implied the same point: "[A detailed description of the course] … can't do any harm. If there was a difference in the back straight to the home straight, you know..."

The issues around declaring 48 hours before the event was identified because of how a course could be significantly different by race day. Trainer 2 described how "…going descriptions are prone to change in a matter of hours." Trainer 4 explained that "…the problems that they have in British racing in the summer because we have 48-hour declarations and they're trying to predict what it's going to be like in two days' time. And with the British summer, it could be totally different from what they were expecting."

Course maintenance

The interview questions (Appendix I) did not include anything about course maintenance because this was not the focus of the study however trainers commented on how maintenance effected going on race day and highlighted practices in other countries. There were some comments about the management of over racing certain courses (and compaction) and difficulties when the courses are small and that some courses manage the land better than others. Trainer 2 states: “so especially some of the smaller tracks.... haven't got enough room to produce fresh ground for later meetings in the year. I'm pretty sure clerks of courses have got to be aware of this, ...but they have to be honest with trainers and participants... as regards preparing courses for each meeting, there has to be future thought throughout the year of producing the best ground possible...” There were also some comments about root structure and how this influenced how the horse responded to the ground and how the ground reacted to higher levels of rain. Trainer 1 stated that racecourses in France were “always a bit softer...” whereas in Canada, Trainer 3 described courses being firmer than GB:

“.... and that was very different (in Canada) because they actually take the opposite view.... you can expect firm ground and [they] sort of shy away from good and good to soft ground, you know.”

5.7 Trainer opinion: conclusions

Clerks have stated that greater detail of the course would support them when talking to trainers therefore these findings from interviewees emphasises how the opportunity to produce a more reliable objective ground assessment prior to or on race day would benefit industry stakeholders. An in-depth discussion with the clerk can be important to the trainers, partly due to lack of confidence in the going values but the clerks need data to help support them in this discussion.

Considering the amount of time that the GoingStick® has been in existence and been used on racecourses (2007) it is interesting that there appears to be a preference toward using a wooden stick over a GoingStick®. The main data analysis and comments from clerks support the suggestion that for some, there is little confidence in the GoingStick® index. Additionally, it is clear there is a difference in opinion, likely to have developed through individual experience. Trainers suggest that independent course assessors would be of benefit, however the use of a more objective and consistent method of measuring the going may help to alleviate the problems currently encountered.

Lack of confidence in the going assessment appears to be because of a variety of techniques used to assess the going, the inconsistency of results using the GoingStick®, the subjectivity of the course assessment, the unpredictability of the weather and the motives of some racecourse to optimise number of runners.
There are some comments about the 48-hour declaration because it can be challenging for trainers and if this 48-hour declaration cannot be changed, increased detail of the course and local weather may be of benefit.

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7. Appendix I

The following semi-structured interview questions were used during interviews with trainers, conducted via telephone. Ethical approval was received 18/06/24 through the School of Animal, Rural and Environmental Sciences Research Ethics Committee, who reports to the University Open Research and Research Integrity Committee.

Questions were developed following a pilot study and the interviewer additionally practiced an unbiased approach using test subjects, prior to the final study.

Engagement/introduction

1. Can I ask firstly, what discipline do you train (i.e. jump / flat or both)?
2. On the morning of race meetings where you have horses running, what do you do to assess the going for your horses?

Opinions of the Going Value and Going Description

3. Can you let me know your thoughts on the official going information that is published before race meetings?
4. What going information do you use on a regular basis?
5. In your opinion, what surface characteristics of racecourse going are important?

Comparability between racecourses

6. Can you comment on whether you think official going values and going descriptors given by clerks throughout GB are directly comparable, broadly comparable or never comparable.
7. Could you suggest or explain why you think this is the case?

Agreement with the clerk

8. We want to ask about how likely it is you agree with official going descriptions Firstly, can you tell us whether you frequently agree or disagree with the published going value and going description given by the clerk?
9. Can you describe why (although this may have already been answered).

Experience under other jurisdictions

10. If you are involved in racing in other countries, can you comment on the differences and/or similarities in assessing going on race days, compared to GB?

Future development and other methods of assessing the going on race day

11. Do you have any suggestions of how the assessment of going could be improved in GB?

Exit question

12. Do you have anything else you would like to add?