GROUND CONDITIONS AND INJURY RISK—IMPLICATIONS FOR SPORTS GROUNDS ASSESSMENT PRACTICES IN VICTORIA

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ABOUT THE AUTHORS

Associate Professor Leonie Otago has extensive experience in the field of risk management and injury prevention from both research and practical implementation perspectives. She has researched the prevention of knee and ankle injuries extensively, and presented at National and International conferences. She has worked with organisations such as Sports Medicine Australia (National and Victorian branches), Smartplay Victoria, Tennis Australia, Netball Victoria, Netball Australia and been awarded grants from Sport and Recreation Victoria, Department of Human Services and VicHealth. She has had extensive experience in sporting organisations as an administrator, coach, coach educator and player.

Dr Peter Swan practices and writes about risk within sport and physical education. He has extensive qualitative research experience and provides both consultative and research services to the educational, legal and sporting communities about risk management, best practice and negligence.

Mr Ian Chivers has been involved in the turfgrass industry for more than 20 years, with a particular emphasis on football and racetrack surfaces. He has recently completed a large research project for the AFL that examined the eight major playing surfaces in the league over three seasons. This work has determined acceptable standards for the playing surface used by elite level AFL footballers and has identified relationships between certain surface characteristics and knee injuries for footballers. This information is being used by the AFL to establish satisfactory playing conditions.

Professor Caroline Finch is Australia’s leading sports injury epidemiologist. Her sports injury prevention research focuses on community level sport and involves close collaboration with sporting bodies and government agencies. She has designed and conducted a number of injury surveillance and injury intervention studies in community and junior Australian football and rugby union. She is a sports safety advisor to government agencies including Sport and Recreation Victoria, Smartplay Victoria, NSW Sporting Injuries Committee, NSW Health and Sports Medicine Australia as well as various sporting bodies.

Professor Warren Payne has undertaken research and published internationally across a range of injury prevention areas, including in the sports of rowing, basketball and netball, as well as occupational injury related to shearsers, fire fighters, soldiers and construction workers. Much of his research has focused upon developing and implementing strategies to reduce the risk of back, knee and ankle injuries, including modifications to equipment and workplace design, activity and employment strategies as well as management systems and culture. He has also undertaken an extensive number of research projects to investigate the factors that affect participation in community sports. This research has included investigating the effect of ‘Health Promoting Environments’, such as safe sporting environments, upon sport participation. This research has
significantly influenced the strategies used by key government agencies to promote participation in sport and recreation.

Dr John Orchard is regarded as Australia’s leading sports medicine expert on the relationship between ground conditions and injury risk. He has conducted the AFL Injury Surveillance System for the last 15 years. Results from his ongoing analyses of the AFL injury data have indicated that there is a relationship between stage of the season, ground conditions and injury. Dr Orchard has also studied National Football League (NFL) injury data in the USA to assess the relationship between ground conditions and injury in that competition.

PERMISSIONS

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EXECUTIVE SUMMARY

Over recent years, questions about the suitability of grounds for sporting activities have risen to the fore, particularly with ongoing drought conditions. Sporting bodies and councils have begun to ask questions about the suitability of their grounds; how they should go about assessing them; and what they should do to address any identified safety concerns. Intuitively, ongoing drought conditions have an impact on the hardness of playing fields. Unfortunately, in the absence of clear evidence-informed validated guidelines, ground managers, Local Government Authorities (LGAs) and State Sporting Associations (SSAs) and their clubs make decisions about the suitability of a turf sports ground for sport based on anecdotal evidence and common sense supposition. This has lead to actions and decision-making criteria that may be hard to defend formally. Moreover, the lack of solid evidence limits the advice that can be provided to LGAs, SSAs and clubs about grounds management and safety risk.

In 2005, the Sport and Recreation Victoria (SRV) portfolio of the Department for Victorian Communities, commissioned a study to review and evaluate issues relating to turf sports ground and surface conditions and their possible relationship to sports safety. This report presents the outcomes of this study. It includes a critical review and evaluation of the standards and related guidelines and practices currently used by turf-based sports and ground managers to assess ground safety and injury risk, as well as an investigation of the current evidence about the relationships between ground conditions and injury risk.

The following boxes summarise the current scientific evidence linking ground conditions to injury risk and highlight where gaps in current knowledge exist.

Summary of what is known about ground and surface conditions as a risk factor for sports injury

<table>
<thead>
<tr>
<th>The evidence linking ground and weather conditions to sports injury risk comes from studies of elite, professional or semi-professional footballers, across all codes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A risk management approach to removing and controlling ground condition hazards needs to include factors such as the presence of hazards and debris, unevenness of the ground and type of surface, as well as ground conditions and the impact of weather conditions.</td>
</tr>
<tr>
<td>There is generally an early-season bias in the occurrence of football injuries. This may be related to harder ground conditions or greater shoe-surface traction at the start of the season in countries such as Australia, but other factors such as player fitness/conditioning, training schedules and the speed of the game are just as likely to be important.</td>
</tr>
<tr>
<td>Circumstantial evidence suggests that it is highly likely that variations in ground conditions are responsible, at least in part, for the early-season bias in football injuries.</td>
</tr>
<tr>
<td>The major characteristics of ground surface that need to be considered are ground hardness and traction. The current evidence linking ground hardness and injury risk is equivocal. The incidence of lower limb injuries may be more related to shoe-surface traction than to ground hardness.</td>
</tr>
<tr>
<td>There is a suggestion of an increase risk of lower limb injuries on Astroturf, compared to natural grass.</td>
</tr>
<tr>
<td>In elite AFL competitions, there appears to be an association between the type of grass and injury rates, particularly for ACL injuries</td>
</tr>
<tr>
<td>Although injuries occur in both formal game settings and training sessions, the relationships with ground and weather conditions are likely to be different.</td>
</tr>
</tbody>
</table>
Summary of what is not known about ground and surface conditions as a risk factor for sports injury

- The relationship between injury risk and ground conditions in sports other than the football codes. In particular, there have been no published studies in cricket, hockey or netball. In Australia, apart from one study in semi-professional rugby league, all other data about injuries and ground conditions comes from the elite AFL competition.
- The extent to which, if at all, the studies in elite, professional or semi-professional football are directly relevant to community and junior football, let alone other sports.
- The extent to which studies conducted overseas (e.g. in soccer and rugby union) can be directly applied to the sporting ground context in Australia.
- The nature of the direct relationship, if any, between ground conditions and injury risk in most sports. This relationship, from football studies, is largely speculative and based on correlational data only. Most studies have not directly measured ground conditions with validated tools.
- The causal pathways and mechanisms by which ground conditions potentially influence injury risk, except perhaps for ACL injuries.
- The extent to which the early-season bias for football injuries can be explained by player fitness and conditioning factors, rather than ground conditions.

Intuitively, there is a relationship between extremes in surface conditions and injury. However, other factors could also play a role in injury risk such as the speed of the game, poor conditioning of players in the early part of the season and the footwear worn.

The equivocal and rather patchy evidence linking injury risk to ground conditions leads to the question as to what are the important ground condition features that LGAs, SSAs and their clubs should be most concerned about. Features considered in this report are above/on ground hazards checks, hardness, rotational traction (grip), shear traction, soil moisture content, grass type and coverage and weather. Commonly, these features are measured with match day checklists, Clegg Hammers, torque wrenches, soil moisture devices and grass/soil samples. Unfortunately, not all of this equipment is directly available to, or within budget constraints of most LGAs or SSAs/clubs themselves. In those situations, suggestions for how to source the testing methods and relevant experts are given. The focus of the discussion, however, is on the assessments that LGAs and SSAs/clubs could reasonably be expected to perform on a regular basis. The recent development of more detailed observational checklists, such as the Derived Score Methods, have the potential to lead to more reliable observational assessments in the future and could avoid the need for expensive equipment. However, they require further development and validation before their use can be widely advocated. Importantly, the value of sports ground inspections in promoting ground safety depends upon the quality and comprehensiveness of the ‘measurements’ used and more importantly the actions taken to address the issues identified.

With this information as background, the current practices of a selection of Victorian SSAs and LGAs were assessed. The use of match day checklists, often developed and advocated by insurance companies, appears to be well accepted by SSAs, which promote them widely across all levels of their sport. In contrast, the level of ground assessment was not high amongst LGAs. Of the 47 LGAs that responded to the survey, almost half (49%) did not have a policy or guideline about sports ground safety or suitability for play. Some LGAs initiated a co-operative approach with clubs to support sports ground safety and this is considered good practice. Both LGAs and SSAs have a hierarchy whereby they are more directly involved in grounds assessments for higher levels of the game than for community or junior participation. Sports grounds that supported better standards of play, or finals, are generally regarded as showpieces and therefore allocated better maintenance and turf management regimes. Similarly, and perhaps surprisingly, these grounds were also assessed for safety far more regularly and comprehensively than community grounds.
All of the published assessments of ground conditions have been made on elite or high performance football fields, generally during the football season and only in relation to the elite or professional level of the sport. It is important to note that the conditions described from elite venues cannot necessarily be applied directly to all venues that host Australian football games at other levels of play, nor to other sports because those venues operate under different financial limitations, water availability, usage patterns, etc. This report provides new data describing ground conditions that could be considered as “representative” for Australian Rules football played at metropolitan, regional and rural levels over a 12-month period, encompassing both football season and non-football season periods. It therefore provides some information about ground conditions for other sports using those fields outside of the March to September period. However, only one 12-month period is covered so caution should be used when interpreting these data, as ground and weather conditions could be quite different in other years. As would be expected, due to annual trends in weather and other environmental factors over a 12-month period, there were significant differences for all of the measured variables between the various dates of assessment. Generally, ground conditions were less optimal in regional and rural grounds, compared to their metropolitan counterparts.

A match day checklist and a Derived Score Method (DSM) checklist were also formally assessed against a range of objective measures on a sub-set of the above football fields to evaluate the value of the DSM. When assessed over time, the overall DSM scores were consistent with a deterioration of the ground conditions, reflecting increasing drought conditions and the wear and tear of a football season.

In summary, this report highlights significant limitations in both the evidence linking injuries to ground conditions and in the reliability/validity of currently available measurement methods. Notwithstanding these limitations, it is clear that LGAs and SSAs/clubs could, and should, assess the conditions of their grounds on a regular basis. Ideally, grounds should be assessed using objective measures but it is recognised that the necessary equipment is expensive and requires “experts” to use it.

On the basis of the information presented in this report, a two tiered approach to sports ground safety and suitability for play is recommended as good practice. The first tier should involve pre-game and pre-training inspection of the sports ground for hazards that are likely to cause injury. These inspections should be conducted by individual clubs before all training sessions and by all clubs before the first use of the ground on match day. The second tier should involve regular weekly inspections of sports grounds by LGAs with the specific purpose of inspecting the ground surface and surrounds for its suitability for play and linking this to the maintenance program in place for that sports ground. Recommended proforma and guidelines for the Good Practice Match Day and Training Session Checklist and the Good Practice Sports Ground Inspection Checklists are provided.

Finally, good practice recommendations are derived from clear parameters by which sports ground surfaces should be evaluated. It is recognised that these parameters have mainly been established for elite sport on major sports grounds using objective measures. In developing recommendations for grounds assessment best practice, this report draws on the currently available information and gives some guidance to sports officials and ground managers. Recommendations for practice have been adapted from a broad risk management approach to sport safety because it is important that grounds assessment becomes a part of the standard responsibilities of all LGAs and SSAs and their clubs. These recommendations are listed on the following pages.
LIST OF RECOMMENDATIONS

The following is a list of the recommendations made in this report, according to the broad context of responsibility for addressing the recommendation. Each recommendation is referenced back to the Chapter where it arose and where the rationale for its need is given.

General recommendations for ground assessment and safety

- Ground managers in Victoria should consider promoting the use of rye grass in their grass mix and reducing the amount of thatch on grasses on all fields. (Chapter 3)
- Strategies for changing the grass profiles on playing fields are more likely to be successful, in the long run, than requiring players to proactively change their boots in relation to the season stage. (Chapter 3)
- Match day checklists should be used by all clubs prior to both games and training to identify hazards to safe participation. Records should be kept of all inspections along with a record of remedial action undertaken. (Chapter 4, 8)
- Match day checklist should be standardised to cover major known hazards related to padding of fixtures, uneven surfaces, holes and debris, sprinkler covers and associated depressions, boundary to perimeter fencing, first aid facilities and emergency access. (Chapter 4)
- A two-staged approach to sports ground safety and suitability assessment should be considered best practice. The first stage should involve pre game and training inspection of the sports ground for hazards using a checklist. The second stage should involve using a validated DSM-type measure, with validated correlates of objective measures. (Chapter 8)
- An educational campaign should be developed by bodies such as Sport and Recreation Victoria, Regional Sporting Assemblies or the Victorian Smartplay Program to highlight injury prevention as a direct outcome of ground safety policies and sports ground audits for safety and playing surface quality.

Recommendations for State Sports Association (SSA)/Club Practice

- Broad risk management approaches to assessing ground conditions adopted by LGAs, SSAs and their clubs should include consideration of general player safety measures, such as boundary placement and padding, and assessments of ground surfaces before play and in the case of inclement weather. (Chapter 3)
- Within each LGA and SSA/club, it should be clearly understood who is responsible for the identification and remediation of hazards. A timeline for the implementation of hazard identification and remedial actions, and their communication to the next levels of the sport should be established. (Chapter 4)
- LGAs and regional/district sports associations should obtain a Clegg Hammer and survey each venue at least four times per football season. Hardness readings exceeding 120 gravities need attention. (Chapter 4)
- LGAs and regional/district sports associations should consider obtaining a Studded Boot Apparatus to survey each venue at least four times per football season. Traction readings exceeding 65 NM need attention. (Chapter 4)
- Given the influential role of the insurance industry, SSAs should work closely with their insurers to develop and refine match day checklists for their sports. (Chapter 5)
- Each SSA and their associate clubs should clearly identify and name a person responsible for removing or controlling hazards identified by the checklists. Guidelines for a timeline of implementation of responses should be developed by the SSA. (Chapter 5)
• Best practice examples highlighting co-operation between sporting clubs and LGAs to establish and maintain sports ground inspection should be developed in partnership and promoted through the sector. This should include a two-way feedback process for all ground assessments and suitability decisions. (Chapter 5)

• All SSAs should require a central lodging of all match day checklists and establish an associated review process. (Chapter 5)

• SSAs should work with their insurers to link match day checklists with injury data to establish if their risk management approaches are reducing injuries and to promptly identify emerging injury issues. (Chapter 5)

RECOMMENDATIONS FOR LOCAL GOVERNMENT AUTHORITY (LGA) POLICIES AND PRACTICES

• Broad risk management approaches to assessing ground conditions adopted by LGAs, SSAs and their clubs should include consideration of general player safety measures, such as boundary placement and padding, and assessments of ground surfaces before play and in the case of inclement weather. (Chapter 3)

• Within each LGA and SSA/club, it should be clearly understood who is responsible for the identification and remediation of hazards. A timeline for the implementation of hazard identification and remedial actions, and their communication to the next levels of the sport, should be established. (Chapter 4)

• LGAs and regional/district sports associations should obtain a Clegg Hammer and survey each venue at least four times per football season. Hardness readings exceeding 120 gravities need attention. (Chapter 4)

• LGAs and regional/district sports associations should consider obtaining a Studded Boot Apparatus to survey each venue at least four times per football season. Traction readings exceeding 65 NM need attention. (Chapter 4)

• LGAs could consider employing contractors or consultants to assess shear traction on their fields to determine the strength of their turf. (Chapter 4)

• LGAs should employ experienced consultants to assess soil moisture content on a regular basis. (Chapter 4)

• Grass type and coverage should be assessed by an agronomist or horticulturist. LGAs should employ such experts to assess their grounds, including for advice about resowing. (Chapter 4)

• The Derived Score Method used by some LGAs is a potentially useful approach and its checklists can identify important factors and hazards. As the scoring systems and weights are not yet validated, LGAs should be cautious when using these for decision-making. (Chapter 4)

• If LGAs need to prioritise their ground assessment practices, the ordering of attention should be (in decreasing order) to assessing hardness, grip, botanical composition and then moisture content/thatch/shear strength. (Chapter 4)

• All LGAs should have a policy and an implementation plan to evaluate sports ground suitability. Almost half of all LGAs do not currently have such policies and guidelines. (Chapter 6)

• The Municipal Association of Victoria, through its insurer Civic Mutual Plus, should ‘drive’ the involvement of all LGAs, particularly those in regional and rural areas, in sports ground suitability policy and implementation strategy development. (Chapter 6)
• It is recognised from a resourcing point of view, that it may not be possible for LGAs to equally maintain and regularly assess all grounds. However, LGAs and their insurers should develop a set of minimum standards for maintenance of all grounds, irrespective of their grading, and adopt them as regular ongoing practice. (Chapter 6)
• All LGAs should consider incorporating some objective measures in their assessments of grounds safety. (Chapter 6)
• Best practice examples highlighting co-operation between sporting clubs and LGAs in establishing and maintaining sports ground inspections should be developed in partnership and promoted through the sector. (Chapter 6)
• Sport and Recreation Victoria, Regional Sporting Assemblies or Smartplay Victoria should develop an educational campaign to highlight injury prevention as a direct outcome of ground safety policies and sports ground audits for safety and playing surface quality. (Chapter 6)
• The likely reason for the higher hardness along the centreline is that of soil compaction under traffic. To overcome this, more regular decompaction of the centreline is required in comparison to the flanks. This needs to be done by contractors or LGAs, with the appropriate equipment, twice a year—once before the start of the cricket season and once before the start of the football season. (Chapter 7)

RECOMMENDATIONS FOR IMPROVING THE EVIDENCE BASE LINKING GROUND CONDITIONS TO INJURY RISK

• Prospective studies, including ongoing injury surveillance and objective ground condition measurements should be conducted over at least two full playing seasons in all codes of football and across all levels of play. (Chapter 2).
• Prospectively collected ground condition assessments should be made on sporting grounds during the appropriate playing seasons for other sports (such as cricket and hockey) and clearly linked to injury data. (Chapter 2).
• Basic scientific work is needed to develop and test models for the causal pathways and mechanisms by which ground conditions and the early-season bias potentially influence injury risk. (Chapter 2).
• A comparative study of representative ground conditions, and their relationship to injury risk, is needed across all levels of play to determine the extent to which findings in elite, professional and semi-professional players can be directly translated to community or junior sport. (Chapter 2).

RECOMMENDATIONS FOR IMPROVING THE EVIDENCE-BASE FOR GROUND ASSESSMENT PRACTICES

• Biomechanical studies should be undertaken to how the measurements obtained from standard ground condition equipment relate to the actual forces and loads experienced by players during sporting activity. Both laboratory and field-testing is required. (Chapter 4)
• Most of the ground condition measures are applied independently and it is not known exactly how they relate to each other or to injury risk. A prospective study of injuries, over at least two seasons, is required to correlate the various ground conditions to each other and injury risk. (Chapter 4)
• Refinements to the Studded Boot Apparatus are needed if it is to be used to measure injury risk, particularly with regards to different stud configurations and non-uniform ground interactions. Such refinements should be correlated with injury and other ground condition measures. (Chapter 4)
• The scoring and weighting systems used in the Derived Score Methods need further development and validation against both more objective ground condition measures and injury risk in players. (Chapter 4)
• Given that the monitoring of football fields occurred within a very dry year, it is pleasing that most of the measures are within the AFL limits. However, a proportion of readings were outside the limits. Further research is needed to determine if these results are repeated in more typical years and if the AFL limits can be reasonably adopted for use at community level (Chapter 7)
• Normative ground conditions, related to injury risk, should be developed for non-elite football and for other sports. This should involve well designed prospective cohort studies of sports participants, their playing habits, associated injuries and objectively measured ground conditions at the same place, at the same time, over at least two playing seasons. (Chapter 7)
• To provide normative data, representative of the range of climatic conditions in Victoria, further ground condition assessments should be made and collated on the grounds used in the trial, or similar grounds, over at least another one or two seasons. (Chapter 7)
• Ground hardness measures should be made on multiple sites across a venue, particularly along the centreline, with supplemental measures on the flanks. When measuring grip or shear strength, it should be possible to make accurate assessments with five randomly selected test points across a venue. (Chapter 7)
• It is possible that a relationship between moisture content and hardness could provide an indirect measure of surface hardness, by monitoring the soil moisture. This requires further research. (Chapter 7)
• Further investigation into the relationships between aboveground factors and grip is needed. This would inform the development of a method for predicting grip on the basis of aboveground factors, if more data is obtained over a series of seasons. (Chapter 7)
• Methods for calculating more accurate water deficiency (potential) measures should be developed. This should include consideration of the optimal timing and frequency of soil moisture assessment. (Chapter 7)
• Current field sampling plans across a venue for ground condition assessment are based on the main distribution of play during Australian Rules football (i.e. the centreline and flanks). Optimal sampling plans should be determined for the assessment of grounds for other activities such as cricket and hockey, to mirror the areas of most use in these sports. (Chapter 7)
• Before recommendations for its widespread use can be made, the DSM requires further formal validation against objective ground condition measures across a variety of grounds, sporting activities and times of the season. (Chapter 8)
• To be fully validated, the DSM should be compared directly with injury incidence data across a range of sports, over at least 2 playing seasons. (Chapter 8)
1. **ABOUT THIS REPORT**

Over recent years, questions about the suitability of grounds for sporting activities have risen to the fore, particularly within ongoing drought conditions. Sporting bodies and councils have begun to ask questions about the suitability of their grounds; how they should go about assessing them; and what they should do to address any identified safety concerns. Unfortunately, in the absence of clear evidence-informed validated guidelines, ground managers, Local Government Authorities (LGAs) and State Sporting Associations (SSAs) and their clubs are making decisions about the suitability of a turf sports ground for sport based on anecdotal evidence and common sense. This has lead to a range of actions and decision-making criteria that may be hard to defend formally. For example, some ground management decisions may be based on performance-oriented measurements for a particular sport, rather than on safety considerations for all players or users of the ground. Other grounds may be managed without regard to the specific needs of different sports. Due to recent drought conditions, resulting in hard dry grounds with poor turf cover, a number of LGAs have restricted or banned the use of some sports grounds, for particular sports or activities, based on a perception of increased injury risk alone. Others have closed grounds to keep what turf they had to avoid resowing the whole ground, thereby minimising any financial burden.

Intuitively, ongoing drought conditions have an impact on the hardness of playing fields. Although hard ground conditions have frequently been reported as being associated with an increased risk of injury, most of the evidence supporting such claims has relied on personal recall of injury and playing conditions; subjective and non-validated observations of playing grounds; or anecdotal and other personal opinions. Media reports have tended to support these perceptions, suggesting that training and competition are severely compromised by drought-affected grounds due to apparent ground hardness-related injury issues, rather than being fully evidence-informed. Unfortunately, there is little solid evidence to support the claims being made and this limits the advice that can be provided to LGAs, SSAs and clubs about grounds management and safety risk.

In 2005, the Sport and Recreation Victoria (SRV) portfolio of the Department for Victorian Communities, commissioned a study to review and evaluate issues relating to turf sports ground and surface conditions and their possible relationship to sports safety. This study included a critical review and evaluation of the standards and related guidelines and practices currently used by turf-based sports and ground managers to assess ground safety and injury risk. It also included an investigation of the current evidence about the relationships between ground conditions and injury risk. This report provides the major findings of this study. In particular, it presents:

- the strength of the evidence linking ground conditions to injury risk in sport
- a description of ground condition parameters
- a broad overview of the generally available guidelines and measurement techniques for grounds assessment
- a review of the current grounds assessment policies and practices of a selection of Victorian SSAs
- a review of the current grounds assessment policies and practices adopted by Victorian LGAs
- additional considerations in ongoing ground assessment, adding to the evidence and improvements to assessment methods
- normative ground condition data for a sample of community football grounds
• recommendations about what could be done to improve the assessment of Victorian sporting grounds.

In presenting these issues, the report summarises the currently available evidence and highlights gaps in current knowledge. In developing recommendations for grounds assessment best practice, this report draws on the currently available information and gives some guidance to sports officials and ground managers. Recommendations for practice have been developed using a broad risk management approach to sport safety because it is important that grounds assessment becomes part of the standard responsibilities of all LGAs and SSAs and their clubs.

A number of the key findings of this report were presented by one of the authors (Leonie Otago) and Dr Dara Twomey (from the School of Human Movement and Sport Sciences, University of Ballarat) at two recent Parks and Leisure Australia professional development seminars in Victoria. A copy of these presentations can be found in Appendix 1.
2. WHAT IS THE EVIDENCE LINKING GROUND CONDITIONS TO INJURY RISK IN SPORT?

As stated previously, there is a general perception that there is a direct link between ground conditions and injury risk. However, the evidence-base supporting such a link has not previously been summarised for a general LGA/SSA audience nor the quality of the evidence formally assessed.

This Chapter provides a brief overview of the current scientific evidence linking ground conditions to injury risk. Studies considering the measurement and assessment of ground conditions are reviewed in the next section. The discussion of ground hardness and turf conditions draws heavily on previous work of one of this report’s co-authors, Dr John Orchard [1]. Other literature published over the past ten years was identified by searching relevant electronic databases (Sports Discus, Pub Med, Scopus etc) and Australian sports safety reports with key words including “sport” “injury” “ground” “weather” and “ground condition”.

THE IMPORTANCE OF ENVIRONMENTAL GROUND FACTORS IN INJURY RISK

Sports injuries result from a complex interaction of many factors related to both the sporting participant and the environment or context in which they participate [2]. Factors relating to the environmental context are known as extrinsic risk factors—because they are external to the person. It could be expected that ground conditions, as an extrinsic risk factor, would influence a person’s risk of injury, particularly if they are participating in a sport that involves considerable running on turf surfaces, as is the case for the football codes.

Environmental sporting ground hazards that have been cited as being associated with injury risk [1-7] include:

- exposed sprinkler heads and uncovered cricket pitches during the winter season
- unevenness of the surface, including potholes, bumps and ridges
- debris, rubbish and rubble on the surface
- type of surface, e.g. concrete, natural turf, synthetic surfaces, clay-based and sand-based soils, etc,
- poor grass/turf coverage, e.g. clumping of grass and uneven cover
- type of grass
- hardness of the surface
- traction of the surface
- weather conditions.

Any risk management approach to assessing the suitability of grounds for sporting activity must consider all of these factors.

Injuries to the lower extremities (legs, ankles, knees, feet, etc) are most commonly associated with ground conditions. Many of the published research studies have focussed on the intrinsic, or person-related, risk factors for these injuries such as muscle imbalance, training and fitness levels, previous injury, etc. Despite their importance, there have been few recent reports of data directly linking environmental factors to injury risk. Some studies, mainly in netball, basketball and tennis, have reported ground reaction forces associated with game movements but they have not considered the impact of different types or quality of the surfaces on injury risk.
Whilst it may be possible to mitigate the effect of some of the above environmental ground conditions with the use of appropriate footwear, and this has been the subject of some research, this report focuses specifically on removing or controlling the environmental hazards. The rationale for this is that the hierarchy of injury control first proposed in Haddon's well known injury prevention framework [8] gives greatest importance to modifying or removing the environmental factors responsible from injury risk. Environmental modification is also one of the three E’s of injury prevention, an internationally adopted approach to safety promotion [9].

LIMITATIONS OF THE STUDIES LINKING SPORTS INJURY RISK TO GROUND CONDITIONS

There are significant gaps in the literature linking ground conditions to injury risk. These should be acknowledged up front to give a clear context and setting for the evidence that is presented in subsequent sections.

A search of the international sports science and sports medicine literature published in the past ten years found surprisingly few studies that linked sports injuries to ground conditions. Almost all the studies that did mention such a link were football related. No recent published study was identified on the impact of turf and ground conditions on the risk of injury in cricket, hockey, netball, basketball or, indeed, most other activities. Readers interested in the evidence from studies published more than ten years ago are referred to the 2002 review by Orchard [10].

To prove an association between a factor and injury causality, it is necessary to collect and analyse data over time [11]. Most of the published sports injury epidemiology studies have not determined causality between ground conditions and injury risk because either they did not collect the necessary ground conditions/weather data or they did not use appropriate methodology to make this link. It is important to emphasise that the majority of the published studies are correlational and therefore only demonstrate that there may be a relationship of some form between these factors. Furthermore, epidemiological studies describing associations between variables cannot explain why these variables might be related.

The link between ground conditions and injury risk was first suggested by studies that identified an early-season bias in injury incidence for the mainly winter-based football codes [1, 10, 12]. These studies all showed that injury rates were higher in the early part of the playing season. Suggestions have been made that one of the reasons for this could be the hardness of the grounds at the end of the summer, before the true winter season begins. These associations are mainly correlational. Without accompanying valid ground conditions data, they have not proven a causal pathways. Nor has the early-season bias been shown in football competitions not played over the autumn-winter season or in sub-tropical climates, or in any other sports.

The evidence for ground hardness/turf type and injury risk comes exclusively from studies conducted in the football codes. All but one of the Australian research studies conducted to date has been in Australian Rules football [1, 9, 10, 13-15], with the most recent study in rugby league [16]. Recent international studies have examined the issue to varying degrees of scientific validity in American football [17], soccer [18, 19], rugby league [20] and rugby union [21, 22]. To date, there has been no published study of the relationship between ground hardness and associated factors with injury risk in soccer in Australia. Given the different weather and ground conditions across the globe, the specific injury risk results from overseas studies would not necessarily apply in the Australian setting. However, the approaches used to assess ground conditions in other countries, and the potential risk factors identified, are likely to be transferable to Australia.
The issue of what sorts of injuries the ground conditions are related to also needs to be considered. Most of the studies do not make it clear in their methodology sections as to whether or not they considered the risk of all injuries or just lower limb injuries. This confusion is compounded by different numbers of cases in different parts of tabular displays with some expansion of types of lower limb injury cases only. Importantly, some studies are quite restrictive and only consider specific types of lower limb injuries. For example, the elite Australian Football League (AFL) studies linking penetrometer readings and grass type to injury risk only considered the risk of anterior cruciate ligament (ACL) injuries [23, 24]. All of the studies relating to grass type and injury risk, relate specifically to the risk of ACL injury [1, 10, 15, 23].

Finally, all but one of the published studies [21], has considered injuries in elite, professional or semi-professional players. Importantly, all of the studies of ground conditions and injury risk in Australian Rules footballers were conducted with elite AFL players on elite AFL grounds. These players play on grounds that are maintained at an extremely high level. Community level and junior players very rarely play on grounds of this condition. Furthermore, the version of the game they play is different to that at the elite level due to the speed and highly competitive nature of the game and physical conditioning status of the elite players [25]. These differences lead to a different injury profile in elite and community players [26]. It is questionable as to whether the results from the elite and professional levels of play are directly relevant to lower levels of competition and play.

THE EARLY-SEASON BIAS FOR INJURIES IN FOOTBALL AND OTHER SPORTS

In general, very little has been published about the seasonal variability in sports injury risk across football codes and other sports. The literature review identified numerous studies, particularly in rugby union, that consistently reported an early-season bias for injuries. There have been fewer similar studies in soccer and American football, which are also played extensively around the world. It is important to note that the lack of reporting of a seasonal bias in a sport does not prove that it does not exist—it may just mean that it was not assessed.

This Chapter gives a brief summary of the evidence supporting the notion of a higher rate of injury early in the season. It was this early-season bias that first led researchers to question if there was a link between ground hardness and injury risk. The early-season bias has been most consistently reported in rugby union. Studies in other forms of football have generally also reported an early-season bias for injuries, albeit with smaller numbers of studies and less agreement amongst studies. However, many other factors could also explain the early-season bias including player preparation and conditioning at the start of a season. Therefore, a link between early-season bias and ground conditions, in all sports, is far from conclusive.
American football

Various studies in American football, which is played from autumn to winter, have reported an early-season injury bias [27-29]. One of these studies also examined weather conditions and found that injuries occurred less frequently on muddy or wet natural grass surfaces than on good or hard surfaces, concluding that the early-season bias was explained by changing ground conditions [29]. The rate of ACL injury in the US National Football League (NFL) shows an early-season bias in matches played on natural grass or artificial turf in the open air, but not during matches played on artificial turf indoors [17].

Australian Rules football

Anterior cruciate ligament injuries in the elite AFL competition exhibit a strong early-season bias [14, 24]. The overall rate of all injuries in Australian Rules football also exhibits an early-season bias in professional [30], adult amateur [25, 31-33] and junior [34] players. Although they did not directly measure ground conditions, McMahon et al. [34] attributed the highest rate of injuries in the first month of their study of junior football to harder grounds and concluded that injuries on harder grounds in juniors were more likely to be fractures associated with ground contact.

Gaelic football

A recent study of elite Gaelic football injuries reported a late-season injury bias [35] but may be subject to recall bias because injury data was collected retrospectively.

Rugby league

Rugby league is similar to rugby union, although it is primarily played in two locations of the world with very different climates—north-eastern Australia (warm temperate to tropical humid) and northern England (cool temperate to humid). Although the two forms of football are very similar, rugby league has not shown the consistent early-season injury bias that is present in rugby union [36-38]. One study of rugby league injuries in a Sydney-based competition showed an early-season injury bias [30] but a study of amateur rugby league players in the Gold Coast (subtropical humid climate) showed a significant late-season bias [36].

Rugby union

Rugby union, particularly when played as a winter competition in the countries of the United Kingdom, South Africa and New Zealand, exhibits a definite early-season injury bias with multiple studies reporting that the total injury incidence is higher earlier in the playing season [21, 39-52]. This bias is greatest for lower leg injuries and cervical spine injuries. An exception to this finding was reported in a long-term schoolboy study conducted in Sydney [53]. An explanation for this exception may be that the rugby season in that study was short, and was generally associated with wetter weather conditions at the start of the season and drier weather conditions towards the end. The author also noted an increase in the number of fractured clavicles during the 1986 season, which was reported to be a very dry winter in Sydney, associated with a harder playing field than usual. The mechanism of these injuries was reported to generally be collision of the player with the ground [53]. A harder playing field in Sydney was given as a possible reason for the larger overall rate of fractured clavicles, in comparison to the rate found in a similar schoolboy survey in the UK [48]. In another UK study [22], although higher rates of rugby union injuries were associated with harder ground conditions, this association disappeared when the time of the season was adjusted for, suggesting that the initial relationship may have been spurious.
**Soccer**

Some soccer studies from the UK and northern Europe have reported a definite trend towards higher rates of injury at the start of the season with a gradual decline over the course of the season [54-59]. A more recent report of the Major League Soccer in the US showed a late-season rather than early-season injury bias, although the sport is a summer competition played from April to September [60]. In another major US study of soccer injuries, no seasonal variation in injury was mentioned [61].

**Touch football**

A study of touch football, a non-contact version of rugby league, did not report any early-season injury bias [62].

**Other sports**

Studies of basketball injuries, using good methodology involving large numbers of exposures and injuries, have not mentioned any seasonal variation in injuries [61, 63-65]. As stated previously, this is not to say that such variation does not exist, as many studies did not consider this factor at all. One study of basketball injuries that reported injury incidence by month of the season, showed a fairly even distribution of injuries across the season [66]. This study used data from a worldwide web search of national basketball Association data and the completeness of the information is unknown.

One Australian study compared the month-by-month injury incidence of four different sports in Perth [31, 32]. A significant early-season bias was present for all four sports studied in the first year of study, but it varied in its intensity [31]. Australian Rules football had the highest early-season bias, with basketball having a much smaller early-season bias that just reached statistical significance. Netball and field hockey had an early-season bias that was less marked than Australian football but greater than that for basketball. Only Australian Rules football showed a significant early-season injury bias in the second year of the study [32]. Unfortunately, no information about the playing surfaces was collected in this study and the authors were unable to rule out the possibility of a reporting bias leading to these results [32]. However, the surface types for Australian Rules football (natural grass) and basketball (hard court) would have been constant, as these sports are only played on one type of surface. Netball is played on natural grass and hard courts, and field hockey is played on artificial and natural grass. A conclusion from the first year of the Western Australian study was that all four sports exhibited an early-season bias, but the sport that was played on natural grass (Australian Rules football) showed a greater early-season bias than the sport that was played on a consistent surface (basketball) [31].

**Summary**

Orchard’s 2005 review [1] found that both intrinsic factors, such as variations in player fitness, and extrinsic factors, particularly the variation in weather and ground conditions, have been identified as possible explanations for the early-season bias. He also concluded that very few studies had performed serial fitness or ground condition measures over the course of a season to correlate these with injury risk [1]. Table 1 reproduces the conclusions that Orchard reached, in relation to the early-season bias.

The few studies that have attempted to monitor ground conditions have generally used subjective methods of assessment [16, 21, 22, 29] or player recall of ground hardness [21]. Only one study has measured the hardness of grounds in the AFL using a penetrometer as an objective measure
This study found a significant trend towards softer grounds as the season progressed, a significant decline in the risk of ACL injury as the season progressed, and a non-significant trend towards increased risk of ACL injury when the ground was harder. The authors concluded that the early-season bias was almost certainly related to ground conditions, but that it was difficult to assess whether ground hardness, or another confounder such as grass type or shoe-surface traction, was responsible.

Table 1. Summary of the evidence for an early-season bias and injury risk factors

| Intrinsic risk factors | Player fitness | At the start of the season, it is thought that players generally have greater general fitness (e.g. aerobic capacity, strength) but less “match fitness” (harder to measure but perhaps less coordination at match-specific tasks) [67]. |
| Quadriceps: hamstring strength ratio | This is an example of a potential risk factor for injury that may change over the course of a season [68]. |
| ‘Abnormal’ knee mechanics on cutting and landing | Ideal coordination patterns which may protect against injury risk [69] may be more prevalent as the season progresses. |

| Extrinsic risk factors | Ground hardness | Grounds may be harder at the start of the season and ground hardness may be a risk factor for injury [21, 22]. |
| Shoe-surface traction | There may generally be greater shoe-surface traction available at the start of the season and this may be a risk factor for injury [70]. |
| Player footwear selection | Players may choose different cleat configurations at the start of the season and these may confer different injury risks [71]. |

| Methodological limitations | Definition of a recurrence | If a recurrent injury is defined as part of the pool of “injuries” then there will be a tendency to a late-season bias. If the pool of “injuries” does not include recurrences, then an early-season bias may result. |
| Survival bias | If there is a high-risk group of players within a cohort whose numbers are diminished by removal due to early-season injuries, an apparent early-season bias may be seen. |
| Recall bias | If the injury incidence for the entire season is determined at the conclusion of the season, a late-season bias may develop due to better recall of injuries which have recently occurred. |

In summary, although not enough studies have directly measured ground conditions, circumstantial evidence suggests that it is highly likely that variations in ground conditions are at least partially responsible for the widely reported early-season bias for football injuries. The most impressive association is that the early-season bias is most often reported in football competitions that are played on natural grass surfaces in temperate climates over autumn-to-winter [13, 21, 22, 24, 28-30, 34, 39, 42, 47, 52]. The early season bias is generally either absent, not reported or even reversed in football competitions not played over autumn-to-winter [35, 38, 60, 72], in subtropical climates [36] and in basketball [61, 63, 64, 73], circumstances that all would not exhibit the standard winter late-season changes in natural grass playing field conditions.
Finally, it is important to remember that the early-season bias could also be due to less fit players, especially at the community level, where less preseason training is done. Alternatively, it could be related to the challenges of players returning to the competition play. For example, it could be that players are more likely to make some mistakes in technique/judgement, etc at the start of a season.

OTHER STUDIES RELATING GROUND AND WEATHER CONDITIONS TO INJURY RISK

A number of studies have looked at weather conditions, as a marker of ground hardness and its relationship to injury risk across some of the football codes. Others have applied subjective assessments of ground conditions in prospective data collections to determine the relationship between ground conditions and injury risk. The literature review only identified such studies conducted within football codes, as summarised below.

**Australian Rules football**

Only one published study, in the elite AFL competition, has jointly considered the impact on intrinsic and extrinsic risk factors on ACL injury risk [14]. Whilst the strongest predictor of injury was an intrinsic risk factor (history of ACL reconstruction), weather conditions associated with dry field conditions were also significantly associated with injury risk. The specific weather patterns were high water evaporation in the month before the injurious match and low rainfall in the year before the match.

Orchard [1] summarised the associations between ground (i.e. hardness and grass type), weather conditions and injuries of various types in elite Australian football players. His summary is reproduced in Table 2.

Orchard [1] also argued that increased surface hardness, and particularly increased shoe-surface traction, may be risk factors for non-contact lower limb injury in elite football. The evidence supporting his view is reproduced in Table 3.

**Gaelic football**

A study in elite Gaelic football [35] asked players to recall all of their injuries over the previous six-month period. For the 95 reported injuries, 29% of the injured players considered that the condition of the pitch contributed to their injury. Although this information was not validated, and is possibly subject to recall bias, dry/hard conditions were ranked as the most likely cause (43% of cases), followed by wet/soft grounds (39%) and uneven grounds (18%).

**Rugby league**

Gabbett et al [16] analysed prospectively collected injury data from two consecutive playing seasons of semi-professional rugby league in Queensland. Daily and historical weather variables were collected from the Bureau of Meteorology and the ground conditions were subjectively rated as heavy, slippery, firm or hard, at each training session and game. They found that harder ground conditions were associated with a significantly higher rate of injury during matches but not during training sessions (Figure 1). Less rainfall was also associated with a higher number of match injuries (Table 4). The major limitation of this study was that only a subjective assessment of grounds conditions, representing a consensus rating of two coaches at 30 different sites prior to each game or training session, was used. However, this is the only Australian study to assess ground and weather conditions on injury risk in a sport outside of the elite AFL.
Table 2. Orchard’s summary of associations between ground and weather conditions and various injury types in elite Australian football.

<table>
<thead>
<tr>
<th>Body region of injury</th>
<th>Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injuries overall</td>
<td>Significantly more likely in games where the predominant species was bermuda grass compared to rye grass (RR 1.25, 95% CI 1.07-1.46).</td>
</tr>
<tr>
<td>Lower limb</td>
<td>Significantly more likely in games where the predominant species was bermuda grass compared to rye grass (RR 1.26, 95% CI 1.07-1.49); trends toward being more likely in northern games (RR 1.14, 95% CI 0.98-1.32) and less likely on softer grounds compared to firmer grounds (RR 0.81 95% CI 0.64-1.02)</td>
</tr>
<tr>
<td>Upper limb</td>
<td>Trend toward being less likely on medium -softer grounds compared to harder grounds (RR 0.71, 95% CI 0.50-1.00)</td>
</tr>
<tr>
<td>Trunk/back</td>
<td>Trends toward being more likely in day games (RR 1.38, 95% CI 0.98-1.96) and on grounds where the predominant species was bermuda grass compared to rye grass (RR 1.36, 95% CI 0.96-1.92).</td>
</tr>
<tr>
<td>Head/neck</td>
<td>Significantly less likely in games in an open field compared to those under an enclosed roof (RR 0.53, 95% CI 0.34-0.85).</td>
</tr>
<tr>
<td>Hamstring</td>
<td>Trend toward being more likely in games where the predominant species was bermuda grass compared to rye grass (RR 1.24, 95% CI 0.97-1.58).</td>
</tr>
<tr>
<td>Quadriceps</td>
<td>Significantly more likely in games where there had been previously low annual rainfall (RR 1.58, 95% CI 1.02-2.46).</td>
</tr>
<tr>
<td>Calf</td>
<td>No noted trends approaching statistical significance.</td>
</tr>
<tr>
<td>Knee</td>
<td>Significantly more likely in games where the predominant species was bermuda grass compared to rye grass (RR 1.31, 95% CI 1.00-1.71).</td>
</tr>
<tr>
<td>Ankle</td>
<td>Significantly more likely in games where the predominant species was a rye grass/poa annua mix compared to rye grass (RR 1.65, 95% CI 1.05-2.60).</td>
</tr>
<tr>
<td>Shoulder</td>
<td>No noted trends approaching statistical significance.</td>
</tr>
</tbody>
</table>

Reproduced from [1], with permission; RR =relative risk

As shown in Figure 1, the study of semi-professional rugby league players in Queensland, identified a differential relationship between ground conditions and injury risk in the game and training contexts [16]. The reason for this is unclear but there could be a few possible explanations. Firstly, the differences in injury risk may reflect differences in the physical intensity of competition, volume of play and other activity, and therefore loads on the body, during the two different playing contexts. Alternatively, the differences could be due to differences in the characteristics of the playing surfaces and shoe-surface traction [10] that were not considered along with the subjective grounds assessment.
Table 3. Orchard’s summary of the evidence supporting surface hardness and increased shoe-surface traction as risk factors for non-contact lower limb injuries in elite football.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Evidence</th>
<th>Further notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-season bias</td>
<td>There is an early-season bias for ACL injuries in the AFL, with late season risk being 0.55 (95% CI 0.37-0.80) of the early season. However, in a multivariate equation this appears to relate significantly to the presence of bermuda grass rather than rye grass in the early-season.</td>
<td>Other studies in Australian football have shown an increase in injuries early in the season [30, 31, 33, 34]. Many rugby union studies have also shown an early-season bias for injuries [21, 39-52]. Shoe-surface traction drops on Astroturf as the temperature cools [74].</td>
</tr>
<tr>
<td></td>
<td>There is an early-season bias for ACL injuries in the NFL on open Astroturf surfaces (late season risk 0.49, 95% CI 0.29-0.82), but not on domed Astroturf surfaces.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>There is trend towards an early-season bias for ACL injuries in the NFL on natural grass.</td>
<td>Sports not using autumn-winter outdoor sequence generally do not report early-season bias [35, 38, 60, 61, 63-65, 72].</td>
</tr>
<tr>
<td>Dry or warm-season bias</td>
<td>Players from teams based in the northern locations of Australia suffer slightly more injuries than Victorian teams in the AFL (RR 1.17, 95% CI 1.12-1.23).</td>
<td>Rugby league teams in England have reported an increase in injury moving from a winter to a summer season [20, 72, 75].</td>
</tr>
<tr>
<td></td>
<td>There is no trend towards an increase in ACL injuries in southern natural grass stadiums in the NFL compared to northern natural grass stadiums.</td>
<td></td>
</tr>
<tr>
<td>Risk of injury on hard surfaces compared to softer surfaces</td>
<td>There is minimal association between ACL injury rate on softer surfaces compared to harder surfaces in the AFL (RR 0.71, 95% CI 0.30-1.71).</td>
<td>Hardness of playing surface is associated with slightly more injuries in rugby union [21, 22].</td>
</tr>
<tr>
<td>Risk of injury on natural grass vs. artificial turf</td>
<td>There are significantly more ankle sprains on Astroturf surfaces compared to natural grass.</td>
<td>Other studies have shown an increased risk of injury on artificial turf in American football [76].</td>
</tr>
<tr>
<td></td>
<td>There is minimal relationship between the risk of ACL injury on natural grass compared to Astroturf.</td>
<td>FieldTurf has a similar rate of injuries overall to bermudagrass in junior American football [77].</td>
</tr>
<tr>
<td>Risk of injury on bermuda grass compared to rye grass</td>
<td>Bermuda grass surfaces are associated with significantly more ACL injuries than rye grass surfaces in the AFL (RR 1.87, 95% CI 1.26-2.77).</td>
<td>Bermuda grass leads to higher shoe-surface traction than rye grass. Kentucky blue grass leads to higher shoe-surface traction than rye grass [78].</td>
</tr>
</tbody>
</table>

Reproduced from [1], with permission. The references in this table have been updated to reflect the reference numbering in this report.

RR: relative risk; an RR>1 is indicative of a risk effect, an RR<1 is indicative of a protective effect; AFL: Australian Football League (elite competition); NFL – US National Football League

Rugby union

Only one study was identified that monitored injuries and ground conditions in a broad population-group of football players. That study used a case-control methodology to follow 1042 New Zealand rugby union players [21]. Both injured and uninjured players completed a questionnaire that
collected, amongst other details, information about the hardness of the playing surface (very hard/hard/soft/very soft) and weather conditions for relevant games. Players were more likely to be injured when they reported playing on very hard or hard grounds. A similar finding was previously reported by Lee and Garraway, though their finding was explained by a time of season effect [22].

**Soccer**

A recent review considered some of the factors associated with lower extremity injury in soccer players [79]. Two of the mechanisms discussed were uneven playing surfaces and too much friction. For the body to properly function and stabilise on uneven surfaces, higher loads need to be placed on ligaments and muscles. If these loads exceed the body’s tolerance and thresholds, injury can occur. Similarly, if there is too much friction, the body’s response to this will be to increase loads associated with twisting and turning movements and this can lead to increased injury risk. This mechanism of injury can occur if the relationship between the shoe-surface and ground traction is not in balance.

![Graph showing relationship between ground conditions and injury rates in semi-professional rugby league players in Queensland, according to context of the activity.](image)

*Reproduced from [16] with permission from Sports Medicine Australia and JSAMS. (Ground conditions were subjectively assessed by two coaches and the final rating is the consensus opinion of the two coaches.)*

There have been few recent reports of instances where uneven playing surfaces have led to injury, maybe because most studies have focussed more on intrinsic risk factors for injury. A case-series report of 32 injured amateur soccer players admitted to an orthopaedic unit in a South African hospital highlighted one case of severe injury related to uneven grounds [80]. The player was running on uneven ground, hit a spot of high ground unexpectedly and sustained a fracture-dislocation of his hip.
Table 4. Conclusions about the relationship between environmental and ground conditions and injury risk in semi-professional rugby league players in Queensland, Australia

| 1. Environmental variables affect ground conditions, with grounds typically softer when temperature and relative humidity are higher, and during conditions of greater rainfall. |
| 2. Injuries are generally not related to environmental conditions, although a higher 365-day rainfall is associated with fewer injuries. |
| 3. Injury rates are higher in matches than training sessions and when ground conditions are harder. |
| 4. For both number of injuries and injury rate, a significant interaction between ground condition and session type exists, with harder ground conditions resulting in a higher injury rate in matches, but not training sessions. |

Adapted from [16]

A prospective two-cohort study of the risk of injury in elite soccer players found no evidence of an increased risk of overall injury when the game was played on artificial turf compared to natural grass [18]. In terms of specific injury types, there was a suggestion of an increased risk of ankle sprains on artificial turf and a lower rate of lower extremity strains (muscle injuries), but the authors cautioned against giving too much weight to these findings due to the small numbers of cases.

An analysis of preseason injuries in 91 English professional football clubs used data collected by club medical staff over two seasons [19]. Although no detail was provided as to how the data was collected, some associations between ground surface conditions (assessed as dry, hard, dry+hard, wet or muddy) were presented in their paper. Seventy percent of the preseason injuries were reported to be associated with dry surface conditions, compared to 51% of in-season injuries. This correlated with a higher risk of slight and minor injuries, overuse injuries and lower leg injuries during the preseason.

EXPLANATIONS FOR A GROUND SURFACE CONDITIONS AND INJURY RELATIONSHIP IN FOOTBALL

Just knowing that there may be a relationship between injury risk and ground hardness is not enough to address the problem. It is also necessary to understand why there is such a link and the actual aetiology/nature of the increased risk [81].

Norton et al [12, 82] explored the aetiology of Australian Rules football injuries in the first and second grades of an adult competition. The study reviewed games of elite football players, for which ground hardness was measured by a penetrometer, and eight additional final games of first and second grade players played on an elite oval, for which ground conditions were not assessed. The results for the first and second grade players may not truly represent the usual play conditions for these levels because their in-season games were not played at the elite venue. The study identified a significant relationship between ground hardness and speed of the game, with faster speeds on harder grounds. It was therefore postulated that it might be the faster speeds that increase the risk of injury rather than the harder grounds, per se. The authors also suggested that
the faster speeds could lead to increased collision impact forces, as well as lower cushioning properties and reduced traction when changing directions or decelerating on harder grounds [82].

**Ground hardness and shoe-surface traction**

The two main surface characteristics that relate to injury in football are ground hardness (the effect that the surface has on absorbing impact energy) and traction (the type of footing or ‘grip’ a playing surface provides) [55, 83-85]. Traction and hardness of natural grass football surfaces have been shown to be highly related to each other [86, 87]. Traction is most correlated with the amount and type of grass cover [70, 86, 87], whereas hardness is most highly correlated (inversely) with soil moisture content [70, 86]. Under constant high-intensity traffic, root zone materials with a higher sand content (as opposed to soil) maintain greater grass cover, have higher traction and have less variation in hardness due to recent rainfall [70].

On average, Penetrometer readings show a slight softening of grounds (i.e. greater penetration into the surface) over the progression of a winter season in the elite AFL competition [24]. As would be expected, surface penetration measurements vary significantly with the amount of recent rainfall [24, 70]. On the other hand, traction shows a constant slow decline over the course of a winter football season with little week-to-week variation depending on rainfall [70].

Nigg and Segesser [84] have argued that injury incidence is more likely to be related to increasing shoe-surface traction than to increased hardness of the surface. Although no study has directly measured traction values and compared these to injury rates, some epidemiological observations support this argument. For example, the relationship between ACL injury in elite AFL players and weather relates to long-term weather variables which are likely to change the grass mix and density, rather than to daily or weekly rainfall [13]. Another study has shown higher ACL injury rates in soccer players on natural grass than gravel, which could be potentially explained by higher shoe-surface traction but not by greater hardness [88]. It should be noted that this study did not control for level of play.

Astroturf has been consistently shown to be a harder playing surface than grass [89-91]. The greater hardness of Astroturf results in faster running speeds for players, which has been hypothesised as a mechanism for higher injury rates [89]. The exception to this is when natural grass becomes frozen, where the surface is at least as hard as Astroturf [90]. By contrast, the results with respect to traction have varied considerably [78, 92-94]. One recent study has shown that traction on Astroturf is greater when the temperature is warmer [74]. In the American NFL, ACL injuries sustained in open Astroturf stadiums show an early-season bias, whereas ACL injuries in indoor Astroturf stadiums do not; this could be explained by temperature-induced changes in traction [17].

Orchard et al. [23] also found that there was a trend towards a lower risk of lower limb injury on softer grounds compared to firmer grounds in elite AFL players. However, there was little evidence to support the notion that harder playing surfaces lead to significantly higher injury rates per se.

Peak torque is a measure of the forces produced to rotate the limbs. The higher the peak torque, the higher the force. In a study measuring peak torque and rotational stiffness at the shoe-surface interface [95], the highest readings for both measures occurred on artificial turf, as compared to grass. The authors noted that lower peak torques may be safer for the player but may detract from their performance. This important point cannot be ignored, as players may be more interested in performance than safety. Livesay et al. [95] also stated their belief that if there was such a thing as an “ideal” shoe-surface interface, then this would vary between sports, player age, performance levels (elite versus community) and potentially many other factors.
Taken together, these studies highlight that the evidence for the effect of ground hardness on injury is equivocal. Unfortunately, the majority of the published studies is restricted to football codes and give no information about the relationships between ground conditions and injury in other sports.

**Artificial turf, natural grass and injury rates**

Artificial turf has been suspected of contributing to injuries for almost as long as it has been used [96]. Many studies have compared the injury rates between artificial surfaces, such as Astroturf (Southwest Recreation Industries, Leander, TX), and natural grass. Some studies have found that artificial turf and grass are associated with a similar overall injury rate [97-101]. Others have found that injuries to the foot and ankle are more common on Astroturf than natural grass [76, 91, 100-103]. Injuries to the knee have been reported as either being unrelated to the playing surface or slightly more common on artificial turf [76, 77, 91, 100-102]. Two major review papers have compared artificial turf to natural grass. Skovron et al. [103] concluded that there was a 30–50% increase in lower-limb injury risk on artificial turf. Nigg and Segesser [84] concluded that there was a definite increase in less serious injuries on artificial turf; a possible increase in severe knee and ankle injuries on artificial turf; but no difference between severe injuries of all types on artificial turf (compared to natural grass).

Surface characteristics of artificial turf and natural grass are quite variable [90], although Astroturf is generally harder than natural grass [89, 104]. When analysed by weather condition, the risk of injury did not vary significantly with weather or stage of season in indoor games on artificial turf. However, cool and wet conditions on natural grass, and cool and dry conditions on Astroturf in outdoor stadiums, both of which occurred more frequently late in the season, were associated with lower injury rates of ankle and knee injuries [17].

Unfortunately, none of the above studies described the grasses that were used on the natural grass surfaces and differences between grass types could not be adjusted for. In one of the few studies that did describe the grasses being compared for elite AFL matches and grounds over a five year period, Orchard [10] reported a 1.26 relative risk of lower limb injury on couch grass predominant grounds, compared to rye grass predominant grounds.

**Other factors**

A major confounder of the relationship between ground surface and weather characteristics and injury risk is the type of shoe worn by the players. For example, on softer and wetter surfaces, there may be an associated decrease in ACL injury risk. However, under such conditions, some players may be more likely to choose footwear with longer cleats and this can be associated with increased ACL injury risk.

Norton et al. [82] found a strong relationship between hardness of the playing surface with overall speed of the game. This finding could be the mechanism by which games played earlier in the season and in warmer climates have higher injury rates. Speed of player movement has also been used as an explanation for higher rates of injury on artificial turf compared to natural grass [89].
THE OCCURRENCE OF ACL INJURIES IN THE ELITE AFL COMPETITION AND GROUND CONDITIONS

Of all the studies linking ground conditions to injury risk, the relationship with ACL occurrence has been the most studied because of a highly plausible mechanism explaining the link between the two (i.e. excessive rotational traction). In a study of ground conditions and ACL injuries in elite AFL, Orchard [1] identified many univariate associations between grounds, match and weather variables with the risk of a non-contact ACL injury. There were strong associations with injury risk for grade of match (higher grade having greater risk), match location (northern venue having greater risk), grass type (couch grass having greater risk), previous month’s evaporation (high values having greater risk) and stage of season (early season matches having greater risk). Low previous year’s rainfall was associated with a trend towards increase ACL injury risk. Softer grounds, as measured by the penetrometer, had lower absolute rates of ACL injuries but this was not statistically significant. Neither the presence of a cricket pitch, an enclosed stadium roof, nor time of the match (night compared to day), showed any association with risk of ACL injury.

It is quite plausible that shoe-surface traction is a risk factor for ACL injury in football, as the theory that increased shoe-surface traction is a cause of knee injuries is well established [92]. In the study by Torg et al. [74], the traction from various boots on various surface conditions was measured. Torg and others presumed that increased traction increased the risk of knee injury and concluded that “at least from the safety standpoint, (players generally choose) the wrong shoes...on the wrong turf”. Players, of course, choose football boots for a very good reason—to improve their performance. It is likely that players will choose boots on a given day that maximise shoe-surface traction and therefore minimise the risk of slipping and reduce the amount of time taken to perform a cutting manoeuvre. This is in direct contrast to what might be recommended for safety considerations.

CONCLUSIONS

This Chapter has considered the evidence linking injury risk to the conditions of the sporting grounds where the activity takes place. Tables 5 and 6 summarise the main findings of this section, in terms of what we do and do not currently know about injury risk in relation to ground conditions.
Table 5. Summary of what we DO KNOW about ground and surface conditions as a risk factor for sports injury

- The evidence linking ground and weather conditions to sports injury risk comes from studies of elite, professional or semi-professional footballers, across all codes.
- A risk management approach to removing and controlling ground condition hazards should include factors such as the presence of hazards and debris, unevenness of the ground and type of surface, as well as ground conditions and the impact of weather conditions.
- There is an early-season bias in the occurrence of football injuries, which may be related to harder ground conditions or greater shoe-surface traction at the start of the season in countries such as Australia. However, other factors such as player fitness/conditioning, training schedules and the speed of the game may be just as important.
- Circumstantial evidence suggests that it is highly likely that variations in ground conditions are responsible, at least in part, for the early-season bias in football injuries.
- The major characteristics of ground surface that should be considered are ground hardness and traction. The current evidence of a link between ground hardness and injury risk is equivocal. The incidence of lower limb injuries may be more related to shoe-surface traction than to ground hardness.
- There is a suggestion of an increased risk of lower limb injuries on artificial turf, compared to natural turf.
- In elite AFL and the US NFL competitions, there appears to be an association between the type of grass and injury rates, particularly for ACL injuries.
- Although injuries occur in game settings and training sessions, the relationships with ground and weather conditions are likely to be different.

Table 6. Summary of what we DO NOT KNOW about ground and surface conditions as a risk factor for sports injury

- The relationship between injury risk and ground conditions in sports other than the football codes. In particular, there have been no published studies in cricket, hockey or netball. In Australia, apart from one study in semi-professional rugby league, all other data linking injuries and ground conditions comes from the elite AFL competition.
- The extent to which, if at all, the studies in elite, professional or semi-professional football are directly relevant to community and junior football, let alone other sports.
- The extent to which studies conducted overseas (e.g. in soccer and rugby union) can be directly applied to the sporting ground context in Australia.
- The nature of the direct relationship, if any, between ground conditions and injury risk in most sports. The relationship, from football studies, is largely speculative and based on correlational data only. Most studies have not directly measured ground conditions with validated tools.
- The causal pathways and mechanisms by which ground conditions potentially influence injury risk, except perhaps for ACL injuries.
- The extent to which the early-season bias for football injuries can be explained by player fitness and conditioning factors, rather than ground conditions.
Table 7 lists recommendations for further research to improve the evidence base linking ground conditions to injury risk.

**Table 7. Recommendations for further research to improve the evidence base linking ground conditions to injury risk**

- Prospective studies, including ongoing injury surveillance and objective ground condition measurements should be conducted over at least two full playing seasons in all codes of football and across all levels of play.
- Prospectively collected ground condition assessments should be made on sporting grounds during the appropriate playing seasons for other sports (such as cricket and hockey) and clearly linked to injury data.
- Basic scientific work is needed to develop and test models for the causal pathways and mechanisms by which ground conditions and the early-season bias potentially influence injury risk.
- A comparative study of representative ground conditions, and their relationship to injury risk, should be conducted across all levels of play to determine the extent to which findings in elite, professional and semi-professional players can be directly translated to community or junior sport.
3. AN OVERVIEW OF KEY GROUND CONDITION FEATURES

INTRODUCTION

Chapter 2 summarised the scientific literature relating ground conditions to injury risk and highlighted the limitation of the current evidence. Intuitively, there is a relationship between extremes in surface conditions and injury. For example, a harder/drier surface would prevent the sliding that reduces torsional loading on the leg during sudden movements or contact with another player, but could increase the risk of injuries, such as contusions and fractures, should a player fall on a hard surface. Equally, a softer surface will reduce friction and cause slipping during sudden movement, but will be a softer landing for players [85].

Friction and torsional resistance from footwear has been shown to be higher in drier conditions on natural grass compared to wet conditions [105] and this may increase the risk of injuries. Lambson et al [71] found that wearing boots with longer and more peripheral cleats was associated with an increased risk of ACL injury due to increased shoe-surface traction on natural grass. The speed of the game has also been correlated with hardness of playing conditions at elite level Australian Rules football and rugby league, with harder grounds having a faster game speed [16, 82]. Norton et al [82] concluded that there would be an increased collision impact force on harder grounds due to faster game speed.

According to Milburn and Barry [85], harder grounds lead to increased strain on ligaments and tendons and therefore contribute to higher injury rates. Although higher rates of injuries were associated with harder ground conditions, this relationship disappeared when adjusted for time of the season, suggesting that the association initially found may have been spurious [22]. In the United Kingdom (UK), when the rugby league season was changed from winter to summer, some of the increase in injury incidence was attributed to ground conditions, but as the ground conditions themselves were not measured, this conclusion remains speculative [75, 106].

This equivocal and rather patchy evidence leads to the question as to what are the important ground condition features that LGAs, SSAs and their clubs should be most concerned about. This Chapter describes these key features. How they can be measured is the subject of Chapter 4.

CONDITIONS ON AND ABOVE THE SURFACE

In his major study of elite AFL ground conditions and injury risk, Orchard [1] argued that preparatory measures should be undertaken to try to minimise the risk of knee and ankle injuries on AFL playing surfaces. As part of a general ‘risk management’ approach to lowering the injury rates in football, he advocated for an examination of the playing surface for excessive irregularities. Although specific data is not available to prove the hypothesis, it is logical to suggest that a relatively smooth playing surface is safer than one with major irregularities, such as potholes. A relevant example in the era of portable natural grass surfaces is the presence of ridges between portable trays or rolls of imported grass. Another contemporary issue is the use of sports fields for alternative events like concerts, which may lead to surface damage.

If a surface has gross irregularities, matches may need to be cancelled until maintenance work is undertaken to correct the irregularities. Portable grass systems should be given a reasonable time to settle between their installation and games being played.
Debris on a field is another obvious hazard that requires careful visual inspection. Glass, aluminium cans that have been mown over, rocks and general rubbish often litter sports grounds. Other debris, including syringes and windrows of mown grass, can present tripping or piercing hazards.

Recessed sprinkler heads on sports grounds are normally made safe by a cover, but this needs to be checked on a regular basis. Areas of erosion around the sprinkler caused by water pressure should be made level with the surrounding ground. A player should be able to run across a sprinkler area and directly place a foot on the top of the area with no disruption to their stride pattern or gait.

Potholes, divots and depressions are hazards that arise for many reasons on sports grounds. They are easily repaired by adding sand or soil and should be tamped to provide a stable surface. Uneven surfaces typically arise through differential wear patterns (e.g. in the goal square) and around cricket pitch areas where loose soil has a different drainage pattern to the adjacent areas. Bare patches of earth with clumped grass or weeds can also lead to uneven surfaces.

Other features of grounds related to general player safety measures should also be assessed. Other known appropriate injury prevention steps should always be taken, such as having a good distance between the side or boundary line of the football field and any hard objects, such as a fence, and heavily padding goal posts so they do not present a significant injury risk [1-7].

**HARDNESS**

The two main surface characteristics that can relate to injury in football are hardness (the effect that the surface has on absorbing impact energy) and traction (the type of footing or ‘grip’ a playing surface provides) [55, 83-85]. Hardness is related mainly to the surface and can be objectively measured.

As highlighted in Chapter 2, there is little direct evidence to support the idea that a harder surface leads to increased injuries. However, an understanding of the basic mechanics of grounds, sports and associated injuries suggests that this will be the case. Fortunately, most professional football grounds generally fall within acceptable levels of hardness.

There may be playing fields in warm climates (such as in Australia) that are affected by drought and subsequent water restrictions can make them excessively hard. In circumstances such as these, it may be appropriate to apply for exemption from water restrictions. In certain situations, cricket wicket areas could be an excessively hard segment of the ground for any other sport played on the ground. An adequate time should be left between the cricket and football seasons to allow good grass cover over cricket wicket tables. Other methods of ground preparation, such as decompaction, could also be examined to reduce hardness.

**TRACTION**

As stated above, traction is one of the two main surface characteristics that may relate to injury in football. Traction relates to the type of footing or ‘grip’ a playing surface provides [55, 83-85]. Traction is most highly correlated with grass cover, hardness and soil moisture content [70, 86, 89].

For the 1997–2000 AFL seasons, Orchard found the rates of injury in Victoria were lower than those of the more northern states of Australia; the greatest difference was associated with ACL injuries [24]. Although this was attributed to weather conditions, and by inference to ground conditions, it is important to note that the type of grass on the football fields also varied with
climate. In another study, Orchard et al.[14] found no significant relationship between ground hardness and the risk of ACL injuries in the AFL, but there was a trend towards an increased risk when the ground was harder. A factor implicated in the incidence of non-contact ACL injuries is the interaction between the player’s shoe and the playing surface [95]. However, there is a lack of reliable findings to confidently support or refute this as a factor in the AFL studies.

There are two types of traction relevant to sports grounds conditions—rotational traction (or grip) and linear traction (or shear strength).

Rotational traction is the force required for the foot or boot to rotate on the grass surface. Higher rotational force increases the risk of footwear (particularly with studs) getting caught in the ground and hence increasing the risk of injuries. This mechanism of injury is particularly relevant to ACL tears and ankle sprains.

Linear traction, translational traction, shear strength and resistance to shear are synonymous terms used by various authors. In a practical sense, linear traction is the force required to cause failure over an undefined shear plane. For a turf surface, it can also be considered as an index of the combination of soil and turf strength. We make the distinction between rotational traction and linear traction in this study (supported by many other researchers, e.g. [84]) because rotational traction has the force applied in a rotation about a centre pivot point, whilst linear traction has the force applied in a single direction through the centre pivot point.

Examination of playing surfaces for the potential to cause excessive traction is difficult (see Chapter 4) and so it is difficult to measure the maximum available traction on football fields. However, general statements can be made that Astroturf leads to higher traction than natural grass in hot weather; that rye grass leads to lower traction than other major grass species such as couch grass, annual bluegrass, kikuyu grass and Kentucky bluegrass; and that an excessive thatch layer leads to increased traction. If possible, rye grass should be used in the profile of a football field. If excessive thatch is present for any grass, then the surface should be scarified.

**SOIL MOISTURE CONTENT**

Soil moisture content (or volumetric moisture content) is the amount of moisture held in the soil. If it is measured within days of substantial rainfall events, the soil will be in its wettest state. The maximum amount of moisture that can be held in the soil without causing run-off across the surface is called the Field Capacity of the soil. Measurements taken on other days when the soil is drier will show varying degrees of water deficit. Moisture content has a very strong negative relationship with surface hardness because, as surfaces get wetter, they become softer. Conversely, moisture deficit has a strong positive relationship with surface hardness, with drier surfaces being harder.

**GRASS/TURF**

In Australia, most football matches are played outdoors on natural grass. Grass needs natural light to survive, so the use of natural grass indoors is only possible if the grass is grown under open conditions. A turfgrass surface is one which has high durability and therefore can recuperate well after the damage of a sporting game [107, 108]. Much of the turfgrass industry is devoted specifically to the sport of golf, as a golf course requires a team of full-time staff to maintain it. The care of football fields is also becoming a specialised industry.
Grass species are divided into warm-season species and cool-season species [107, 108]. The warm-season grasses thrive in conditions where the soil temperature is greater than 10 °C at all times. Cool-season grasses thrive under soil temperatures ranging from slightly below freezing conditions to approximately 20 °C. Most sporting fields do not use a single grass species in their profile. Sporting fields that require good grass coverage over a variety of different temperatures will use a combination of grasses.

Many stadiums with natural grass surfaces play football over seasons with widely varying temperatures. Therefore, both warm-season and cool-season grasses may be needed as part of the grass profile. During the autumn, oversowing of the warm-season variety (e.g. bermuda grass) is performed, often using a process called scarification to create a suitable seedbed for the cool-season variety. This process cuts the lateral growth of the warm-season grass and may reduce thatch [15].

**Grass types**

The botanical composition of grass surfaces has been found to be an important factor, particularly with ACL injuries. The types of grasses used on football fields are bermuda grass, kikuyu grass, rye grass and rye/annual blue grass mix. Most of the elite AFL grounds are covered in either rye grass or annual blue grass or a mixture of both [23]. In a study of AFL matches and grounds over a five year period, there was a 26% increased risk of lower limb injury on bermuda grass predominant grounds compared to predominantly rye grass grounds [14]. Rye grass is considered to lead to lower shoe-surface traction than bermuda grass because it creates less thatch and does not contain stolons which may create excess friction between footwear cleats and the grass layer [12, 15, 109, 110].

Chivers et al.[15] recently analysed the percentage of bermuda grass and annual blue grass over the course of the season on various AFL grounds and found a high correlation between grass type and ACL injury incidence. Their findings suggest that annual blue grass, mixed with either rye or bermuda grass, may be associated with a higher ACL injury risk than rye grass alone. Since rye grass has been traditionally associated with cooler climates, it has been the predominant grass type on Victorian football fields. As a consequence of the current climatic changes and escalating drought experienced, it may no longer be the most suitable grass type for football fields in Victoria.

Grass types used on the major AFL venues from 1996–1999 were retrospectively identified in 1999 by consultation with ground managers at each venue [23]. Thereafter they have been recorded prospectively. Grass types for each ground-season were subdivided as follows:

- Couch, where *Cynodon dactylon* (or its hybrid species) made up greater than 75% of the visible grass for the entire season.
- Kikuyu, where *Pennisetum clandestinum* made up greater than 75% of the visible grass for the entire season
- Rye, where *Lolium perenne* made up greater than 75% of the visible grass for the entire season
- Rye/Poa mix, where a combination of rye grass (*Lolium perenne*) and annual bluegrass (*Poa annua*) made up greater than 75% of the visible grass for the entire season.

Couch grass and kikuyu grass are warm-season grasses, whereas rye grass and annual bluegrass are cool-season grasses [107, 108]. Where a grass profile was made up of a combination of warm-season and cool-season grasses, the warm-season grass was considered to be the predominant species in the months of the season where the average overnight minimum was >10 °C. Cool-season grass was considered predominant in the months of the season where the
average overnight minimum was 10 °C or less. Therefore, all combinations of warm and cool season grasses could be classified according to one of the four criteria above, depending on the month of the year. The only exception to the 10 °C rule cited above was that at Telstra Dome in Melbourne, which used couch grass and rye grass. Rye grass was considered to have been predominant from April (rather than May), which was the cut-off month for the other Victorian grounds. This is because Telstra Dome is a partially indoor stadium with a retractable roof, where couch grass becomes dormant earlier than it would elsewhere in the same climate, due to the relative lack of sunlight.

Rye grass appears to offer protection against ACL injury compared to couch grass and this appears to be chiefly responsible for the previously observed northern-bias for ACL injury in the AFL competition. Grass species, as a single consideration, may not be able to fully explain the ACL early-season bias, as stage of season appears to still be relevant as a risk factor even when grass type is taken into account. It may be possible that intrinsic factors are relevant to the early-season bias. For example, early in the season players have had relatively more recent weight training in the gym compared to football-specific drills. It is also possible that within grass species, characteristics of the turf, such as thatch depth, change over the course of the season, may be relevant to injury risk. Both traction and thatch depth have been shown to decrease on football fields over the course of a season [15, 70]. This may be related to a higher incidence of ACL injuries at the start of the AFL season when greater thatch depths could “trap” players’ boots preventing free rotation of the foot and placing more stress on knee ligaments. This hypothesis could also explain the early season bias observed in other football codes where different grass profiles are used.

Rye grass is also considered to lead to lower shoe-surface traction than couch grass [12, 24, 111] because it creates less thatch and does not have stolons (above ground runners) between the blades which may create excess friction between the shoe cleats and grass layer. Studies that have compared traction of grass types have been conducted in a single climate [78, 112], which does not address the relative traction of couch grass growing in a warm climate compared to rye grass growing in a temperate climate. Couch grass grows by creeping and forms a matting below its leaves. In contrast, rye grass grows in bunches or tufts, without creeping stems to knit the bunches. Couch grass is generally considered to have greater wear tolerance than rye grass because of its matting.

A confounding factor could be the operation of over sowing of rye grass, which usually involves scarifying the couch grass to create a suitable seedbed. It is possible that scarify, on its own, reduces the risk associated with couch grass by reducing the thatch and cutting the lateral growth into smaller segments.

Unfortunately, it is not simply a matter of mandating that all Australian Rules football grounds use rye grass to reduce the ACL injury rate. Rye grass is poorly tolerant of heat, drought and extreme cold, and pure rye grass is less wear tolerant than a combination of couch and rye grass. There may be other injuries that could be increased by use of rye grass (although none of these have been noted to date) and more players slipping on rye grass surfaces may affect the spectacle of the game. However, turf managers should be aware of the trends observed in the elite AFL studies and consider promoting rye grass as part of their turf profile, as well as trying to reduce the amount of thatch where possible, using techniques such as scarification.
Thatch depth

Although there are other potential confounders, it appears that rye grass generally offers a safer surface with respect to ACL injuries in elite AFL than couch grass and perhaps some other grasses. The likely mechanism is a decreased thatch layer leading to lower shoe-surface traction.

A number of grasses such as couch and kikuyu grass, have a vigorous above-ground creeping-growth pattern, or stoloniferous growth. These growth patterns lead to such grasses forming a thatch layer (organic material between the soil and the grass leaves) [107, 108]. If grounds are not well maintained, stoloniferous grasses can form a thick thatch layer than could increase injury risk. The stronger and thicker the thatch, the more likely it is that boot studs will get caught in it. This has implications for shoe/stud type in these conditions. It may be easier to get players to change their boots, in certain circumstances, than for the grass to be changed. However, this strategy is an example of an ‘active’ intervention and would require players to proactively change their behaviours. As a general rule, ‘passive’ interventions that do not rely on player behaviour, such as changing the grass type, are likely to be more successful in the long run [9].

Rhizomes

Rhizomes are the means by which many grasses spread under the soil surface. The number of rhizomes is highly related to the presence of grasses that produce rhizomes, such as couch grass and Kikuyu grass. It would appear that the species of grass included in the turf cover and the related number of rhizomes are the predominant factors influencing the shear strength of the turf.

Artificial turf

The only major football code regularly played on artificial surfaces is American football, although artificial grass is also the favoured surface for field hockey. Artificial surfaces are named after their brand, and in the twenty-year period between 1975 and 1995 this industry was dominated by Astroturf. Astroturf was renowned for being harder than natural grass surfaces [89] (except under freezing conditions where natural grass could also become hard), although a general statement could not be made about shoe-surface traction, which is a variable quality in both natural and artificial surfaces. Because Astroturf is considered by American football players to be excessively hard, it is gradually being superseded by second-generation artificial surfaces, such as FieldTurf, Astroplay and Momentum Turf. The second -generation surfaces are softer than Astroturf and are comparable in hardness (under most conditions) to natural grass. However, like Astroturf and natural grass, it is hard to make general statements about shoe-surface traction on new generation artificial surfaces because there are no published studies of this.

Impact of changes to ground surface preparation

Very few studies of the impact of changes to ground surface preparation have been published. In the AFL competition, ACL injury incidence has fallen in recent years, in association with non-randomised changes to grass types and softening of the playing surfaces [12, 24]. Because these changes have been assessed using historical controls only, it is impossible to adjust for other possible coexisting changes in the competition.

Mueller and Blyth [110] reported a decrease in knee and ankle injuries in a cohort of high school American football teams that were randomly chosen to have their fields resurfaced. Unfortunately, they published very little detail about the specifics of the resurfacing, such as soil type, drainage, grass type etc. Although the reduction of injuries in this study was impressive, it does not appear to have been replicated in other studies and may have been due to a range of other factors.
WEATHER

Weather is usually measured in terms of rainfall, either on the day of a game or in the days preceding it. Rainfall has an obvious impact on the playing surface. Other weather conditions include lightening storms [113].

The major and serious risks arising from hazardous weather conditions relate to localised lightning, the combination of wind, rain and cold leading to hypothermic conditions and conditions of extreme heat. The weather, as it relates to player safety, should be considered in an ongoing manner throughout match day.

Weather is a variable for which intervention is generally not possible, other than the construction of indoor or closed stadiums. Ground conditions in outdoor stadiums are passively influenced by the weather, but can be manipulated by changing soil type (and texture), grass types (and composition), cutting height (mowing) and watering or covering practices as the weather changes. The surface-related factors responsible for playing quality have been previously reviewed [86, 114], although these reviews have been focused on aesthetic presentation and player satisfaction, which may not correlate with injury risk.

SUMMARY AND CONCLUSION

This Chapter has described the key factors associated with sports grounds both from a surface and on/above surface perspective (Table 8). Table 9 makes some broad recommendations based on these key findings. The recommended procedures for measuring these factors are discussed in Chapter 4.

In any case, the public, competing teams and player associations need to be assured that all available measures are being taken to address adverse ground conditions. There is no doubt that ground management techniques, based on a risk management and hazard reduction approach, have the potential to reduce risk of injuries.
Table 8. Summary of what ground condition factors need to be assessed

- Irregularities in playing surfaces can increase the risk of injury, as can the presence of other hazards such as debris, uncovered sprinkler heads, etc.
- According to the limited studies to date, hardness and traction are the two main surface characteristics that relate to football injury.
- Both hardness and traction are related to the grass surfaces and soil moisture, which is affected by weather.
- Grass type, particularly the presence of thatch, appears to be related to ACL injury risk in the elite AFL competition. However, the type of footwear and studs used by players may confound this relationship.
- Weather patterns, such as excessive rain, can change the soil moisture content and, potentially, the profile of injuries.

Table 9. Recommendations for prevention in relation to ground condition factors that need to be assessed

- Ground managers should consider using rye grass in their grass mix and reducing the amount of thatch on grasses on all fields.
- Broad based risk management approaches to assessing ground conditions adopted by LGAs, SSAs and their clubs should include consideration of general player safety measures, such as boundary placement and padding, and assessments of ground surfaces before play and in the case of inclement weather.
- Strategies for changing the grass profiles on playing field are more likely achieve long-term success, than requiring players to proactively change their boots during the season.
4. MEASURING GROUND CONDITIONS

INTRODUCTION

Chapter 3 gave an overview of which ground condition features LGAs, SSAs and their clubs should be most concerned about. This Chapter describes the methods that can be used to measure them. Unfortunately, not all measures are directly available to, or within budget constraints of, most LGAs or SSAs/clubs. In those situations, suggestions on how to source the testing methods and relevant experts are given. The focus, however, is on assessments that LGAs and SSAs/clubs could reasonably be expected to perform on a regular basis.

This Chapter begins with a discussion of some important issues relating to measuring ground conditions, including accuracy and timing. It also further explains why there is no strong evidence to inform ground conditions decisions at this stage. The basis, uses and limitations of measuring devices for assessing the ground condition factors discussed in the Chapter 3 are presented.

ISSUES IN MEASURING GROUND CONDITIONS

In any standard measurement of ground conditions, the question of validity and reliability is always an issue. If a measure is not valid and reliable, it will have limited use in the field because it is not accurate and may lead to misleading conclusions and decisions. The key questions to ask about the accuracy of different testing measures are:

- Is the equipment being used for the purposes for which it was originally designed?
- Has the equipment been shown to measure factors directly related to the impacts and forces that athletes might experience during sporting activity?
- If different people used the same piece of equipment to measure the same ground, would they get the same result?
- If someone used the equipment to measure the same ground at different times on the same day (or some days apart), would they get the same result?
- Do subjective and objective assessments of the same ground condition agree?
- Is the application of, or interpretation of data from, the equipment based on clearly defined criteria that provide an objective assessment of the ground conditions?
- Does application of, or interpretation of the reading from, the equipment require the user to make a subjective judgement?
- Does the equipment directly measure a ground condition factor, or does it measure something supposedly related to it?

The ground condition measures considered in this report have all been validated and tested in the context for which they were originally designed. However, it needs to be noted that this has almost exclusively been in the absence of athletes. For example, the use of the Clegg Hammer for turf surface assessment has been validated with many observations and different observers/operators. However, it has not specifically been validated in the context of sporting grounds assessment in relation to the likely physical loads placed on players on different grounds and their association with injury risk. This is a major gap in the international literature.

As mentioned a number of times in Chapter 2, a major limitation of much of the published research to date is that most conclusions about ground conditions and injury risk have been based on correlational observations rather than direct measurements. In their case-control study, Alsop et al
collected information from injured players about ground conditions at the time of the injury during an interview with them, up to some weeks after their injury. Uninjured players were also interviewed by telephone and were asked to recall the ground conditions during their most recent game. In both instances, the ground conditions data was based solely on player recall and this data is only as good as the players’ recall. It is not known if injured players have a different recall of ground conditions than uninjured players, but this could certainly be the case if they believe their injury to have been caused by bad ground conditions. As the information could not be checked, its reliability could not be assessed. This is known as a subjective assessment of ground conditions.

In the most recent Australian study in rugby league, ground conditions were also only subjectively rated[16]. Two coaches each assessed ground conditions at 30 different sites before each training session and match, using a rating scale of heavy, slippery, firm or hard. Their subjective assessments were then compared and the coaches asked to reach a consensus rating. Once again, the accuracy of this data is not known because it represented the opinions of just two people, and was not checked against another more accurate or objective source. The approach used here, is by no means restricted to this study and has been adopted by other studies as well[22].

The quality of any of the reported links between ground condition factors and injury risk is only as good as the information about the ground conditions at the time of injury. If this information is based on recall over a few weeks, a person’s own judgement or other un-validated data sources, then the strength of any association is questionable. Unfortunately, experiences across the broad spectrum of scientific research have highlighted many instances when subjective data does not stand up to the test of comparison against more objective measures.

Another problem with many subjective measures, such as questionnaires and checklists, is that the information being asked, and the ratings they are asked to apply, rely too much on the understanding of the people using them. If ambiguous wording is used, or the actions flowing from the ticking of certain boxes or options is unclear, then different responses could be given, just because people interpret and apply the measurement tool differently.

Objective measures require the use of scientifically proven equipment in the way in which they were designed and intended. The only studies that used objective measures of ground conditions have been conducted in the AFL. Orchard[24], Orchard et al [23] and Norton et al[82] each used a penetrometer to objectively measure ground hardness but, as discussed below, this is not the best measure of ground hardness. Only one published study could be found that used other objective measures and that study looked specifically at ACL injuries in elite AFL players[15]. These objective measures are those discussed in this Chapter.

One of the reasons for the lack of studies using objective measures is the lack of specific evidence assessing their direct relationship to the forces experienced by an athlete. Currently, it is possible to identify a measure of hardness using the Clegg Hammer, for example, and to be confident that it is reliable, repeatable and accurate. However, the relationship between the number that is derived for hardness (or any other parameter) and the forces that a human athlete experiences when contacting the ground are yet to be formally linked. Therefore, these measures are not calibrated to human athletes but are just inferred to be correct. The lack of scientific information supporting such an assumption is a major information gap.

In addition, it is not known within the specific context of sports ground assessment, if different people using the same piece of equipment at the same or different times will get the same measurement, let alone draw the same conclusions from it. Such validation issues will be the subject of new research by Dr Dara Twomey at the University of Ballarat, in 2007–2008.
The following sections provide the rationale for the use of measurement devices to assess various ground features. Where it is required, the reliability and validity of such measures is discussed. If the information is not presented, then information about the accuracy of the measures has not been published to date.

GENERAL GROUND CONDITION ASSESSMENT CHECKLISTS

The best way to undertake a general ground condition assessment, particularly for the on and above ground factors, is by a checklist. All Victorian community level football clubs are required to complete a match day checklist on ground safety. These checklists have been developed by the sports governing body’s insurer and are a mandatory requirement. They are primarily concerned with the identification and removal of hazards before the game. The surface of the ground is assessed in very general terms.

Insurance companies have prepared checklists for both SSA and LGA specific sports ground assessment processes across a range of sports. These checklists focus on identifying known hazards that increase the risk for participants and therefore the likelihood of injury. Examples of this are checking grounds for debris, holes, correct padding of goals, sprinkler covers in place and grass length. There is a presumption (and common sense indicates) that if there is a hazard present and noted then it will be corrected before play.

The ability of a match official to report the ground conditions accurately for the entire playing surface is certainly questionable. Moreover, such checklists are only as good as any action that directly flows from them. Merely using a checklist to identify some hazards that need addressing and then filing the form without immediately addressing the hazards does not reduce injury risk.

The Sports Safety in Australia report [115] summarised the results of published surveys that described whether or not sporting clubs had a policy on inspection of the playing surfaces. All clubs would have implemented the policy through match day or other checklists. As Figure 2 shows that not all surveyed clubs had a match day checklist and this ranged from 50 to 100% of clubs in each study. The number of clubs that also checked the playing surfaces prior to training was much less, ranging from 25 to 65%, even for those clubs that regularly checked their surfaces before matches.
Figure 2. Summary of the proportion of sports clubs having a policy on inspecting playing surfaces before training and games

Match day checklists

Match day checklists, and the inspection process they require, have the potential to play an important role in identifying hazards on sports grounds. They require a trained eye to visually scan a ground to look for known and observable hazards before a game. They offer the observer prompts, reminders and things to look for. They are a last line of defence and are there to ensure that the ground is fit for play. They are not, and should not be seen as, capable of evaluating the quality of the playing surface.

Match day checklists are a valuable part of risk management or a general safety checking process. Clubs using them tend to allocate the role of safety officer to a committee member and this role should be is seen as important for player safety. The usefulness of match day checklists is limited by the regularity of their use. They should be used by all clubs before any training and game situation.

An example of a match day checklist is given in Appendix 2. This particular match day checklist is required as an insurance prerequisite by JLT Sport, a division of Jardines Lloyd Thompson, which offers insurance for Australian Rules football clubs. This match day checklist is simple to use and its validity has been shown by its application in the football setting over time. It can certainly be used to identify hazards on a playing field but does require action to rectify them. However, the form contains a mixture of subjective and more objective questions. An example of a more objective assessment is “Are sprinkler covers correctly in place?” However, questions such as “Have weather conditions or water made the surface unsafe” are more subjective, as they require the user to make a value judgement about unsafe in this context.

Given their value in identifying hazards, it would be worth investing in further development of match day checklists. As minimum practice, all clubs should use some form of a match day checklist.
before all games. As the name implies, some people may believe these assessments are only necessary before a game. However, hazards can still lead to a risk of injury at training [119] and such checklists should also be applied before every training session too.

**Hardness**

Ground hardness relates mainly to the surface and, to a lesser extent, the weight of the body. It can be objectively measured in a number of ways.

Hardness varies substantially from point to point on natural grass surface playing fields and readings may vary across testing positions on the field due to this factor alone. This has implications for the sampling methodology for selection of the number and location of sites for testing. Enough repeated samples across different sites on a field are needed (see Chapter 7 for further discussion of this).

**Clegg Hammer**

The Clegg Hammer is the most accepted device for measuring the hardness of a player field, which electronically measures impact deceleration in gravities [15, 120]. However, there are some problems associated with using a Clegg Hammer:

- the hammer comes in different weights (e.g. 0.5 kg, 2.25 kg and 5 kg) which are not directly comparable and all can be dropped from a variety of different heights, and a varying number of times. The 2.25 kg hammer dropped from 457 mm is often preferred in Australia and the USA [21, 99]. Although the 0.5 kg and 2.25 kg Clegg Hammers have a high correlation with each other [28], ratings cannot be assumed to be equal between different hammer weights. This is particularly so when grounds are extremely wet and dry where the lighter (0.5 kg) weight is a far less accurate measure of surface hardness than the 2.25 kg weight
- all weights used are much lighter than the human body and may react differently to the surface and not give readings representative of what an actual human body would achieve
- natural grass compacts (and becomes harder) under impact from the Clegg Hammer so readings taken after three drops of the hammer, which is often but not always the technique used, are substantially harder than readings on the first drop in the same location.

Orchard [1] found that hardness readings taken at AFL grounds using a Clegg Hammer (with a 2.25kg mass dropped from 45cm) have been between 40 and 120 gravities. In recent seasons, Clegg hammer readings have shown trends towards being higher at Victorian venues than northern venues and being higher later in the season. This is the opposite to what would be expected if hardness were a significant risk for ACL injury [1]. Furthermore, there is no relationship between the presence of a cricket pitch area and ACL injury risk, which would have been expected if hardness was a major risk factor [1].

Despite the fact that hardness may not be relevant to ACL injury risk in the AFL competition, grounds in this competition only display a limited range of hardness measurements. Astroturf, very dry natural grass fields in relative droughts which have not been watered and frozen natural grass fields are all significantly harder than 120 gravities as measured by the Clegg Hammer [89-91, 121]. Football matches of various types are played on these sorts of fields on various occasions, although none of these field types are relevant to the AFL competition.

The AFL has adopted a preferred range of hardness readings for elite level AFL football measured by the 2.25 kg Clegg Hammer dropped from 45 cm of between 55 and 70 gravities, with an acceptable range of between 40 and 105 gravities [109, 122]. There is currently a proposed
standard for measuring the surface hardness of soccer pitches in England, with a recommended range of 20-80 gravities, as measured by the 0.5 kg Clegg Hammer dropped from 300 mm [123].

Chapter 7 of this report shows how Clegg Hammer hardness readings vary across a playing field and gives recommendations for the number and range of test sites to be used with this device.

Photos 1 and 2 show the operation of the Clegg Hammer. Operationally, the 2.25 kg hammer is raised to a set mark on the shaft and then dropped to the ground. The rate of deceleration is measured on the digital readout face. The weight is dropped three times in the one location, with usually the first drop and the third drop recorded. The third drop of the Clegg Hammer is far more reliable than the first drop and is therefore a more accurate representation of both the surface and the perception the players have of the surface [122].

The influence of the thatch layer is reduced in the later drops as it is compressed and this further supports the use of the third drop. Results are often expressed as the average of two records and are converted to gravities by a multiplication by 10.

![Photo 1. The Clegg Hammer in its down position](image)
The Clegg Hammer is simple to operate and understand. It can be used by LGAs, SSAs/clubs and consultants. A Clegg Hammer costs around $6000–$10,000 and they are readily available through Dr. Baden Clegg P/L of Perth, W.A..

Numerous studies have validated Clegg Hammers for use on sporting grounds, though none have considered the specific relationship of the readings to athletes [124-131]. According to Orchard [1], the Clegg Hammer only measures the hardness of the top layer, which is not deep enough to estimate accurately the hardness of the surface on the human body when running. However, some preliminary testing (unpublished) by two authors of this report (Leonie Otago and Ian Chivers) showed that the 2.25 kg weight dropped from 45 cm, had a similar range of response to that of a 75 kg student jumping onto a force plate in a laboratory, thereby contradicting Orchard’s view.

Each LGA and regional or district sports association should obtain a Clegg Hammer (2.25 kg weight) and use it to survey each venue at least four times per football season according to a thorough assessment routine. Hardness results greater than 120 gravities should be reviewed.

**Penetrometer**

The Penetrometer has been used as an alternate measure of hardness in elite AFL studies [24, 120, 132]. This device is popular in horse racing as an aid to rating track conditions. It provides an estimate of hardness by dropping a weight, which strikes a shaft (of smaller surface area) into the turf. It can only be used on natural grass surfaces.

The Penetrometer really measures penetration into the soil of a small square rod; it does not measure hardness (Photo 3). While penetration is related to hardness it is not the same as
hardness and is affected by other factors such as the inclusion of reinforcement materials or stones in the soil profile, which do not have an influence on surface hardness. Hardness is better defined as the measure of deceleration that an object incurs when it falls onto the surface, not when it penetrates into the surface [133]. The hardness of surfaces like basketball courts cannot be assessed with a penetrometer and the only reason this equipment has been adopted for use at all is that it is used by the racing industry as a measure of track condition. For the racing industry, there is some relevance to use of the Penetrometer, as horses do actually penetrate the surface.

Due to the way it works, the Penetrometer estimates an aspect of hardness (i.e. penetration) for a much greater effective weight than the Clegg Hammer (i.e. one that is heavy enough to displace soil rather than bounce off it). However, with respect to human activity on natural grass sports fields, the opposite criticism to the Clegg Hammer applies. In practice, an average player’s boot cleats will penetrate the first few millimetres of the soil. However, the Penetrometer measures a composite of the hardness of the first few centimetres of the surface, including soil that is much deeper than will interact with the boots of the average player.

Use of the Penetrometer also has other limitations in that measurements are often not consistent between users and adjacent locations on the field can vary substantially in rating. The best studies about reliability of the Penetrometer all relate to horse racing and its use as a management aid (for assessing the need for irrigation) and as a component of track rating. There is only one published paper that speculates about its capacity to accurately measure sports field conditions [24].

The Penetrometer is available in Australia, though it is not easy to sourced. It costs about $1500 per item.
It is not necessarily easy to get an accurate number with a Penetrometer. In fact it is very easy to get the wrong reading. This high level of operator error is significant, especially if conditions are less than ideal, and argues against widespread use of Penetrometers for sporting ground assessments.

**TRACTION**

Unfortunately, there are no internationally recognised standards for the measurement of shoe-surface traction on sporting fields [94]. This is partially because traction is a function of both the playing surface and the shoe. Strictly speaking, there will be different values for shoe-surface traction for every variety of playing shoe on each surface. Like hardness on natural grass, traction will vary substantially in different sections of the field, making the sampling method more complicated. However, measurements of traction with a standard device can be made quite effectively on an artificial surface.

The devices most commonly used to assess traction are *torque wrenches*. These measure the force required to shift a cleat-like apparatus embedded in the playing surface. Unfortunately, most studies that report shoe-surface traction use different methodologies and devices.

Orchard [1] has argued that there is a need to use and further develop a range of instruments to measure ground conditions. He suggested that the greatest need is for a portable, readily available, inexpensive device that can measure Maximum Available Traction (MAT) on a given field at a given time [78, 112]. The MAT would be the amount of shoe-surface traction for the boot stud configuration that gave the highest reading on the day. On a dry day, this would usually be a moulded-sole configuration and on a wet day, this would usually be a longstop (cleat) configuration. The concept of MAT is an important one, as players will generally choose footwear for a given surface that will maximise the amount of traction that they will get on that surface. Although it is difficult to measure objectively, subjective opinion is consistent that players can perform at higher levels (i.e. run faster, change direction more efficiently, avoid slipping over etc.) if they have greater traction [129].

**Studded Boot Apparatus**

The Studded Boot Apparatus was first used by Canaway and Bell [134] in a study of soccer pitches in the UK. It was developed to measure the rotational strength of turf of football pitches. This is an important playing parameter, as players want adequate grip on the surface. Rotational strength can be related closely to the grip that players feel when moving across a playing surface [126, 135]. The studded boot has subsequently been used to assess both natural and artificial sports turf surfaces [87, 109, 136].

The way the equipment works is that a plate with protruding studs is dropped from a set height onto the turf surface. The force required to rotate the plate is measured using a torque wrench and a reading is obtained. This reading is a measure of the minimum force required to permit free rotation of the studs in the turf surface. Photos 4 and 5 show the Studded Boot Apparatus in operation.
A significant limitation of the Studded Boot Apparatus is that it does not progressively measure the rotational strength (or grip) as the plate is rotated from its landing position. The conventional equipment only measures the minimum force needed to allow free rotation. This does not allow comparisons of the degree of rotation needed to reach this force or the force required for any given angle of rotation. These measures would be very relevant in providing complete comparisons of turf surfaces and are potentially useful in relation to studies of the occurrence of injuries to players.

A further limitation of this equipment is that it does not relate to the stud patterns on current football boots. Even if it did, people do not place their foot flat on the ground to rotate. In practice, the studs penetrate the surface to varying depths and this cannot be replicated with this device.

An adaptation of the Studded Boot Apparatus has been developed by one of the authors of this report (Ian Chivers). This was designed to progressively measure the grip (rotational torque or traction) as the boot is rotated from this starting position. Some preliminary testing was carried out
on three AFL venues at the end of the 2004 football playing season and significant differences were recorded for many of the observed variables. The results of this will be reported by the author elsewhere.

There is no doubt that the equipment for measuring rotational traction, or grip, needs to be improved. There is also a need to measure different types of ground surfaces. Further improvements to the equipment are possible and additional treatments which would be valuable to explore and which could be expected to affect the rate of increase of grip are:

- the use of sand topdressing in place of scarifying
- the use of sand topdressing in conjunction with scarifying
- different stud patterns and/or different shoe soles
- the depth of thatch in the turf surface.

The standard Studded Boot Apparatus is available commercially and is relatively cheap ($300). The reliability and validity of this equipment has been widely published [124, 126-129, 131] and it can be used by different operators with little error across a number of surfaces. The main difficulty is its size and weight, which makes it difficult and cumbersome to operate.

Each LGA and regional or district sports association should obtain a Studded Boot Apparatus and use it to survey each venue at least four times per football season according to a thorough assessment routine. Traction results greater than 65 Nm should be reported.

**Clegg Shear Tester**

The Clegg Shear Tester is used to measure linear traction or shear strength. The Australian-designed Clegg Shear Tester provides a rapid evaluation of “shear strength” of the turf at the surface in a horizontal direction [15]. In an assessment of the relationship of grass surfaces to ACL risk in elite AFL players, no relationship was found between measures using the Clegg Shear Tester and the rate of ACL injuries [15]. However, the instrument can be a useful guide to turf strength, as it can clearly measure differences in turf surfaces.

A relationship has been found between high Clegg Shear Tester readings and a prolonged recovery period for footballers’ legs following match play [107]. Players were adversely affected and responded that their recovery period was lengthened for shear strength readings greater than 85 Nm.

Its validity and reliability have been reported by Chivers and Aldous [109]. There is also a close, though not perfect, relationship between the Clegg Shear Tester results and those for both traction and hardness with higher shear strength usually occurring with higher traction and higher surface hardness.

In the test, a 50 mm long and 3mm wide aluminium blade penetrates the surface to a depth of 40 mm. Peak shear strength is taken in a horizontal direction and measured in Nm. To operate, the apparatus is placed on the ground and pushed downwards to lock in position with the pegs in the corner of the base (Photo 6). In doing so, the blade is fully inserted into the ground. To obtain a strength reading the lever is pulled backward and the turf torn in an upward arc (Photo 7). The maximum force is recorded in Nm. The operator needs to stabilise the apparatus with one foot and one arm.
This equipment has little operator error and costs about $7000. It is available through contractors and consultants and it is recommended that LGAs employ them to do this test. When traction readings are higher than 60 Nm, additional testing with the Clegg Shear Tester should be undertaken to determine if the playing surface is too strong or too hard.
SOIL MOISTURE CONTENT

Water content is measured in volumetric soil moisture, i.e. the percentage of the soil volume that is occupied by water.

Hydrosense soil moisture meter

The Hydrosense measures the average moisture content of the soil profile to the depth to which the probes are inserted. Probes should be set at both shallow (top 75 mm of the profile) and deeper settings (120 mm of soil profile).

An electrical wave flows from one rod (or guide) to the other across the full length of the rod. The guides need to be installed to their full depth, otherwise there will be areas that will read as zero and this affects the average measurement for the whole length of the field. This is difficult for dry grounds where it is sometimes impossible to get the rods fully inserted. The rods can be inserted in two directions—perpendicular to the surface to give an average soil moisture reading for the top 120 mm of soil (Photo 8) and at 45 degrees to perpendicular (Photo 9) to give the average soil moisture for the top 75 mm of the surface.

Readings are given as the percentage of soil volume that is moisture, i.e. the percentage of the volume of the soil that is occupied by water, as opposed to some other measurements that give the percentage of the weight that is water.

Photo 8. Hydrosense soil moisture meter in the ground (deep testing)
The Hydrosense equipment is available commercially for around $1000 and is easy to use, not subject to operator error and reasonably reliable. The equipment is more fragile than the others discussed above and operators can quickly make a mess of the sampling rods. Therefore, this equipment is probably best used by consultants. Sampling must involve several tests in the one location as soil moisture conditions vary considerably within a short distance on a sports field owing to different soil texture, compaction, drainage and irrigation factors.

GRASS COVERAGE
An agronomist or horticulturist, who is familiar with the grass types, needs to visit the playing fields and assess the botanical composition, which will include the percentages of grass types and level of cover at various parts of each field.

Botanical composition and coverage
To assess the botanical composition of the ground profile, a screwdriver, or any other pointed object is tossed about on the inspection area (usually around 10 sq.m. area) and the plant that it is in contact with (or the bare ground) is noted (Photo 10). Thus, if it is in contact with a ryegrass leaf, it is recorded as a ryegrass hit. If it is in contact with bare ground it is recorded as such (Photo 11). This is repeated 50 times per quadrant to get an exact content of each component. This is time intensive and slow work. An experienced person can quite quickly get a close approximation of the percentage makeup of the turf visually.

When assessing grass types, one of the authors of this report, Ian Chivers, usually divides the turf up into some rough groups—firstly the sown species are given individually (rye grass, tall fescue, kikuyu, couch grass), and then the most common weed Poa annua (annual winter grass) is recorded separately. He then groups the annual broadleaf weeds and annual grassy weeds as
other groups. The bare ground percentage is the remainder. A very experienced assessor can start with bare ground and work backwards on heavily worn areas.

![Photo 10. Grass survey on rye grass](image10)

**Photo 10. Grass survey on rye grass**

![Photo 11. Grass survey on bare ground](image11)

**Photo 11. Grass survey on bare ground**

**Thatch depth and rhizomes**

To measure thatch depth, a core sample is taken with a 50 mm wide sampler that is worked into the soil perpendicular to the ground surface (Photo 12). The depth of thatch is measured directly from the sample. Thatch is the layer of dead or decaying vegetative material that forms between the green leaves and the soil. It is purely organic with no soil. Many people confuse this with "mat" which is the organic material and sand/soil mix that occurs below the thatch layer. Unfortunately, this distinction is not always made clear in the literature.
This same procedure is used to count rhizomes as they will be cut by the process and can be felt in the mat and soil layers as identifiable cross-sections of roots. Rhizomes are the means by which many grasses can spread under the soil surface and can bob-up at some distance from the mother plant to form daughter plants. This distance varies from plant type to plant type with some (e.g. kikuyu) having many rhizomes while other have none. Sometimes this is useful, as visually there may be no appearance of a viable plant due to heavy wear, but there may still be an underlying layer of viable rhizomes from which the plant will resume growth following winter or when wear is reduces.

Photo 12. A core sample for assessment of thatch and rhizomes

WEATHER

Weather and rainfall data can be obtained from the local weather observation stations and Bureau of Meteorology. However, it is important to note that the Bureau of Meteorology data also does not indicate rainfall at specific sports sites and if the sports ground is not near a Bureau of Meteorology recording site, the rainfall totals may be inaccurate, especially when associated with storm rain.

In some experimental work and observational studies [13, 16, 21], researchers have used rainfall data for the site being observed as a measure of soil moisture. This practice can lead to incorrect assertions of cause and effect as rainfall data alone does not account for:

- soil type differences and the tendency of some soils to retain or drain water
- surface slope as steeper slopes have faster drainage
- other drainage variables of the soil profile such as soil depth and installed drains
- grass types as different grasses have different water usage rates
- season of occurrence as this will affect the water use of the grasses
- applied irrigation water.
Inclusion of evaporation rates and allowance for different grasses using derived crop factors brings the calculated value closer to reality but is not a very reliable measure because it does not include the soil factors mentioned above.

It is possible that sunshine hours may be as relevant as rainfall data, although this is obviously not relevant in the case of venues that suffer from extensive shade.

**DERIVED SCORE METHOD OF SPORTS GROUND INSPECTION**

The Derived Score Method (DSM) involves establishing a Derived Score (DS) of ground suitability based on comparisons with a weighted score previously established at a satisfactory level. This typically considers grassed areas for vigour, height, cover and evenness. Worn and bare area and wicket areas are evaluated, as well as holes, cracks, hardness and damage by vehicles, etc. This method still requires an ‘eyeballing’ approach but has objective measures underpinning part of the scoring system. A number of LGAs are currently using this approach. The approach was created by Ricky Bell of The City of Greater Geelong in conjunction with Civic Mutual Plus in 2001 (personal communication with Ricky Bell, 2007) (Appendix 3). As a critique of the DSM has not been previously published, this section provides an assessment of it. The model evaluated both here and in Chapter 8 is the 20th October 2006 version 3 from the City of Greater Geelong.

The approach has intuitive appeal as it enables a score to be given across various ground characteristics that are thought to underpin ground suitability for play. These scores are then summed to give an overall score for the ground. If the overall score is below a previously established satisfactory score, the ground is considered unsuitable for play and if above that score, it is considered suitable. The DSM concept depends upon both the scoring system used and the validity of the areas evaluated.

Overall, the DSM scores a ground out of 74 across the areas shown in Table 10. A score above 54 /74 or 73% is considered as the benchmark for declaring a ground safe. It is unclear why or how this value was set.

<table>
<thead>
<tr>
<th>Observation Area</th>
<th>Overall proportion of score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassed areas</td>
<td>22/74 or 30%</td>
</tr>
<tr>
<td>Wicket area (transition to other areas)</td>
<td>10/74 or 14%</td>
</tr>
<tr>
<td>Worn / Bare Areas</td>
<td>13/74 or 18%</td>
</tr>
<tr>
<td>Hardness</td>
<td>9/74 or 12%</td>
</tr>
<tr>
<td>Other (cracks, holes, sprinklers)</td>
<td>20/74 or 26%</td>
</tr>
<tr>
<td>Non playing areas</td>
<td>No scores given</td>
</tr>
</tbody>
</table>

The DSM acknowledges that any one observation may ‘render the playing surface unsafe’. However, the assumption of an aggregated score is based on the relative contribution of these areas to ground suitability for play and hence its safety. It is not possible to say with any certainty or validity that there is any evidence for the magnitude and relativities of these scores, at this time. It would seem that the assigned scores were derived from a consensus discussion amongst a group of users and experts but they have not been objectively or scientifically validated. Therefore, it is not possible to conclude that the scoring component of the DSM is developed well enough for wholesale adoption across the State presently.

Elsewhere in this report, we have argued that surface evenness (as it relates to player stability), grass cover (as it relates to evenness and traction), shock absorbency (as it relates to hardness),
grip (as it relates to traction and slipperiness), and other known hazards should be incorporated within any system of ground inspection. An examination of the DSM and its capacity to evaluate these areas is considered below.

**Grassed areas**

There are four observations made and scored in relation to the grassed surface. These relate to the percentage of grass cover (scored 0–8), grass condition or vigour (scored 0–3), grass height (scored 0–3) and its evenness in terms of undulations and tussocks (scored 0–8). In terms of ground safety, these incorporate aspects of surface evenness, traction and shock absorbency. Potential problems within this section, however, relate to the capacity of the observer to make these judgements and the actual standards set. For example, ideal grass height of 20–40 mm receives a maximum score of 3 whereas grass height above 40 mm receives a score of 2. The key question for ground safety considerations is whether this is based on horticultural standards for mowing, player performance or player safety or none of these. Vigour standards are similarly unclear and the scores seem to be relative to the requirements for re-sowing, or the need to save turf, rather than to player safety considerations.

**Wicket areas**

There are two observations made and scored in this dimension—whether the pitch is level with its surrounds (scored either 0 or 5 on a yes /no basis) and whether the surface is suitable for play (scored 0 or 5 on a yes no basis). Surface evenness, as it relates to player stability in the first observation, is important but the second question is so subjective that it is not a useful measure. What constitutes safe or unsafe in this context is also unclear?

**Worn/bare areas**

There are two observations in this dimension. The first relates to whether the surface is level and if there are holes (scored 0–8 on three levels) and the second relates to firmness and ask whether travelling from grassed to bare areas would cause stability problems (scored 0–5 across three levels). The issue of holes is replicated from the grassed areas dimension and firmness is the wrong nomenclature for the issue of players travelling across changing surfaces. This dimension requires careful re-consideration.

**Hardness**

There is one observation in this dimension. The observer is asked to designate the ground as either extremely hard to hard (scored 0–4) or firm to pliable (scored 5–9). This dimension relates to the shock absorbency of the ground but it is unclear how the observer would make such a judgement other than through experience. This single item receives a higher proportion of the overall score than any other single item and given the cumulative scoring model used, must be considered as the most important single factor within the DSM. As the previous Chapters of this report would suggest, there is little evidence to support this in terms of ground suitability and player injury.

**Other factors**

There are four observations made in this dimension. The first of these relates to judging whether there are cracks in the ground greater than 20 mm in width (scored 0–5). The next observation relates again to holes, with the observer asked to judge whether holes are present and if they are a tripping hazard (scored 0–5). The last two observations relate to visible damage to the ground
caused by machinery or animals (scored 0–5) and sprinkler safety in terms of evenness with adjacent surfaces (scored 0–5). This dimension relates to surface evenness and replicates some of the match day checklists currently in use. The justification for the 20 mm dimension for cracks is unclear but is presumably related to ground hardness and moisture and the obvious tripping danger for players in studded boots.

Non-playing areas

There are three non-scored observations in this dimension related to signage and the safety of light towers. The third observation requires a scan for any other hazard. Again, these areas are covered in match day checklists but still have relevance.

Summary

This examination of the DSM shows that there are three almost identical observations, related to holes and undulations (surface evenness). In total, 41 or 55% of the 74 points allocated are assigned to this factor alone. Whilst the majority of these factors are important for player safety, they do not cover all of the potential hazards, particularly with regards to hardness. Therefore the scoring and scaling of at least this evaluated version of the DSM is not ready at this time for wholesale adoption by LGAs.

The decision as to whether or not a ground is suitable, and therefore safe for play, should be made on the basis of evidence that the likelihood of injury to players related to the surface is increased if play was to occur. This judgement cannot be made as a result of the scoring model of the DSM at this stage. Similarly, there are sections of the DSM that appear to lack validity as to their role in rendering a sport surface unsafe or safe. Therefore there are too many unknowns underpinning the current DSM and its scoring system should be used with caution. Nonetheless, the concept of a DSM is a good one and warrants further development, including formal validation against player safety factors and injury statistics.

SUMMARY AND CONCLUSIONS

The main equipment used in studies for measuring ground hardness include the Clegg Hammer and the Penetrometer. The Clegg Hammer measures maximum deceleration for a light object but does not penetrate the thatch layer, and the Penetrometer measures depth of soil penetration [24]. Studies using a Penetrometer have indicated a slight softening of the ground over the progression of the winter season that can vary significantly with the amount of recent rainfall [24]. Studies of traction have shown very little week-to-week variation, but a slow decline over the course of the winter season.

There appears to be no universally accepted tool to measure shoe-surface interaction. The studded boot apparatus, which measures rotational traction or grip, has increased in popularity but its use has not yet been well published or validated against real-world sports performance. The reliability of most measuring tools in the context of the human-ground interface and relationships between their measurements and injury risk have not been well established.

The recent development of more detailed observational checklists, and the associated Derived Score Methods, have the potential to lead to more reliable observational assessments that are better than just subjective checklists and which could avoid the need for expensive equipment.
Table 11 summaries the key points from this Chapter. Recommendations for ongoing ground condition assessment practices are listed in Table 12.

### Table 11. Summary of key points in relation to ground condition measures

- None of the ground conditions measurement devices have been specifically validated in the context of real-world injury risk to players on different sporting grounds. While extensively validated and checked in the context for which they were developed (i.e. grounds assessment), the relationships between their measures and the actual loads on players whilst engaged in sorting activity is unknown.
- Match day checklists have the potential to play an important role in identifying hazards on sports grounds before both matches and training sessions.
- The Clegg Hammer is the preferred measure of ground hardness (compared to the Penetrometer) because of the relevance of the parameters it is testing and its inter-rate variability.
- There are no recognised standards for assessing shoe-surface traction on sporting fields, but the Studded Boot Apparatus shows some potential.
- The Clegg Shear Tester is a useful guide to turf strength but its relationship to injury risk is unclear.
- Hardness and traction can vary across a field and sampling plans involving repeat measures at different sites across a field are needed.
- Soil moisture content should be assessed at both shallow and deeper levels to account for differences in soil properties.
- Grass types and coverage are related to ACL injury risk and may be related to other injuries.
- Weather factors such as rainfall, inclement weather and sunshine can all influence ground conditions and their suitability for play.
- The Derived Score Method used by some LGAs to assess ground safety requires further validation and development. It has potential as a useful measure for assessing sports ground surface suitability for play but requires further development and validation before its scoring system is applied.

### Table 12. Recommendations for improved ground condition assessment practices

- Match day checklists used to identify hazards to safe participation should be used by all clubs before both games and training. Records should be kept of all inspections along with a record of remedial action undertaken.
- Within each LGA and SSA/club, it should be clearly understood who is responsible for the identification and remediation of identified hazard. A timeline for the implementation of hazard identification and remedial actions, and their communication to the next levels of the sport, should be established.
- Match day checklists should be standardised to cover major known hazards related to padding of fixtures, uneven surfaces, holes and debris, sprinkler covers and associated depressions, boundary to perimeter fencing, first aid facilities and emergency access.
- LGAs and regional/district sports associations should obtain a Clegg Hammer and survey each venue at least four times per football season. Hardness readings exceeding 120 gravities need attention.
- LGAs and regional/district sports associations should consider obtaining a Studded Boot Apparatus to survey each venue at least four times per football season. Traction readings exceeding 65 NM need attention.
- LGAs should consider employing contractors or consultants to assess shear traction on their field to determine the strength of their turf.
- LGAs should employ experienced consultants to assess soil moisture content on a monthly basis.
- Grass type and coverage should be assessed by an agronomist or horticulturist. LGAs should employ such experts to assess their grounds, including for advice at resowing.
- The Derived Score method used by some LGAs is a potentially useful approach and its checklists can identify important factors and hazards. As the scoring systems and weights are not yet validated, caution should be used when using these for decision-making.
- Should LGAs need to prioritise their ground assessment practices, the ordering of attention should be (in decreasing order) to assessing hardness, grip, botanical composition and then moisture content/thatch/shear strength.
Table 13 lists recommendations for improving the evidence-base for ground assessment practices

Table 13. Recommendations for improving the evidence-base for ground assessment practices.

- Biomechanical studies need to be undertaken to assess the extent to which, if at all, the measurements obtained from standard ground condition equipment relate to the actual forces and loads experienced by players during sporting activity. Both laboratory-based and field-testing is required.
- Most of the ground condition measures are applied independently and it is not known exactly how they relate to each other or to injury risk. A prospective study of injuries, over at least two seasons, is required to correlate the various ground conditions to each other and injury risk.
- Refinements to the Studded Boot Apparatus are needed, if it is to be used to measure injury risk, particularly with regards to different stud configurations and non-uniform ground interactions. Such refinements need to be correlated with injury and other ground condition measures.
- The scoring and weighting system used in the Derived Score Methods need further development and validation against both more objective ground condition measures and injury risk in players.
5. CURRENT PRACTICES OF SELECTED VICTORIAN STATE SPORTING ASSOCIATIONS IN RELATION TO DETERMINING GROUND SUITABILITY

INTRODUCTION

An introductory letter was sent to four SSAs (representing Australian Rules football, cricket, soccer and hockey). These SSAs were selected because these sports were considered the major users of sports turf grounds in Victoria. The letter requested a copy of their current policies and guidelines to determine sports ground conditions and suitability for play. A follow-up email was sent one week after the original due date as a reminder.

The content of the policies and guidelines related to sports ground safety and suitability were analysed from three SSAs (Australian Rules football, cricket, soccer), as the SSA for hockey did not respond to the letter. The policies and guidelines were analysed according to a checklist developed by one of the authors of the report (Peter Swan). The policy and guideline titles provided by the responding SSAs are presented below in Table 14.

<table>
<thead>
<tr>
<th>SSA</th>
<th>Document/s provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victorian Football League</td>
<td>Match day checklist</td>
</tr>
<tr>
<td>Victorian Country Football League</td>
<td>Match day checklist</td>
</tr>
<tr>
<td>Cricket Victoria</td>
<td>Match day checklist</td>
</tr>
<tr>
<td>Soccer Australia</td>
<td>Ground and playing conditions checklist</td>
</tr>
<tr>
<td></td>
<td>Match day checklist</td>
</tr>
<tr>
<td>Hockey</td>
<td>No response</td>
</tr>
</tbody>
</table>

A semi-structured interview schedule was also developed to explore:

- the extent to which these documents were implemented
- perceptions of the value and impact of sports ground safety policies
- any differences that exist across sporting levels (elite, sub elite, community).

A key informant (KI) on sports ground safety policy implementation was identified within each of the four SSAs being considered (Australian Rules football—Victorian Country Football League and the Victorian Football League, soccer, cricket—Premier League and Cricket Victoria and hockey). For both football and cricket, two bodies were nominated for each sport by the SSA to ensure that the community level of participation was well covered and so six interviews were conducted. The KIs were mainly mid-level managers, whose full-time role included issues of risk management. In the case of hockey, the KI was a volunteer nominated by the SSA and an expert in artificial turf—he had no formal role within the state hockey organisation.

A 30-minute interview was conducted with each identified KI according to a pre-determined interview schedule. Interview transcripts were transcribed and coded according to common themes that arose.
THE IMPLEMENTATION OF GROUND SAFETY CHECKS

Australian Rules football

The two KIs from Australian Rules football believed that there were excellent levels of implementation of ground safety checklists. At the community level, there was a match day checklist completed by all clubs throughout 80 different leagues in rural and regional Victoria. The checklist was developed by their insurer and was a mandatory requirement of the insurance scheme.

One KI noted, ‘they get to the footy ground and they set it all up and they probably wander around and have a look at the goal padding, sprinkler covers, assess the ground, rubbish and if its too hard they whack a bit of water on.’ Whilst it is clear this KI believed that there was almost 100% compliance, there was no requirement for the completed checklists to be forwarded to the league. Clubs were asked to hold them for seven years.

At the Victorian Football League level, the KI indicated that, there was a formal requirement for both clubs to acknowledge that the ground was suitable for play before a match. Both clubs were required to formally ‘sign off’ on this and to forward a report to the KI by noon each Friday (day before play). In addition, clubs were required to complete a match day checklist signed by club team managers, team captains and the umpires confirming that the ground was safe for play and suitable for players. This is both comprehensive and detailed. The KI said, ‘we have relocated games on the basis of the Friday reports, you know when a ground is effectively under water or the cricket wicket rock hard, to make sure the game is played on a satisfactory surface for all the players.’

Cricket

The Cricket Premier League is organised around 18 metropolitan clubs each with two grounds. The KI stated that the ground safety policy of Cricket Victoria was implemented via a checklist that was completed before each day of play. This was produced by their insurer and was mandatory. Similar to the football example above, there was no evidence of their completion nor a formal requirement to provide checklists to the SSA, rather an expectation placed upon clubs. The KI stated that, ‘it is retained by the clubs on file so that down the track if there is any type of claim against the insurer they have a week by week record of the ground being safe.’ Because this level of sport requires professional ground staff there was a close liaison with the LGA in these matters.

At the community level, there was a ground checklist produced for the sport by the insurer and expected to be completed related to ground safety. In this case, the relevant cricket association in the metropolitan, regional and rural areas was responsibility.

Soccer

The KI indicated that there was an expectation that all clubs completed a match day checklist on ground safety. This checklist was developed by their insurer and was comprehensive, covering surface safety, surrounds, equipment safety and the like. The KI stated, ‘we have asked in the past, we asked and expected our clubs to complete a match day checklist, but the take-up from our clubs has been extremely poor.’ The soccer SSA expected a copy of the completed checklist to be forwarded to the Association.

The KI went on to say, ‘so we have had to change our tack and we are putting the onus and the responsibility on to the match officials. Normally they arrive a good hour and a half before the
fixture and they can get around to making the necessary inspections they need to do.’ The KI further said that on matters of ground safety this occasionally led to games being cancelled and that clubs were written to on other matters and expected to rectify certain issues, such as the lack of a stretcher or unsafe goal netting.

**Hockey**

The SSA for hockey nominated a volunteer to discuss sports ground safety. This KI considered that undertaking inspections of synthetic grass surfaces was equally as important as for natural turf. He noted that synthetic surfaces deteriorated and could become unsafe for many reasons, including algae, spills, seam tears and uneven wear. In relation to surface safety he said, ‘there’s a bit of a checklist, but it is not very elaborate, it has been done by the association.’ He went on to indicate that there is a need for self-assessment guidelines to be prepared for clubs. ‘The clubs really need to be given some information to enable them to keep an eye out for the tell tale signs and to be aware of the risk factors.’ The KI said that Hockey Victoria undertakes a pre-season inspection of grounds and issues recommendations to clubs based on these inspections.

**Summary**

Overall, in cricket, Australian Rules football and soccer there is a belief that the policies of the SSA are being implemented and that this has been achieved through checklists developed by the insurance industry. In Australian Rules football and cricket, it was noted that such checklists cannot be too onerous as volunteers were stretched already and, whilst the people who conducted the checklists were seen as experienced, there was no training or in-house education provided in their use. Hockey is clearly in a development phase in relation to surface and ground safety and suitability for play. The KI for hockey summed up the process when he stated that, ‘hazards can be eliminated by good maintenance and regular monitoring.’

**PERCEPTIONS OF THE VALUE AND IMPACT OF SPORTS GROUND SAFETY POLICIES**

All the SSA KIs predominantly viewed the value of sports ground safety policies and their implementation in terms of meeting their obligations regarding insurance. When asked if the use of checklists had improved sports ground safety the typical response was, ‘well as you know the issues of litigation are major and through consultation with our broker,’ and ‘yes, it has made people aware of what is acceptable and what is unacceptable in terms of risk.’ It was considered that an injury prevented by effective padding of goal posts or the levelling of a hole goes unseen and it is not unreasonable that injury prevention is backgrounded in these conversations.

The KI for soccer was able to indicate that the number of insurance claims had significantly decreased in the last four years. He felt that this was related to when they introduced ground checklists.

It is well known that a barrier to safety implementation is the mistaken belief of many officials and players that injury is an inevitable consequence of sporting participation [2]. It is important to understand these barriers to safety and the consequences of inaction when encouraging the prevention of injury and safe participation [81, 137]. As insurance consideration were clearly the effective driver in this situation, this could be capitalised on as a motivator for safety improvements in all sports.
It is worth noting that soccer was the only SSA which required clubs to submit ground safety audits to the SSA and which could also demonstrate declining injury claims.

DIFFERENCES ACROSS LEVELS OF PLAY

It became clear from the interviews that in the case of Australian Rules football, soccer and cricket there was much more direct and detailed involvement by the SSA, than for hockey, in ensuring suitable and safe surfaces for the higher levels (mainly sub elite) of sport. These grounds were subject to exacting specifications and were expected to be monitored regularly. Community level sport was managed at another level by local sporting associations. The SSAs provided policies related to sports ground safety and suitability for other levels of play but were not directly involved in their implementation. From a sports injury perspective, a community ground may well have more players using the surface on a weekly basis, more injuries directly related to the quality of the surface and hazards related to its maintenance than elite or sub-elite grounds.

SUMMARY AND CONCLUDING REMARKS

The use of match day checklists appears to be well accepted by SSAs and they promote them widely across all levels of their sport. All of the major SSAs involved in this study had policies and guidelines for use by clubs at all levels of competition and the match day checklists were the means of implementing them. The sports insurance companies have also prepared sports ground assessment checklists and processes for use in specific sports. These checklists focus on the identification of known hazards that increase the risk for participants and therefore the likelihood of injury. Examples of this are checking grounds for debris, holes, correct padding of goals, sprinkler covers in place and grass length.

Whilst the SSAs required the match day checklists to be completed, only one of them required them to be forwarded centrally to the Association. It was assumed by the other SSAs that there was close to 100% compliance with the use of the checklists but this could not be assessed by them. Interestingly, the one SSA that did require central lodging of forms was also able to draw conclusions about a related decline in injury claims because of this checking process. In all cases, the insurance imperative was a strong motivator for implementing the checklist process.

There is a presumption (and common sense indicates) that if there is a hazard present and noted then it will be corrected prior to play. However, the use of a checklist for safety is only as good as the remedial action that takes place in response to identified issues. Most SSAs reported using the checklist information to make decisions about the safety of play, but without a central lodging and monitoring of such returns, it is not possible to say if this is universal. Within each SSA and their associated clubs, a person responsible for the identification and control of any identified hazard should be named. This could be the designated safety officer, referee or umpire, or the coach. SSAs and their clubs should also establish a clear timeline for the implementation of any remedial actions needed.

The SSAs indicated a hierarchy whereby more direct and detailed involvement in grounds assessments existed for higher levels of the game than for community or junior participation.

Whilst the analysis of LGAs practices, to be presented in Chapter 6, highlighted the links between them and SSAs, this was not raised by the SSA key informants, who were more focused on the match day checklists. Nonetheless, observations about the need to develop best practice examples of co-operation between SSAs/clubs and LGAs still stand.
The key findings from the analysis of current SSA practices is summarised in Table 15.

Table 15. Summary of key findings in relation to the current ground suitability assessments by selected Victorian SSAs

- The SSAs for Australian Rules football, cricket, hockey and soccer all believed grounds that were monitored for safety and suitability had lower risk for participants.
- Each of the SSAs for Australian Rules football, cricket and soccer encourage the use of a match day checklist by clubs as a means of implementing their ground safety policies and practices.
- Insurance issues are a strong motivator for the SSAs for Australian Rules football, cricket and soccer in developing and implementing match day checklists.
- There is a hierarchy whereby more direct and detailed involvement of the SSAs for Australian Rules football, cricket and soccer in grounds assessments occurs only for higher levels of the game.
- Most of the SSAs for Australian Rules football, cricket and soccer do not require central lodgement of completed match day checklists.

RECOMMENDATIONS FOR IMPROVED GROUND ASSESSMENTS BY SSAS

Based on the findings summarised in Table 15, Table 16 lists recommendations for improving ground assessment practices by SSAs. Recommendations for the structure of the assessment procedures are discussed elsewhere in this report.

Table 16. Recommendations for improving ground assessments by SSAs

- Given the influential role of the insurance industry, SSAs should work closely with their insurers to develop and refine suitable match day checklists for their sports.
- Each SSA and their associate clubs should clearly identify and name a person responsible for removing or controlling any hazards identified by the checklists. Guidelines for a timeline of implementation of responses should be developed by the SSA.
- Best practice examples highlighting co-operation between sporting clubs and LGAs in establishing and maintaining sports ground inspection should be developed in partnership and promoted through the sector. This should include a two-way feedback process on all ground assessments and suitability decisions.
- All SSAs should require a central lodging of all match day checklists and establish an associated review process.
- SSAs should work with their insurers to link the match day checklists with injury data to demonstrate that their risk management approaches are reducing injuries and to promptly identify emerging injury issues.
6. THE CURRENT PRACTICES OF VICTORIAN-BASED LOCAL GOVERNMENT AREAS IN RELATION TO DETERMINING GROUND SUITABILITY

INTRODUCTION
A key aim of this report is to describe the current ground suitability assessments practices of Victorian LGAs. This information was obtained from a survey of all 79 Victorian LGAs. An introductory letter was written to each LGA, requesting a copy of their current policies and guidelines for determining sports ground conditions and suitability for play. A follow-up email was sent as a reminder one week after the original due date.

Overall, 47 LGAs responded given an acceptable response rate of 60%. An analysis of the response rate is seen in Figure 3. The response rate amongst rural and regional LGAs was higher than that from metropolitan LGAs (69% versus 45%). The full list of responding and non-responding LGAs is given in Appendix 4.

Of the 47 LGA responses received, 23 (49%) indicated that they had no policies or guidelines on sports ground safety or suitability for play. All of these 23 LGAs were from regional or rural Victoria, representing 70% of all responses from these LGAs. In total, 24 sets of policies and/or guidelines were received (14 from metropolitan LGAs and 10 from rural or regional LGAs).

POLICIES AND GUIDELINES
The content of the 24 policies and guidelines on sports ground safety and suitability was analysed. The documents varied greatly. Some were policy statements related to maintenance programs, whilst others were detailed measures of ground status. Some were as brief as a checklist with a subjective evaluation requiring a someone to indicate whether the ground was safe (or not). An indication of this variability is shown by the descriptors used for the policies and guidelines used by LGAs presented in Table 17.
Table 17. Descriptors used in policies and guidelines used by 24 Victorian LGAs

- Maintenance Standards
- Ground Suitability Assessment
- Playing Surface Audit Form
- Season Changeover Report
- Recreation Reserve Suitability Assessment
- Specifications for Grounds
- Sports Ground Inspection Form
- Risk Management Guidelines for Sports Grounds
- Asset Management Form
- Sports field Inspection Process
- Tenancy Agreements for Sports

The policies and guidelines were analysed according to a checklist developed by one of the authors of this report (Peter Swan) and the results and discussion of these are presented in this Chapter. It is important to note that that the following discussion is based only upon material received from the LGAs. In a number of cases, the researchers were able to determine that particular LGAs had further material (e.g. on their websites, etc.) that was not forwarded. Whilst this may limit the accuracy of the reported information, it probably reflects the lack of knowledge of, or seriousness with which these matters are considered at, the LGAs.

Table 18 outlines three specific areas of the policies and guidelines received from LGAs that underpin sports field safety. These relate to sports ground maintenance policies, sports ground safety policy and sports ground suitability guidelines. Twelve LGAs had all three processes in place.

Table 18. Policies and guidelines from analysis of 24 LGA responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does a maintenance policy for sports grounds exist?</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Does a sports ground safety policy exist?</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>Do ground suitability guidelines exist?</td>
<td>70%</td>
<td>30%</td>
</tr>
</tbody>
</table>

The majority of LGAs have developed a process on an aspect of sports ground safety. Ground maintenance includes mowing specifications, top dressing, decompaction programs and watering programs, and underpins all safety measures. The formal process of having a maintenance policy leading to a ground safety policy and then to having a way of readily assessing grounds is important. Fifty percent of the LGAs had evidence of this transition from policy through to measurement. However, it is unknown how many LGAs actually implement the rating guidelines or do the measurements, as opposed to merely having the capacity to do these measures.
PROCESS ADOPTED FOR THE DEVELOPMENT OF SPORTS GROUND SAFETY POLICIES AND GUIDELINES

Horticultural industry standards underpin the LGA’s sports ground maintenance policies. In contrast, there was a range of developers of sports ground safety and suitability guidelines identified by the responding LGA (Figure 4).

![Figure 4](image)

**Figure 4. Groups reported by LGAs as being responsible for developing ground suitability guidelines**

The combinations category in Figure 4 represents LGAs adapting specifications and guidelines from other sources, including the insurance guides, to meet their own needs. The ‘LGA’ category represents instances in which the LGA devised their own guidelines.

The insurance organisation Civic Mutual Plus (CMP) is owned by the Municipal Association of Victoria, and is the self-insurance arm for councils in Victoria and Tasmania. The broker agency for CMP is JLT (Jardines). Civic Mutual Plus has a Recreation Reserve Suitability Form and guidance notes available to all LGAs. Four LGAs used this in its original form, whilst a number had either adapted it to meet their particular needs or used part of it in combination with local guidelines. In a few instances, private consultants were used to assess sports ground suitability on a regular basis and their reports used subjective and objective indicators of ground safety and suitability for play.

DECISION MAKING PROCESSES

An examination of the maintenance policies for sports grounds was undertaken and the aspects of mowing specifications, top dressing and even surfaces, weed control, decompaction and watering schedules were listed features. Often these aspects were prepared as specifications that contractors were required to meet. Table 19 lists the commonly considered features.

It is interesting to note that many LGAs classified their grounds (e.g. premier quality, high quality, medium quality and low quality) according to their current quality and use. The maintenance
specifications were set much lower for the poor quality or community grounds. At face value, this appears a reasonable strategy from a resource allocation point of view. However, from a risk management and safety perspective this seems contradictory and potentially risk enhancing, as such practices could exacerbate the chance of injury in these settings.

Table 19. Common features of ground maintenance specifications as reported by LGAs

<table>
<thead>
<tr>
<th>Common features</th>
<th>Number of policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowing specifications (height, absence of windrows, etc)</td>
<td>10</td>
</tr>
<tr>
<td>Top dressing (bare, uneven, worn grassed areas)</td>
<td>6</td>
</tr>
<tr>
<td>Weed control, oversowing</td>
<td>8</td>
</tr>
<tr>
<td>Sprinkler head and surrounds function and safety</td>
<td>9</td>
</tr>
<tr>
<td>Debris and litter removal</td>
<td>5</td>
</tr>
<tr>
<td>Watering requirement</td>
<td>4</td>
</tr>
<tr>
<td>Decompaction</td>
<td>2</td>
</tr>
<tr>
<td>Meet sport guidelines re boundary space</td>
<td>2</td>
</tr>
</tbody>
</table>

The evidence used to underpin sport ground safety guidelines varied enormously across LGAs. Some used a complex system of rating and scoring across a range of ground parameters, whilst other simply asked someone to note whether the ground was safe for play.

In analysing the LGA guidelines, the underlying measures used were categorised using the following descriptors:

- objective measures related to the direct measurement of factors such as surface compaction or hardness by Clegg Hammer testing.
- subjective eyeball checklists which require someone to consider a number of factors (this varied from 1 to 10 factors) and to make a decision about the action required based on the inherent risk. Most often people are required to indicate whether a particular feature was OK (meaning no fault). For example, Hardness = (OK or not) or Depressions and holes = (OK or not).
- Derived Score Methods based upon comparisons with a weighted score previously established at a satisfactory level. This typically considers grassed areas for vigour, height, cover and evenness. Worn and bare area and wicket areas were assessed as well as holes, cracks, hardness and damage by vehicles etc. This approach still requires eyeballing but has objective measures underpinning the scoring system.

A number of LGAs used a combination of objective measures and derived scores to assess ground suitability (Figure 5). One third of LGAs used no guide for their ground safety checklists and a further third only use subjective checklists. It is important to note that there were no instances where only objective measures were used, suggesting that objective measures, alone, are not considered enough for making decisions about whether or not to stop play.
TIMING AND REGULARITY OF GROUND INSPECTIONS

Observations of sports grounds to evaluate suitability and safety are important. Equally important is the regularity of such observations. There was considerable variation in the stated inspection regimes for the LGAs. It was difficult to decipher what terms like ‘regular inspection’ actually meant and, without definitions of such terms, it was not possible to ensure that they are adequate.

The relationship with, and expectation placed upon, ground users to undertake match day inspections of grounds also varied considerably. The most comprehensive approach taken involved weekly inspection of the grounds by the LGA or contractor followed by club match day inspections and reports submitted to council. In rural LGAs, it was often a Change of Playing Season report that was required by the LGA, with clubs or ground management committees expected to inspect the ground before competition. Table 20 depicts these variations.

Table 20. Frequency of inspection regimes of LGAs and their contractors

<table>
<thead>
<tr>
<th>Inspection using guidelines (audit)</th>
<th>Number of LGAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly (1)</td>
<td>3</td>
</tr>
<tr>
<td>Fortnight (2)</td>
<td>1</td>
</tr>
<tr>
<td>Monthly (3)</td>
<td>3</td>
</tr>
<tr>
<td>Quarterly</td>
<td>1</td>
</tr>
<tr>
<td>6 Months</td>
<td>1</td>
</tr>
<tr>
<td>Change of season alone</td>
<td>4</td>
</tr>
<tr>
<td>Change of season plus either (1), (2) or (3) above</td>
<td>3</td>
</tr>
<tr>
<td>Unclear or no inspection</td>
<td>8</td>
</tr>
</tbody>
</table>

It was again notable that where LGAs ranked their sports grounds (e.g. premier, district, community), inspection and audit regimes were carried out less regularly at local or lower quality sports grounds. Whilst the correlation with sports injuries at these categories of grounds is unclear, such a decision appears hard to justify. This is largely because lower quality grounds may have equal time usage to better grounds and are more likely to ‘fail’ safety audits more regularly. This raises the question of whether these low quality grounds should be used until they are brought up to an acceptable level.
Two LGAs indicated that it was up to clubs to decide if a ground was suitable for play and, in both instances, they advised clubs to use SSA guidelines.

Ten of the 24 LGAs expected clubs to undertake match day inspections of the sports ground for suitability to play. In one instance where an LGA had no formal policy and no guidelines for audits, they required clubs to appoint a Safety Officer who was responsible to ascertain if the ground was suitable for play. Clubs were generally advised by the LGAs to use SSA checklists for match day inspections. However, four LGAs provided specific-purpose match day inspection forms to clubs.

**GROUND CLASSIFICATION FOLLOWING AUDIT**

Following the inspection of sports grounds it was necessary to classify grounds according to the outcomes of the inspection. Table 21 indicates the major classifications used across the LGAs.

<table>
<thead>
<tr>
<th>Classification used</th>
<th>Number of LGAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable for play</td>
<td>7</td>
</tr>
<tr>
<td>Unsuitable for play</td>
<td></td>
</tr>
<tr>
<td>Acceptable for play</td>
<td>4</td>
</tr>
<tr>
<td>Unacceptable for play</td>
<td></td>
</tr>
<tr>
<td>Closed</td>
<td>2</td>
</tr>
<tr>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>Extreme risk through to low risk</td>
<td>3</td>
</tr>
<tr>
<td>Good, satisfactory</td>
<td>2</td>
</tr>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Unclear or no classification used</td>
<td>6</td>
</tr>
</tbody>
</table>

The chain of events or action following ground classification is obviously of great significance because just identifying something as poor, for example, does not rectify the problem. LGAs and the community at large want to use sports grounds and this desire may over ride, or be made in the absence of, safety considerations and the ramification of injury, if it means that events would otherwise be cancelled.

There were clear statements in some of the LGA policies that if a ground was unsuitable for play it should be closed. Equally, there were cases where remediation or maintenance works requests were the outcome of the classification. Obviously, other action/s could take place as maintenance staff, sport and recreation managers and clubs encounter unsuitable conditions that a formal guideline does not consider. For example, a club president may phone a maintenance crew and ask that they fill in depressions around a cricket wicket area. Figure 6 depicts an analysis of the guidelines leading to particular action.

It is important to delineate between ground audits as a reporting mechanism and as a viable means of assessing risk to participants. A significant issue to address is whether a rating of unsuitable or unacceptable grounds means that they are also unsafe and should be closed to enable repair or rectification. In one set of guidelines received, the LGA submitted a quarterly consultant’s report as an indication of the guidelines they used. Within that report the consultant indicated that five grounds were in an unacceptable condition for use and that a further nine
grounds needed specific remedial work prior to the grounds being used. It is not known how the LGA responded to this report. There were three other examples of clear flow charts in policy documents for decision making following ground classification as unsuitable for play. This provides a clear and useful way for LGAs and clubs to move forward along a risk management path.

![Figure 6. The range of actions by LGAs following ground classification](image)

**THE EXTENT TO WHICH THE LGA POLICIES ARE BEING IMPLEMENTED**

A semi-structured interview schedule was developed to further explore:

- the extent to which LGAs implemented the policies
- perceptions of the value and impact of sports ground safety policies
- any differences that exist across metropolitan, regional and rural LGAs
- any differences that exist across sporting levels (elite, sub elite, community).

A key informant (KI) on sports ground safety policy implementation was identified within each of two metropolitan, two regional and two rural LGAs. These LGAs were selected through a purposeful sampling process. All six KIs were heavily involved in implementing their LGA sports ground assessments. The council roles of the KIs interviewed included recreation officers, parkland managers and risk and compliance officers. Some had a direct role in inspecting sporting facilities whilst others had staff reporting to them about the inspection process. All had considerable experience in this area. A 30-minute interview was conducted with the each identified KI following a pre-determined interview schedule. Interview transcripts were transcribed and coded according to common themes that arose.

**Metropolitan**

The two KIs outlined the sports ground assessment process used in their LGA. Both rated their grounds hierarchically from Premier (which catered for VFL level football or Premier League cricket) to community. One KI said, ‘so a major ground is checked weekly and the next level down is fortnightly, right down to checked only between seasons.’ He added that mowing and maintenance contractors did audits and repairs as they went about their round. Both LGAs used consultants to undertake Clegg Hammer testing and report to council quarterly. Both were aware that Australian Rules football and cricket clubs also completed their own match day checklists.
Clubs were not expected to be involved in any way in the council process. The role of clubs was also spelt out clearly in a seasonal tenancy manual. There appeared to be no feedback process from clubs to the relevant LGA, and vice versa.

Regional
Both KIs outlined the way sports grounds were rated in their LGA. In both cases, grounds were either designated as council run or managed by a committee of management. It tended to be that the grounds in outlying areas, and away from major population centres were run by a committee of management to which council allocated funding. One KI noted that a suitability assessment was done on major grounds at change of seasons. He stated, ‘as I said we have twice yearly checks for suitability, but the fact that we have grounds men on the grounds virtually five days a week means any problems are picked up as part of the maintenance.’ Both used a generic checklist that had been developed by their insurer (Civic Mutual Plus) and adapted by them. One KI noted that, within their LGA, they had developed a match day checklist for sports and clubs that did not have one provided by their SSA. When asked what happened to the report she said, ‘they file it, but if there is an injury, for example, they send it to us. Otherwise I would have a hundred on my desk every week.’

Rural
Both KIs noted that they defined their grounds in terms of council managed or committee of management, similar to the regional LGAs. In one rural LGA, Council assessed the grounds they-managed for safety and suitability for purpose twice a year. All sports were expected to undertake a match day inspection and to use their SSA process. In the other LGA, inspections of council managed grounds were carried out between seasons and mid-season by council staff. The grounds under committee of management were seen as being well run and a great example of community spirit. One KI noted that, ‘many of our grounds back onto to bushlands, so we might have rabbits and echidnas digging them up, so the people know to have loam on site for any unsafe areas or holes before play commences.’ These grounds were not inspected unless there was a request from the committee of management.

Differences across metropolitan, regional and rural LGAs
Within the metropolitan LGAs interviewed, councils controlled all sports grounds. In regional and rural LGAs only major grounds were managed and maintained by council. In outlying and smaller communities the sports grounds were managed, maintained and inspected for safety by committees of management. This immediately brings in issues of training of volunteers to identify and report hazards. Consultant turf experts were involved in the interviewed metropolitan LGAs (inspecting all grounds quarterly) whilst regional or rural LGAs did no mention this.

PERCEPTIONS OF THE VALUE AND IMPACT OF SPORTS GROUND SAFETY POLICIES
All the KIs believed that the process their LGA had in place worked effectively and that their grounds had improved because of a formal process. Most LGAs readily mentioned that they were meeting the risk management requirements of their insurer (CMP). One KI stated that ‘the major motivator is that liability issues play a big part in council life. Sports grounds have been seen as a bit of a soft target.’ Another added, ‘we have been able to dig up ground assessments when there has been an injury and some parents who wanted to sue have backed right off.’ One KI
mentioned that enhancing safety meant ‘that grounds are safer for our people and we have reduced our exposure to litigation.’

Two of the KIs spoke about how clubs were now becoming aware of ground and venue safety and that the assessment process, when done in conjunction with clubs, was educative. One KI said ‘so by communicating with clubs and going through the checklist with them at each of the venues, they’ve got a better understanding and now they ring up and complain about this or that on the ground being a risk, that’s great.’

OTHER IDENTIFIED ISSUES

When discussing how, and whether, people who inspected sports ground were, or should be, trained in some way, there was complete agreement from the KIs. The proformas used were simple and the people experienced. Training was not considered necessary and the KIs felt that there was enough pressure on volunteers already.

Another issue related to the finances provided by council for sports ground maintenance. Regional and rural KIs discussed this at length indicating how stretched they were, whilst adequate resources were considered to be available in the metropolitan LGAs as expressed by the KIs. It is interesting to note that there was no indication of how the KIs knew that the checklists and inspections were done correctly.

SUMMARY AND CONCLUSIONS

Information about the ground suitability assessment practices of LGAs was obtained primarily from a survey of all LGAs. Four out of every ten LGAs contacted and invited to contribute to the study did not respond. Unfortunately, the reasons for this are unclear but may be related to some LGAs not having policies and hence not considering it unnecessary to respond. Based on the responses to the surveys, 49% of all LGAs did not have a policy or guideline related to sports ground safety or suitability for play and it could be expected that at least this same fraction of non-responders would also not have a policy or guidelines. The higher response from regional and rural LGAs may reflect increasing concern on their part on the effect of ongoing drought conditions on their grounds. However, further information needs to be obtained to confirm this.

The above description and analysis of LGA policies and guidelines related to sports ground suitability for play showed enormous variation, as might be expected. From a risk management perspective, it is a great concern that 49% of respondents indicated that they currently had no policies or guidelines in place related to ground safety and suitability for play. Where policies and guidelines did exist, there was great variability in their utility and identification of responsibility for implementation and action. For some LGAs, policies and guidelines were used to initiate a co-operative approach with clubs to support sports ground safety. The value of sports ground inspection in promoting ground safety depends upon the quality and comprehensiveness of the ‘measurements’ used and more importantly, the actions taken to address the issues identified.

Amongst the LGAs participating in the key informant interviews, there was considerable interest and activity in sports ground safety. Once again, it was highlighted that sports grounds that supported better standards of play were regarded as showpieces and, therefore, allocated better maintenance and turf management regimes. Similarly, and perhaps surprisingly, these grounds were also assessed for safety far more regularly and comprehensively than community grounds.
It would appear that LGAs generally believe that grounds that were monitored for safety and suitability had lower risk for participants. Despite this, it was interesting that injury reduction was not fore-grounded in the interviews as having a major value or impact for grounds assessment. It may be necessary to provide evidence to clubs about the nature and types of injury that have been or potentially could be, reduced by providing safer grounds and how ground assessment is part of this process.

The key findings from the analysis of current LGA practices are summarised in Table 22.

**Table 22. Summary of key findings in relation to the current ground suitability assessments by Victorian LGAs**

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance issues and insurance liability dominated the discussions about the reasons for sports ground assessment.</td>
</tr>
<tr>
<td>Only about half of the 47 LGAs who responded to an invitation to participate in this study had a policy or guideline on sports ground safety or suitability of play.</td>
</tr>
<tr>
<td>Where LGAs had a policy or guideline on ground suitability, only half provided evidence of a formal process linking maintenance policy to safety policy and to guidelines for rating suitability of grounds.</td>
</tr>
<tr>
<td>Many LGAs classify their grounds according to quality and the level of play of the sports that use them. Maintenance specifications, and regularity of inspection requirements, were set much lower for the grounds classified as poor quality or deemed community grounds.</td>
</tr>
<tr>
<td>A hierarchy exists across LGAs whereby premier grounds are maintained and monitored at more stringent and regular levels than poorer quality or community grounds.</td>
</tr>
<tr>
<td>It appears that the level of attention to ground conditions tends to deteriorate the further one goes from the metropolitan area.</td>
</tr>
<tr>
<td>Even though Horticulture industry standards underpin sports ground maintenance policies, there is considerable variation in such policies across LGAs.</td>
</tr>
<tr>
<td>Two-thirds of the 47 responding LGAs use either no guideline, or only a subjective checklist, for their ground safety checks.</td>
</tr>
<tr>
<td>Many SSAs have guidelines for grounds assessment and some LGAs advise clubs that use their facilities to use their SSA guidelines.</td>
</tr>
</tbody>
</table>

**RECOMMENDATIONS FOR IMPROVED GROUND SUITABILITY POLICIES AND GUIDELINES OF LGAS**

Based on the findings summarised in Table 22, Table 23 lists recommendations for improving ground suitability policies and guidelines of LGAs. Recommendations for the components and structure of the assessment procedures are discussed elsewhere in this report.
Table 23. Recommendations for improving ground suitability policies and guidelines of LGAs

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All LGAs should have a policy and an implementation plan for assessing sports ground suitability. It is disconcerting that almost half of all LGAs did not have such policies and guidelines.</td>
</tr>
<tr>
<td>The Municipal Association of Victoria, through its insurer Civic Mutual Plus should ‘drive’ the involvement of all LGAs, particularly those in regional and rural areas, in sports ground suitability policy and implementation strategy development.</td>
</tr>
<tr>
<td>It is recognised from a resourcing point of view, that it may not be possible for LGAs to give equal amounts of maintenance and regular assessment to all grounds. However, a set of minimum standards for all ground maintenance of all grounds, irrespective of their grading, should be developed by LGAs and their insurers and adopted as regular ongoing practice.</td>
</tr>
<tr>
<td>All LGAs should consider incorporating some objective measures in their assessments of grounds safety.</td>
</tr>
<tr>
<td>Best practice examples highlighting co-operation between sporting clubs and LGAs in establishing and maintaining sports ground inspection should be developed in partnership and promoted through the sector.</td>
</tr>
</tbody>
</table>
7. OBJECTIVE ASSESSMENT OF GROUND CONDITIONS AT REPRESENTATIVE GROUNDS

INTRODUCTION

As has been stated previously, all of the published assessments of ground conditions have been made on elite or high performance football fields, mainly during the months of the football season and only in relation to the elite or professional level of the sport. Studies from the playing venues used for elite AFL football have led to the development of a set of “normal” playing conditions for this level of the game [15, 109]. The described set of conditions from these venues cannot necessarily be applied directly to all venues that host Australian football games at all levels of play because those venues operate under different financial limitations, water availability, usage patterns, etc. Imposing a normal range of conditions derived from surfaces that are used by full-time professional footballers onto suburban, regional or rural venues is likely to be inappropriate.

Australian Rules football, at the non-elite level, is often played under conditions that would not occur for elite footballers. Venues are managed with less intensity, with much smaller budgets and often by volunteers working without much guidance. Whilst these non-elite venues can often produce high quality surfaces, this may not always be the case and it should be expected that the range of conditions defined for the elite AFL venues cannot be applied equally across the suburban, regional and rural venues.

This section of the report provides a first attempt at describing ground conditions that could be considered as “representative” for Australian Rules football played at metropolitan, regional and rural levels in one calendar year. The assessments were made over a 12-month period, encompassing both football season and non-football season periods, and provide some information about ground conditions for other sports using those fields outside of the March to September period. However, as only one 12-month period was covered, caution needs to be used when interpreting these data, as ground and weather conditions could be quite different in other years.

ASSESSMENT AND ANALYSIS METHODS

Although the assessments were made across a calendar year, the sampling of grounds was based on a selection of Australian Rules football associations. This decision was made so that comparisons could be made with the only other readily available normative data (from the elite AFL).

Three Australian Rules football associations within Victoria were selected for analysis on the basis that, collectively, they represented metropolitan, regional and rural football. Each association was considered to represent three distinct grades of Australian Rules football competition.

The three associations/areas chosen were: the North Central Football League (Buloke Shire – rural); the Geelong Football League (City of Greater Geelong – regional) and the Southern Districts Football League (Kingston City Council – metropolitan).

The management of the leagues each nominated three venues, representing each of their top, medium and lowest tier venues. The top tier venues (tier A) were those with which the leagues had few, if any, ground condition problems and were often the site of their competition finals. The
middle tier venues (tier B) were those that were seldom a cause for concern, but which would not host finals. The third, and lowest, tier venues (tier C) were those that were often likely to cause problems requiring relocation of matches.

These nine venues were each assessed on five separate occasions—at the start and end of the cricket season (November 05 and February 06), and three times during the football season: early, mid and late season (April, June and August 2006).

On each occasion, ground assessments were made on the same nine locations within each venue in the pattern shown in Figure 7. This pattern of sampling ensured that valid assessment of each venue was provided (in terms of what is known to be valid for elite venue testing). It also ensured that a number of sites along the centreline of the ground were assessed, in line with where most of the football action takes place. It is not known how relevant this centreline assessment would be during the cricket season but, as the standard sampling plan is used for football fields, it was adopted here. The same locations were assessed on each visit to each venue.

The tests undertaken at each site are summarised in Table 24.

Data for hardness, grip, shear strength, volumetric moisture, thatch and rhizomes were averaged for each location within each venue. Within each venue, the location data was pooled according to the location’s proximity to the centreline of the ground (see Figure 7). Data from locations A, C, E, G and I were pooled and termed as the “centreline”, while data from locations B, D, F and H were pooled and termed the “flanks”.

Botanical composition data relating to “% couch grass” and “% Kikuyu grass” were pooled to create a new measure, “% stoloniferous”, as these grasses are known to produce many above-ground stolons (or runners). Such grasses have been related to the incidence of ACL injuries in AFL footballers [15, 23].

The volumetric moisture content was assessed on each occasion at all venues. At various times, these assessments followed within days of substantial rainfall (i.e. in excess of 25 mm in total) events. These readings could then be interpreted as representing the “Field Capacity” (FC) of the soil. If there was no substantial rain, the highest reading was taken as the FC. This term essentially refers to the maximum amount of moisture that can be held in the soil without causing run-off across the surface. Measurements taken on other days when the soil was drier than when it was at FC showed varying degrees of water deficit. The dryness of the soil, or the moisture deficiency, was calculated as the difference between the value of volumetric moisture at FC and
that recorded on the day. The validity of this derived measure is based on the assumption that the highest reading obtained in each location at each venue was the FC. The calculation was made for each of the shallower and deeper readings of volumetric moisture obtained using the Hydrosense meter.

As might be expected, the measurements were highly correlated with the date of measurement. For this reason, the data is presented according to date of assessment.  

Tables 25 and 26 provide ranges for desirable and undesirable surface conditions, as determined from the elite AFL studies. Table 25 was derived statistically from objective ground observations [109]. Table 26 was derived from qualitative responses from the perceptions of 1993 elite AFL footballers players about ground conditions, compared to objective measures taken on the grounds played at each assessment time [122]. The results in Table 25 provide a comparison for the non-

---

As might be expected, the measurements were highly correlated with the date of measurement. For this reason, the data is presented according to date of assessment.  

Tables 25 and 26 provide ranges for desirable and undesirable surface conditions, as determined from the elite AFL studies. Table 25 was derived statistically from objective ground observations [109]. Table 26 was derived from qualitative responses from the perceptions of 1993 elite AFL footballers players about ground conditions, compared to objective measures taken on the grounds played at each assessment time [122]. The results in Table 25 provide a comparison for the non-

---

1 All data was assessed by one-way analysis of variance (ANOVA), with a Tukey pairwise comparison to identify which particular means differed, when an overall effect was found. All correlations between variables were calculated using Pearson’s coefficients.
elite ground assessments presented here. With regards to grip, the subjective assessments of players were either that they were preferred or not preferred (i.e. no middle range was given).

Table 25. Summary of “normal” ranges of ground condition measures for grassed elite AFL football fields

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>Unacceptably low</th>
<th>Low normal</th>
<th>Preferred range</th>
<th>High normal</th>
<th>Unacceptably high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (g/10)</td>
<td>&lt;3.0</td>
<td>3.1 to 6.97</td>
<td>7.0 to 8.9</td>
<td>9.0 to 12.0</td>
<td>&gt;12</td>
</tr>
<tr>
<td>Rotational Grip (Nm)</td>
<td>&lt;20</td>
<td>21 to 39</td>
<td>40 to 54</td>
<td>55 to 74</td>
<td>&gt;75</td>
</tr>
<tr>
<td>Shear strength (Nm)</td>
<td>&lt;20</td>
<td>21 to 54</td>
<td>55 to 84</td>
<td>85 to 120</td>
<td>&gt;120</td>
</tr>
</tbody>
</table>

(Source [109])

Table 26. Elite AFL players’ preferred ranges of measured values of hardness and grip

<table>
<thead>
<tr>
<th>Measure</th>
<th>Preferred range</th>
<th>Acceptable range</th>
<th>Non-preferred range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (3rd drop of Clegg Hammer)</td>
<td>6.5 to 8.5</td>
<td>5.5 to 10.5</td>
<td>&gt;10.5</td>
</tr>
<tr>
<td>Grip (Nm)</td>
<td>35 to 65</td>
<td>25 to 35</td>
<td></td>
</tr>
</tbody>
</table>

(Source [122])

GROUND HARDNESS

Comparisons across regions

Figure 8 shows that there was generally some variation in hardness across regions on all assessment dates. There were significant differences between the regions only for the months of November 05, February 06 and June 06. As the figure shows, the hardness of the metropolitan venues was much more consistent throughout the year, with readings usually within a relatively narrow band. The band in which they were occurring was within the desired range for the elite AFL venues [109].
In comparison, the regional and rural venues showed a far wider range of readings, especially throughout the cricket season. Unfortunately, there is no comparable range of values of hardness desired for cricket as exists for elite AFL football. Nonetheless, the values obtained were very high and well beyond those normally accepted for football. It is also worth noting that pre-season Australian football is often undertaken during the February to March period, towards the end of the cricket season. It is possible that ground conditions at this time could have adverse effects on footballers unless they are taking appropriate precautions such as wearing soft-soled shoes.

The increased hardness of the regional and rural venues in August 2006 reflects the very dry conditions experienced across non-metropolitan Victoria during the winter of 2006. Similarly, heavy rainfall was experienced over the late March to early April period, which would explain the rapid decline in surface hardness over that period.

**Comparisons across tiers**

Figure 9 shows that significant differences occurred across the various tier levels on all dates except April 06. While these differences occurred, they are difficult to explain within the confines of this study. It had been expected that there would be an increasing hardness in moving from tier A to B to C venues over the summer period, as it was thought likely that irrigation systems would be less efficient on the lower tier venues. Wedderburn, the lowest ranked ground, had no irrigation system. It had also been expected that the lower tier venues would have poorer drainage than higher tier venues and would become softer over the winter period. The latter occurred for the April 06 period when the grounds had been subject to heavy rainfall, but did not occur beyond that time.
Comparison within venues

There were significant differences between the hardness readings taken on the centreline and those taken on the flanks, across all venues, in November 05 and August 06 (Figure 10). The centreline was also harder on the other dates but not significantly so. The likely reason for the higher hardness along the centreline is that of soil compaction under traffic.
GRIP (ROTATIONAL TRACTION)

Comparisons across regions

There were significant differences across regions in grip at all assessment dates, except for August 06 (Figure 11). However, there was no consistent trend towards one or other region having higher (or lower) grip than the others.

![Figure 11. Grip measure for each region for all testing times](image)

* indicates months where significant differences (p<0.05) were found.

In a pattern similar to that of hardness, the grip during the cricket season was much higher than that measured during the football season. The values obtained were well in excess of 30 Nm which is regarded by Valiant [138] as being more likely to cause a higher incidence of knee ACL injuries in American football. Unfortunately, this study by Valiant [138] is the only published figure and it is not known if it relates to anything meaningful in our context. However, they are within the bounds of the same grip recordings encountered on some elite AFL venues, admittedly those with the highest rates of ACL injuries. Whether or not the high cricket season readings are of concern is not known, as the rate of ACL injuries in not high in cricketers.

Comparisons across tiers

There was a trend towards having higher grip on the tier A venues and significant differences occurred for this measure on all dates except June 06 (Figure 12). The third tier venues had either lower or equal grip than either the first or second tier venues.
Comparison within venues
There were no significant differences for grip across the flanks and the centreline of the venues.

SHEAR STRENGTH

Comparisons across regions
Significant differences for shear strength between regions were found for all dates of assessment (Figure 13). Rural grounds had higher shear strength, than both metropolitan and regional grounds, on all dates. There was also a clear change in shear strength between dates with particularly high readings for shear strength occurring during times when the venues were driest, i.e. in February and August.

Values in excess of 80 Nm were high and outside of the preferred range for AFL football. These levels were reached on several occasions on regional and rural venues, but not on metropolitan venues. Considering that the data presented as averages, there were many occasions during the drier months when shear strength went outside of the desired range for the elite level of AFL football.
Figure 13. Shear strength for each region over the testing period

Comparisons across tiers

Significant differences between tiers for shear strength were found in November 05 and April 06 (Figure 14). Tier C venues had the lowest shear strength compared to tier A and B venues. Whilst this relationship was not always substantial, the trend was towards lower shear strength for lower tier venues. This could be an indication that either the associations selected their tiers based on an implicit understanding of shear strength or venues with superior management that provided higher shear strength were favoured.

Figure 14. Shear strength for each tier of venue over the testing period

* indicates months where significant differences ($p<0.05$) were found.
Comparisons within venues

Whilst there was lower shear on the flanks when compared to the centreline, with the exception of November, there was only one statistically significant difference. This occurred in April 06.

WATER DEFICIENCY

In this assessment of the playing grounds, water deficiency was calculated as the difference between the highest recorded measure at any one venue (on any one of the assessment dates) and the measure obtained on the other dates. Thus, for the wettest day of assessment, the water deficiency was nil (zero), and for the driest day it was greater than for the days when conditions were moderately moist. A large value for water deficiency implies that the surface is far drier than its potential maximum, presumably in response to both dry and hot weather, and to less effective irrigation practices. Similarly, a low value for water deficiency implies either rainfall that is more constant and cooler weather or better irrigation practices, or both.

This measure of water deficiency is not an accurate measure of soil water potential, as defined in soil science texts, but can be considered as a rough approximate of that. There are currently available methods for calculating soil water potential for doing this, though they may not be easy to apply, without relevant expertise. It would be relatively easy to determine the true water deficiency that occurs at any one venue. Further research is needed to achieve this simple, but valuable, extension to any work that might occur in the future.

Water deficiency was analysed by region, tier and centreline for each of the dates of assessment and strong interactions between region and tier for the various assessment dates were found. Significant results were obtained for regional differences in water deficiency, but not for differences between tiers or centreline. The following data therefore relates only to differences in water deficiency conditions between the regions.

Shallow testing depth

Significant differences were found on all except the February and June assessment (Figure 15). The February assessment was undertaken during a wet period and water deficiencies were either low or nil. In November 05 and in August 06, water deficiencies were higher than the other two assessments of April and June 06.
Figure 15. Water deficiency at 75 mm for each region over the testing period

It is assumed that the influence of good irrigation capacity (either through better irrigation systems or through a lack of water restrictions) is clearly favouring the metropolitan venues, which can maintain a more constant water deficiency apart from when rainfall has occurred. In comparison, the rural and regional venues fluctuated more widely in deficiency with some very dry conditions being recorded, particularly in November 05.

This data relates to the shallow depth of testing. Shallow test readings would be expected to fluctuate more widely than deeper readings due to the influence of shallow irrigation, light rainfall and more transient environmental events. For this reason, testing was also required at a deeper testing depth.

**Deeper testing depth**

Significant differences between regions were found for the water deficiency at the greater depth of 120 mm (Figure 16). The chart is quite different to that for the shallower depth (Figure 15) in both the amount and the timing of the maximum water deficiency. The percentage water deficiency found at the 120 mm depth was far less than found at the 75 mm depth and reflects the greater water storage capacity of the soil at deeper levels.

Comparison of Figures 15 and 16 also shows that there is a major difference regarding the timing of the maximum water deficiency, with the February 06 assessment being the lowest measurement for the shallow testing and the April 06 measurement being the least for the deeper test. This probably indicates that water is moving very slowly into the soils over time. Whether or not this is a bad thing for a given venue depends on other factors such as the soil characteristics. To apply these findings, more research is needed to determine the optimal timing and frequency of soil moisture content assessment.
Significant differences between the mean values for water deficiency at depth were found across regions. Metropolitan venues were generally more constant in their average deficiencies in comparison to regional or rural venues. This is likely to be indicative of superior irrigation capacity, as discussed earlier. Uniformity of water deficiency would provide more uniform growing conditions for the winter-active perennial grasses such as rye grass, which prefers not to be dried out, rather than the summer-active perennials, such as couch grass, which are quite tolerant of occasional drought stress.

RELATIONSHIPs BETWEEN THE GROUND CONDITION MEASURES

Relationships between the ground condition measures discussed above, and other factors listed in Table 26, provides further insight into these ground condition parameters. These relationships are determined by the use of correlation coefficients. In all tables below, only significant correlations (p<0.05) are specifically stated.

Factors associated with ground hardness

The strength of the relationships between all of the measured ground condition factors (Table 25) and hardness is shown in Table 27. Only those factors that had significant correlation coefficients (at $p \leq 0.05$) with the third drop of the Clegg Hammer are included. The third drop is the preferred measure because it is less variable and much less influenced by the depth of thatch, because it has been slightly compacted by this time. Furthermore, the subjective assessments of ground hardness by AFL players is most closely aligned to the third drop.

There are a number of very strong relationships between ground hardness and other measured factors. The direct measure of moisture had a very strong negative correlation with surface hardness for both the shallower and the deeper readings of moisture i.e. as the surfaces get wetter, they become softer. Similarly, moisture deficit had a strong positive relationship with surface hardness, and particularly for the shallower measurement of moisture. This is to be
expected, as are the similar relationships between thatch depth, kikuyu percentage and stolon percentages. The strong relationship between moisture content and hardness provides a possible indirect measure of surface hardness, through the means of monitoring the soil moisture, although this would require further development before it could be recommended as good practice.

Table 27. Correlations between hardness, as measured by the Clegg Hammer, and other measures

<table>
<thead>
<tr>
<th></th>
<th>Nov 05</th>
<th>Feb 06</th>
<th>Apr 06</th>
<th>Jun 06</th>
<th>Aug 06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture shallow</td>
<td>-0.727</td>
<td>n.s.</td>
<td>-0.522</td>
<td>-0.768</td>
<td>-0.643</td>
</tr>
<tr>
<td>Moisture deep</td>
<td>-0.721</td>
<td>-0.207</td>
<td>-0.518</td>
<td>-0.756</td>
<td>-0.600</td>
</tr>
<tr>
<td>Moisture deficit shallow</td>
<td>0.737</td>
<td>n.s.</td>
<td>0.549</td>
<td>0.677</td>
<td>0.666</td>
</tr>
<tr>
<td>Moisture deficit deep</td>
<td>0.508</td>
<td>0.248</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.303</td>
</tr>
<tr>
<td>Thatch depth</td>
<td>-0.238</td>
<td>n.s.</td>
<td>-0.251</td>
<td>-0.338</td>
<td>-0.204</td>
</tr>
<tr>
<td>% kikuyu</td>
<td>-0.410</td>
<td>-0.287</td>
<td>n.s.</td>
<td>-0.407</td>
<td>-0.194</td>
</tr>
<tr>
<td>% bare</td>
<td>0.316</td>
<td>0.316</td>
<td>n.s.</td>
<td>0.235</td>
<td>n.s.</td>
</tr>
<tr>
<td>% rye</td>
<td>0.306</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.378</td>
<td>0.402</td>
</tr>
<tr>
<td>% stolons</td>
<td>-0.308</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-0.440</td>
<td>-0.390</td>
</tr>
<tr>
<td>% poa</td>
<td>n.s.</td>
<td>0.252</td>
<td>-0.231</td>
<td>n.s.</td>
<td>-0.261</td>
</tr>
</tbody>
</table>

Notes: ns= not significant; a negative coefficients implies that the increased values of one variable are associated with a reduced level of the other.

Having strong relationships between the vegetative cover and soil hardness suggests that it might be possible to augment the readings on soil moisture content with information about the vegetative cover to provide reasonable predictions of soil hardness. To test this hypothesis, regression relationships were tested. Fifty-six percent of the variability in ground hardness could be explained by soil moisture, thatch depth and % bare space. Taking into account the fact that this relationship has been developed from all nine venues in aggregate, across all five assessment dates, it is quite strong. It could be expected that an even stronger relationship would be found, if each venue were investigated in isolation.

Significant relationships were found between surface hardness and grip during the summer but not in winter. For the summer months, the strength of the relationships suggests that harder surfaces provide greater grip. This relationship appears to break down during the cooler (and mostly) wetter months. Therefore, measurement of ground hardness cannot be used as an indirect measure of grip during the football season.

Factors associated with grip

Significant correlations were found between many of the measured parameters across all of the venues within each of the dates (Table 28).

Table 28. Correlations with grip as measured by the studded boot apparatus

<table>
<thead>
<tr>
<th></th>
<th>Nov 05</th>
<th>Feb 06</th>
<th>Apr 06</th>
<th>Jun 06</th>
<th>Aug 06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>0.369</td>
<td>0.547</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Water deficit shallow</td>
<td>0.531</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Water deficit deep</td>
<td>0.413</td>
<td>0.351</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>% Poa annua</td>
<td>0.202</td>
<td>0.323</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.425</td>
</tr>
<tr>
<td>% stoloniferous grass</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.317</td>
<td>n.s.</td>
<td>0.480</td>
</tr>
<tr>
<td>% bare ground</td>
<td>-0.353</td>
<td>0.244</td>
<td>n.s.</td>
<td>-0.283</td>
<td>-0.377</td>
</tr>
<tr>
<td>Thatch depth</td>
<td>0.237</td>
<td>n.s.</td>
<td>0.389</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

During the cricket season, there was a strong relationship between grip and both hardness and the water deficit at depth. These relationships do not apply during the football season.
The other significant factors are all related to the grass cover in some manner, either through its composition or with the amount of thatch that it forms. This also suggests that grass cover factors could be reasonable predictors of grip and hence predictors of conditions that may give rise to lower limb injuries. It should be noted, however, that this injury link evidence has only been demonstrated for ACL injuries and ankle sprains. Further research is needed to develop a method of predicting grip based on aboveground factors, if more data is obtained over a series of seasons.

Factors associated with shear strength

Significant correlations were found between shear strength and many of the measured parameters across all of the venues within each of the dates (Table 29).

| Table 29. Correlations between shear strength and other parameters |
|---------|---------|---------|---------|---------|---------|
|          | Nov 05  | Feb 06  | Apr 06  | Jun 06  | Aug 06  |
| Studded Boot | 0.319   | 0.549   | 0.345   | 0.290   | n.s.    |
| % Couchgrass | 0.349   | 0.221   | 0.390   | 0.215   | n.s.    |
| % Stoloniferous grass | n.s. | 0.249   | 0.290   | 0.271   | n.s.    |
| Number of rhizomes | 0.344   | 0.318   | 0.263   | 0.198   | 0.324   |

It would appear that above ground factors, such as grass type, are important determinants of shear strength. Of particular relevance is the percentage of stoloniferous grasses and this is likely to be influencing the nomination of tiers of venues as these grasses are known to be hard wearing, tolerant of close mowing and able to tolerate both high temperatures and dry weather. Such grasses are often used for high quality cricket venues as they produce a very good surface for that sport. However, it must be noted that these grasses have also been associated with high grip, both in this study and in AFL work [15], and that this may lead to a greater chance of ACL injuries for footballers, at least at the elite level. It is possible that a preference for venues with higher percentages of stoloniferous grasses could be exposing players in the faster, more competitive finals matches at least, to higher chances of ACL injuries in highly contested and skilled Australian Rules football.

For most assessment dates, there was a strong relationship, though not perfect, between the shear strength of the turf and the rotational strength, as measured by a studded boot. This in turn implies that the two measures of turf conditions, whilst somewhat related are not always measuring the same thing.

The August 06 assessment produced only one significant relationship, and that was for a below surface factor, the number of rhizomes. It is likely that the winter dormancy of the warm season grasses, and the corresponding active growth of the cool season grasses, changed the grip and hardness to the extent that previous relationships were lost. The presence of rhizomes, and their number, is not affected by season of growth to the same extent as visible above-ground and hence the pre-existing relationship has continued. The number of rhizomes is also highly related to the presence of grasses that produce rhizomes (couch grass and kikuyu grass). Therefore, there is an internal correlation that is reflected within these findings.

It is notable that hardness, moisture deficit and soil moisture had little relationship with shear strength across the dates of assessment. While these factors appear to affect the grip on some occasions, they do not appear to affect shear strength.

In summary, it would appear that the species of grass included in the turf cover, and the related factor of the number of rhizomes, are the predominant factors influencing the shear strength of the turf.
Factors associated with moisture deficiency

There were numerous significant correlations between the moisture deficiency and the other measured parameters such as hardness and/or grip at the deeper setting of the Hydrosense (Table 30). In contrast, for the shallow settings there were few significant correlations indicating that these factors are not consistently related to more superficial surface moisture. The data in Table 30 have been developed from the full data set of all dates, venues and locations on a venue for the deeper setting of the Hydrosense moisture meter.

Table 30. Significant correlations between moisture deficiency and other study parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation coefficient with Moisture deficiency to 120 mm depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studded Boot</td>
<td>0.520</td>
</tr>
<tr>
<td>Hardness (Clegg 3rd drop)</td>
<td>0.537</td>
</tr>
<tr>
<td>Clegg Shear Tester</td>
<td>0.371</td>
</tr>
<tr>
<td>% couchgrass</td>
<td>0.223</td>
</tr>
<tr>
<td>% kikuyugrass</td>
<td>0.182</td>
</tr>
<tr>
<td>% ryegrass</td>
<td>-0.175</td>
</tr>
<tr>
<td>% Poa annua</td>
<td>-0.150</td>
</tr>
<tr>
<td>% stoloniferous</td>
<td>0.294</td>
</tr>
<tr>
<td>Rhizomes</td>
<td>0.115</td>
</tr>
</tbody>
</table>

Many of the relationships in Table 30 are relatively strong and intuitively sensible. For example, as the moisture deficiency increases (i.e. as the soil gets drier), there is an increase in surface grip, surface hardness and shear strength. This occurs at the same time as an increase in the percentage of couch grass, the percentage of kikuyu grass and the number of rhizomes, and a decrease in the content of both rye grass and poa annua. All of these relationships could have been predicted to some degree, but what is surprising in this data is the strength of the relationships. They also suggest that it may be possible to monitor satisfactory playing conditions through an understanding of the moisture profile of the playing venue.

SUMMARY OF COMPARISONS AGAINST ELITE AFL GROUNDS

Tables 31–33 show the proportion of readings at the metropolitan, regional and rural sites that are within the normative ranges for elite AFL grounds. Only some hardness measurements, in both regional and rural grounds, were in the unacceptably high range.

Table 31. Distribution of the hardness (Clegg Hammer) readings across regions relative to the “normal” ranges of ground condition measures for grassed elite AFL football fields

<table>
<thead>
<tr>
<th>AFL norms</th>
<th>Unacceptably low</th>
<th>Low normal</th>
<th>Preferred range</th>
<th>High normal</th>
<th>Unacceptably high</th>
</tr>
</thead>
<tbody>
<tr>
<td>% metropolitan venue readings</td>
<td>&lt;3</td>
<td>3 to 7</td>
<td>7 to 9</td>
<td>9 to 12</td>
<td>&gt;12</td>
</tr>
<tr>
<td>0</td>
<td>35.6%</td>
<td>44.7%</td>
<td>19.7%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% regional venue readings</td>
<td>0</td>
<td>29.5%</td>
<td>26.5%</td>
<td>30.3%</td>
<td>13.6%</td>
</tr>
<tr>
<td>% rural venue readings</td>
<td>0</td>
<td>42.0%</td>
<td>27.5%</td>
<td>22.1%</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

Figures are the % of all readings in each category
Table 32. Distribution of the grip readings across regions relative to the “normal” ranges of ground condition measures for grassed elite AFL football fields

<table>
<thead>
<tr>
<th>AFL norms</th>
<th>Unacceptably low</th>
<th>Low normal (21 to 39)</th>
<th>Preferred range (40 to 55)</th>
<th>High normal (55 to 74)</th>
<th>Unacceptably high (&gt;75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% metropolitan venue readings</td>
<td>0</td>
<td>19.9%</td>
<td>70.6%</td>
<td>9.6%</td>
<td>0</td>
</tr>
<tr>
<td>% regional venue readings</td>
<td>0</td>
<td>37.9%</td>
<td>28.8%</td>
<td>33.3%</td>
<td>0</td>
</tr>
<tr>
<td>% rural venue readings</td>
<td>0</td>
<td>20.5%</td>
<td>53.8%</td>
<td>25.8%</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figures are the % of all readings in each category*

Table 33. Distribution of the shear strength readings across regions relative to the “normal” ranges of ground condition measures for grassed elite AFL football fields

<table>
<thead>
<tr>
<th>AFL norms</th>
<th>Unacceptably low (&lt;20)</th>
<th>Low normal (21 to 54)</th>
<th>Preferred range (55 to 84)</th>
<th>High normal (85 to 120)</th>
<th>Unacceptably high (&gt;120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% metropolitan venue readings</td>
<td>0</td>
<td>32.6%</td>
<td>65.9%</td>
<td>1.5%</td>
<td>0</td>
</tr>
<tr>
<td>% regional venue readings</td>
<td>0</td>
<td>45.9%</td>
<td>46.7%</td>
<td>7.4%</td>
<td>0</td>
</tr>
<tr>
<td>% rural venue readings</td>
<td>0</td>
<td>16.7%</td>
<td>62.9%</td>
<td>20.5%</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figures are the % of all readings in each category*

**CONCLUSIONS AND RECOMMENDATIONS**

As would be expected, due to annual trends in weather and other environmental factors over a 12-month period, there were significant differences for all of the measured variables between the various dates of assessment. The seasonal changes were the over-riding changes that defined the nature of the surface variables. For every measurement, the influence of assessment date was more significant than was the region, tier or specific venue location factors such as hardness, grip and shear strength.

For each assessment date, there were significant differences between regions for surface hardness, grip and shear strength. Whilst there was a consistent relationship of rural venues having higher shear strength than the metropolitan and regional venues, no consistent relationship was found for hardness or grip. This is most likely to be related to a greater context of clay in soil that has increased soil strength. Hardness measures were found to be consistent on metropolitan venues over assessment dates, but to vary quite considerably in regional and rural venues.

There were often differences between tier levels for the measured variables, but there was no clear trend in the differences in line with the ranking given to those venues by the associations. It is likely that the choice of tiers by the associations does not necessarily indicate superior or more risk-averse playing conditions. Rather, it may just be reflecting the likelihood of that venue being unusable due to wet conditions at the time of football finals, but it may also be affected by other factors such as the availability of public amenities.
There was a difference across the venues for surface hardness, which indicated firmer conditions on the centreline when compared to the flanks. No similar relationship was found for grip or shear strength. On every date, measurements on the centreline were harder than on the flanks and the likely reason for this is that of soil compaction under traffic. Soil compaction is well known to restrict root length and root density of grasses, to restrict recovery of grasses after wear, to lower infiltration rates of water and to provide conditions more suited to weaker annual grasses [139]. To overcome this problem, more regular decompaction of the centreline, in comparison to the flanks, could be needed. This should be done by contractors or LGAs, with the appropriate equipment, twice a year—once before the start of the cricket season and once before the start of the football season.

The species of grass included in the turf cover, and the related factor of the number of rhizomes, are the predominant factors influencing the shear strength of the turf. Further examination of grass coverage (in terms of either composition or amount of thatch), could lead to the identification of strong relationships between aboveground factors and grip. It may be that these grass coverage factors are reasonable predictors of grip and hence predictors of conditions that may give rise to lower limb injuries. This requires further investigation and it is reasonable to expect that a method of predicting grip based on aboveground factors could be developed if more data is obtained over a series of seasons.

In generalising the results of the data presented in this section, it is important to note that the assessments were conducted over a very dry 12-month period. This potentially limits valid predictions from these findings and appropriate recommendations considerably. Nonetheless, these data represent the first collection of objective measures of sports ground used for football, outside the elite AFL competition.

Although this Chapter provides a summary of ground conditions assessments in sports grounds, it has not been able to provide full normative data for this, in relation to injury risk. There would be advantages in generating a normative table, of the form of Table 27, for non-elite football but this would require a prospective study over at least one season, collecting both injury and ground conditions data from the same fields, at the same times.

**Implications of findings for ground assessment sampling**

The difference in hardness observations on the centreline and flanks clearly highlights the need to measure hardness across the entire playing surface to obtain a fair report on the venue. It would not be appropriate to take a hardness measure just at the point most conveniently close to the ground entry.

Sampling of the surface for grip and shear strength would appear to be less influenced by position on the playing surface than hardness and it may be adequate to simply do a small number of tests (say 5 locations) across a venue.

**Implications of findings for ground assessment methods**

The assessment of soil moisture levels could be a proxy for assessment of factors such as hardness, grip and shear strength, especially during the cricket season, if baseline conditions of maximum soil moisture are known. It is likely that if the potential maximum moisture has been identified, and assuming that this character is not changed by physical means, such as top dressing, then knowledge of the moisture deficit can indicate the likely hardness, grip and shear strength for that venue. In the event that physical works have altered the local conditions, then the
relatively simple procedure of determination of the new Field Capacity of the soil should be repeated.

The grass types, and their coverage, are a significant contributor to surface hardness, grip and shear strength. In particular, if the content of the stoloniferous grasses— kikuyu grass and couch grass—is high then it is also likely that the surface will be dry, the ground will be harder, grip will be higher and shear strength will be stronger. LGAs are advised to seek advice from an agronomist on this.

It is important to note that this report does not address the question of whether the standards for Australian Rules football grounds venues outside the elite AFL game need to be lower, or more varied, than those used by the AFL. Nor does it consider whether there is an acceptance of a higher risk of injury on the non-elite level venues. These questions are beyond the scope of this work.

Table 34 provides a summary of the key findings arising from this assessment of a sample of Victorian sporting grounds. Recommendations arising from these key findings for ongoing ground assessment are given in Table 35 and recommendations for improvements to the current evidence are given in Table 36.

Table 34. Summary of key findings in relation to assessment of ground conditions in a sample of metropolitan, regional and rural sports grounds

<table>
<thead>
<tr>
<th>Ground hardness measures were consistent across the a 12-month period in metropolitan venues. In regional and rural venues, these measures were quite variable across 12 months, particularly during the months of the football off-season, or cricket season.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground hardness measures were within the norms for elite AFL grounds in metropolitan grounds over a 12-month period and during the football season for in regional and rural grounds.</td>
</tr>
<tr>
<td>There were significant differences in ground hardness between the centreline and flanks in all grounds and this is most likely due to high compaction of the soil. There were no such differences for measures of grip or shear strength.</td>
</tr>
<tr>
<td>The measures for grip on all metropolitan, regional and rural sports grounds were within the AFL preferred or high normal range specified for elite AFL grounds across a 12-month period.</td>
</tr>
<tr>
<td>The shear strength measures were within the norms for elite AFL grounds in metropolitan grounds over a 12-month period. In contrast, for regional and rural grounds, shear strength was sometimes outside the preferred elite AFL ground range during the football season. However, the implications of this, if any, for injury risk in players who use those grounds is not known.</td>
</tr>
<tr>
<td>The assessment of soil moisture levels, might be a proxy for assessment of factors such as hardness, grip and shear strength, especially during the cricket season, but this requires further investigation.</td>
</tr>
<tr>
<td>Grass type and coverage appear to be related to surface hardness, grip and shear strength. An easy augmentation of the monitoring of soil moisture to include observations of the composition of the grass would substantially improve both the prediction of soil hardness as well as the likelihood of lower limb injuries for footballers.</td>
</tr>
<tr>
<td>The ground condition assessments were conducted over one very dry 12-month period. It is not known whether these data are representative of ground conditions during wetter years. Nonetheless, the results suggest that ground conditions are better in metropolitan venues, than in regional and rural venues.</td>
</tr>
</tbody>
</table>
Table 35. Recommendations for ongoing ground assessment and maintenance in metropolitan, regional and rural sports grounds

- Ground hardness measures should be made on multiple sites across a venue, particularly along the centreline, with supplemental measures on the flanks. When measuring grip or shear strength, it should be possible to make accurate assessments with just 5 randomly selected test points across a venue.
- The likely reason for the higher hardness along the centreline is that of soil compaction under traffic. To overcome this, more regular decompaction of the centreline in comparison to the flanks is required. This should be done by contractors or LGAs, with the appropriate equipment, twice a year—once before the start of the cricket season and once before the start of the football season.

Table 36. Recommendations for ongoing ground assessment and maintenance in metropolitan, regional and rural sports grounds

- Given that the monitoring of football fields occurred within a very dry year, it is pleasing that most of the measures are within the AFL limits. However, a proportion of readings were outside the limits. Further research is needed to determine if these results are repeated in more typical years and if the AFL limits can be reasonably adopted for use at community level
- Normative ground conditions, related to injury risk should be developed for non-elite football and for other sports. This should involve well designed prospective cohort studies of sports participants, their playing habits, associated injuries and objectively measured ground conditions at the same place at the same time, over at least two playing seasons.
- To provide normative data, representative of the range of climatic conditions in Victoria, further ground condition assessments should be made and collated on the grounds used in the trial, or similar grounds, over at least another one or two seasons.
- It is possible that a relationship between moisture content and hardness could provide a possible indirect measure of surface hardness, through the means of monitoring the soil moisture. This requires further research.
- Further investigation into the relationships between aboveground factors and grip is needed. This would inform the development of a method for predicting grip on the basis of aboveground factors, if more data is obtained over a series of seasons.
- Methods for calculating more accurate water deficiency (potential) measures should be developed. This should include consideration of the optimal timing and frequency of soil moisture assessment.
- Current field sampling plans across a venue for ground condition assessment are based on the main distribution of play during Australian Rules football (i.e. the centreline and flanks). Optimal sampling plans should also be determined for the assessment of grounds for activities such as cricket and hockey, to mirror the areas of most use in these sports.
8. A COMPARISON OF OBJECTIVE AND SUBJECTIVE GROUND ASSESSMENT PRACTICES- A CASE STUDY AT THREE RURAL SPORTS GROUNDS

INTRODUCTION

As discussed in Chapter 4, both subjective and objective measures are available for grounds assessment purposes and used to varying extents. A limitation of most subjective measures is that they have not been validated against the more objective and scientific methods, and there can be little confidence in their accuracy. Chapter 4 suggested that the DSM method used by some LGAs had some merit but required further development and evaluation before it could be widely adopted.

This Chapter presents a formal assessment of a match day checklist and DSM checklist against a range of objective measures. In doing so, it provides a preliminary investigation of the value of the DSM. This comparative case study was conducted at the three rural venues of Donald, St Arnaud and Wedderburn, for logistic and convenience reasons. These venues were chosen because they were included in the objective assessments discussed in Chapter 7. Even though the venues assessed in this comparative study are all from rural areas, the comparison of measures is likely to be valid for application to other areas.

It was considered useful to attempt to relate objective data (hardness, grip, shear strength, thatch depth and soil moisture) to the practical ‘eyeballing techniques’ that are the most common forms of ground suitability for play formats in use. For this reason, on the same day in each of April, June and August 2006 that the objective ground data was being collected (see Chapter 7), two subjective ground suitability assessment guidelines were also applied to these grounds by an independent author on each testing occasion.

MATCH DAY CHECKLIST ASSESSMENT

The first subjective guideline used was the Match Day Checklist (Appendix 2) that is required as an insurance prerequisite by JLT Sport a division of Jardines Lloyd Thompson who offer insurance for Australian Rules football. This was chosen because it is widely available and used and has been shown to have high content and face validity.

In the Match Day Checklist, a ‘rater’ from each club is required to sign off that a ground is suitable for play after completing a checklist of ten questions requiring yes / no responses. The match day checklist results for the three grounds are shown in Table 37.

<table>
<thead>
<tr>
<th>Date</th>
<th>Donald</th>
<th>St Arnaud</th>
<th>Wedderburn</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 06</td>
<td>Fit for Play</td>
<td>Fit for play</td>
<td>Fit for play</td>
</tr>
<tr>
<td>June 06</td>
<td>NOT fit for play</td>
<td>Fit for play</td>
<td>Fit for play</td>
</tr>
<tr>
<td>August 06</td>
<td>Fit for play</td>
<td>Fit for play</td>
<td>Fit for play</td>
</tr>
</tbody>
</table>

As discussed in Chapter 4, match day checklists are a last minute check for hazards and are very important. However, they only assess the quality of the playing surface in very general terms.
June, 2006 when the Donald ground was assessed, the match day check list assessment identified there was an uncovered sprinkler and associated fitting that made the ground unsafe if play was to commence in the near future. A photograph of this is shown in Photo 13.

![Photo 13. Uncovered sprinkler and associated fitting that made the Donald ground unsafe for play on the observation day](image)

This illustration highlights the key role of match day checklists in the identification of hazards that are easily remedied prior to play commencing.

**DERIVED SCORE ASSESSMENT**

The DSM method reviewed in Chapter 4 was used here (Appendix 3). This ranked ground suitability based upon comparisons with a weighted score previously established at a satisfactory level. With this derived score assessment method, the rater is required to make a judgement and score the ground on a particular measure such as evenness, and firmness.

The derived score ratings are shown in Table 38.

<table>
<thead>
<tr>
<th>Date</th>
<th>Donald</th>
<th>St Arnaud</th>
<th>Wedderburn</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 06</td>
<td>78</td>
<td>79</td>
<td>70</td>
</tr>
<tr>
<td>June 06</td>
<td>76</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td>August 06</td>
<td>70</td>
<td>67</td>
<td>64</td>
</tr>
</tbody>
</table>
The ‘weighted score’ used for comparative purposes was 64, as specified on the DSM form (Appendix 3). Using this, if the ‘actual score’ obtained from an assessment of a field is equal to or greater than the weighted score (i.e. ≥64), then the ground condition is considered acceptable for play. On this basis, as shown in Table 38, all grounds were rated as acceptable on all occasions.

Whilst there are some very useful aspects of this DSM assessment process, there are also major shortcomings. For example, in the derived score method, the cover, vigour, height and evenness of the grassed area are all rated against known measures for sports surfaces. In contrast, when it comes to hardness of the ground, the question asked is simply, ‘Is the ground too hard to play on?’ If the response is yes, a score of zero is awarded and if it is no, a score of 8 is given. However, it should be noted that the question, itself, is very subjective and could be open to interpretation.

The DSM showed a deterioration (lowering) in scores over the period of April to August on all three grounds, due largely to drought conditions and the wear and tear of a football season. Also, the ranking of the three grounds by the football association were confirmed by the scores, whereby the poorer quality grounds had lower scores.

Photograph 14 highlights the wear and tear caused by Australian Rules football use. Photographs 15 and 16 show the changes in the grassed areas due to drought conditions at the Donald ground in the April 06 to August 06 period.

Photo 14. Football ground showing turf wear and tear
Photo 15. Donald ground in April

Photo 16. Donald ground in August
COMPARISON OF THE MATCH DAY CHECKLIST AND DERIVED SCORE METHOD

Figure 17 summarises the results of the match day checklist and the Derived Score Method on each assessment date at each site. All of the derived scores are in the acceptable range as they are all >64. Only one of the match day checklists led to a conclusion that the ground was unsafe for play. Figure 17 shows that this particular observation was not related to the derived score on this date.

The major conclusion to be drawn from this comparison is that match day checklists are critical for identifying hazards and should be used in conjunction with other assessment methods.

Figure 17. Comparison of the results of the match day checklist and the derived score method

OBJECTIVE GROUND ASSESSMENTS DATA

In Chapter 7, the ground condition assessments were averaged over all venues. In this section, the data collected for each venue is shown separately. The data in Figures 18–22 all show a trend towards the three grounds becoming harder over the season, with decreased grip due to grass changes, diminishing soil moisture, and increasing shear strength over the five month period. Where appropriate, as comparison, each figure also shows data derived from a study of AFL grounds [109] and shown in Table 25 in this report. All data is shown graphically as box and whisker plots.  

*In this section, the data is graphically displayed with box and whisker plots. These plots show both the variability within a particular field at a given time and a comparison across times for any given field (as well as comparisons of fields assessed at the same month.). In these figures, the boxes represent the inter-quartile range, or the middle 50% of data values, with the lower limit corresponding to the 25th percentile and the top of the box to the 75th percentile. The line intersecting the box is the median, such that 50% of all observed data values lie either above or below the line. The whiskers show (approximately) the lower 2.5th percentile and the upper 97.5th percentile, such that 95% of the data lies within the range spanned by the whiskers (and boxes).*
Above 12 considered unsafe

Preferred range 7-9

Figure 18. Hardness measure results for the three rural grounds over the three testing dates
Figure 19. Rotational traction (grip) results for the three rural grounds over the three testing dates

Figure 20. Shallow assessment of volumetric soil moisture content at three rural grounds over three testing dates
Figure 21. Deep assessment of volumetric soil moisture for the three rural grounds over the three testing dates.

Figure 22. Linear traction measures for the three rural grounds over the three testing dates.
COMPARISON OF THE RESULTS OF DERIVED SCORE METHOD AND THE OBJECTIVE MEASURES

A critical question for consideration in this case study is whether or not the trends in the ground suitability scores from the DSM relate to the trends observed in the objective measures of hardness, grip, moisture and linear traction at the same grounds. This question is important because it is likely that rating of grounds for suitability of play will most likely continue to be done either subjectively or using simple objective measures for the vast majority of sports ground situations.

In practice, application of the DSM would lead to a single score, which is then used to make decisions about the ground. Similarly, hardness, traction, moisture and shear strength measures are averaged to give an overall rating of the ground. For this reason, Figures 23–27 show the relationships between the median DSM overall scores and the averaged objective measures. Linear correlations between the two measures are also shown. Whilst there was an indication of a negative relationship (i.e. lower values of the DSM were associated with higher values of the other measure) between DSM and hardness and shear strength, none of these relationships was particularly strong. There were moderate positive relationships between the DSM overall score and both shallow and deep soil moisture content, perhaps reflecting the large weighting given to grass factors in the DSM. There was no association between the overall DSM score and grip.

![Graph showing relationship between derived score and hardness](image)

**Figure 23.** Relationship between the derived score and hardness, as measured by a Clegg Hammer
Figure 24. Relationship between the derived score and rotational traction (grip) as measured by the studded boot device

correlation = 0.27

Figure 25. Relationship between the derived score and the shallow soil moisture content

correlation = 0.66
As Figures 23–27 show, there is no strong relationship between the overall DSM and the objective ground condition measures. There could be a few reasons for this. Firstly, the DSM gives large weight to factors associated with grass coverage and these objective measures may not be strongly related to just that component. Similarly, it may be that the objective measures relate to
only a small component of the DSM assessment and not to the overall score, as such. Further investigation and validation studies are needed to assess this.

In terms of the specific components of the DSM, the following observations were also made against the objective measures gathered on ground conditions at Donald, St Arnaud and Wedderburn.

**Grassed areas**

Within the DSM, scores are given for grass cover, vigour, height and evenness of cover. It was noticeable that all three grounds received lower scores across this aspect as the drought, wear and tear from traffic and seasonal changes to the grass surfaces occurred. Potentially this may be related to the changes in grip, soil moisture and linear traction when measured objectively.

**Wicket areas**

The DSM specifically reviews the transition from cricket pitch area (whether synthetic or turf), to the other playing areas and asks the ‘rater’ to evaluate the evenness of this transition. This is a form of hazard identification and not related to the objective methods considered.

**Worn/bare areas**

The DSM attempts to evaluate the evenness and firmness of the sports ground by the ‘rater’ judging if there are clumps, undulations and surface changes and whether these are likely (foreseeable) to cause stability problems for participants. Part of the rotational traction (grip) measure also considered grass type, and bare patches etc. Accordingly there may be some relationship between the subjective DSM and the objective evaluation of grip. The extent and nature of any relationship is unknown, however, common sense would indicate that there should be some consistencies.

**Ground hardness/cracks/holes**

The DSM subjectively asks the ‘rater’ to indicate whether the ground is too hard to play on. Unfortunately, how and on what basis such a judgement is made is unknown, as no guidance is given. Similarly, cracks in the ground (indicating low soil moisture and high soil hardness) over 20mm impact upon the score given. The notion of measurement of these factors versus visual judgement of their presence is important as the DSM does not attempt to use a related or known objective correlate to ground hardness. This aspect requires development if the DSM is to be effective in considering the quality and the suitability of surfaces for participation.

Intuitively, it would appear that the deteriorating trends observed in the DSM scores of the three grounds is linked to the changes in the objective measures of the same grounds. Evidentially it is not possible to say much more. However with development, the DSM has the potential to be based upon correlates of objectives measures that are known to underpin both the quality and implied suitability of a particular sports ground.

**SUMMARY AND CONCLUSIONS**

The DSM has been applied to three rural venues, over three dates to assess its relationship with other measures. Although there is some degree of relationship between the DSM and the more objective measures, there are, by no means, strong and direct (as shown by correlations approaching 1).

When assessed over time, the overall DSM scores were consistent with a deterioration of the ground conditions on all three grounds. This change reflects the real-world state of these grounds.
associated with increasing drought conditions and the wear and tear of a football season. Furthermore, the poorer quality grounds had lower overall scores, generally supporting the ranking of the three grounds by the football association.

Recommendations for the ongoing use of the DSM and for its further development are given in Tables 39 and 40.

Table 39. Recommendations for improved ground condition assessment practices using the DSM

- A two-staged approach to sports ground safety and suitability assessment is likely to be best practice. The first stage should involve pre-game and training examination of the sports ground for hazards using a checklist. The second stage should involve the use of a validated DSM-type measure, with validated correlates of objective measures.
- Match day checklists used to identify hazards to safe participation should be undertaken by all clubs prior to games and training. Records should be kept of all inspections along with a record of remedial action undertaken.

Table 40. Recommendations for further development of the DSM

- Before recommendations for its widespread use can be made, the DSM requires further formal validation against objective ground condition measures across a variety of grounds, sporting activities and times of the season.
- To be fully validated, the DSM should also be compared directly with injury incidence data across a range of sports, over at least two playing seasons.
9. SUGGESTIONS FOR COMPONENTS OF A GOOD PRACTICE APPROACH

INTRODUCTION

This report has highlighted significant limitations in both the evidence linking injuries to ground conditions and in the reliability/validity of currently available measurement methods. Notwithstanding these limitations, it is clear that LGAs and SSAs/clubs could, and should, assess the conditions of their grounds on a regular basis. Ideally, grounds should be assessed using fully objective measures. However, it is recognised that the necessary equipment can be expensive and requires “experts” to use it.

In the absence of fully objective measures, a best practice approach to grounds assessment should involve a two-tier approach of match day checklists for hazard identification before matches and training sessions, as well as a more objective checklist for assessing ground conditions. The DSM used by some councils is an example of the latter, but its scoring system requires further development and validation before it can be recommended for widespread use. Having said this, use of the DSM is unlikely to cause harm, though it may give undue weight to the assessment of some factors and hence lead to unnecessary decisions being made. However, the likely extent of this cannot be determined without further work.

The first tier involves pre-game and pre-training inspection of the sports ground for hazards that are likely to cause injury. This process should be conducted by individual clubs before all training sessions and by both clubs before the first use of the ground on match day. A standardised checklist relevant to the particular sport being played should be used to record the observations and any outcomes. The form should be kept on record by the relevant SSA for subsequent analysis and review and by club(s) for insurance purposes.

The second tier involves the regular inspection of sports grounds by the relevant LGA with the specific purpose of inspecting the ground surface and surrounds for its suitability for play. This inspection process should be conducted weekly (early in the week) and be linked to the maintenance program in place for that sports ground. Best practice indicates that there are clear parameters by which sports ground surfaces should be evaluated. It is recognised that these parameters, as discussed in this report, have predominantly been established for elite sport on major sportsgrounds using objective measures. This is not regarded as practical for the majority of grounds in use for community sport and best practice indicates that inspection should be based upon visual inspection and subjective correlates of these objective measures. A number of LGAs are currently doing this. In the near future, it is possible that simple apparatus and objective tests will become a practical option. It will still be necessary to validate this approach and to consider using a scoring system.

TIER ONE: MATCH DAY AND TRAINING SESSION CHECKLISTS FOR CLUBS

The purpose of match day and training checklists is to check the playing surface and surrounds for observable hazards. Such hazards are likely to cause injury to players if left unchecked. It is important that the checklist are completed by both clubs before the first use of a venue in the case of a competition match and by the home club conducting training. At all times the checklist should
only be completed when the ground inspection has been conducted by walking over and visually inspecting the sportsground. An appropriate pathway would be as shown in Figure 28. This includes a circuit of the full boundary, traversing of the full centreline and a second circuit within the field (about 20m from the boundary) to cover the flank and in-field areas.

![Figure 28. Recommended pathway for match day and training session hazards checks](image)

Jardine Lloyd Thompson (JLT) Sport has prepared Match Day Checklists for Australian Rules football, cricket and soccer (Appendix 2) and these include questions about ground safety, the provision of first aid facilities and also change room and toilet safety. These forms are excellent and in wide use. However, the checklists could be enhanced by the inclusion of a positive statement defining ‘a safe condition,’ eg, the ground is free of debris, followed by an indication of the action taken to make the ground safe if the statement is not accurate. This would then imply that if there is debris on the ground, it should be cleared before play commences.

The main hazards to safe play that are likely to be seen on/at sports grounds, which are capable of being addressed or corrected immediately (i.e. pre game), are:

- debris on ground
- erosion (holes and depressions) around sprinkler heads
- holes and depressions around water supply taps
- sprinkler or tap covers missing or damaged
- uneven surfaces (eg cricket pitch to surrounds surface transition)
- fence and surround safety
- sporadic vandalism (cars doing wheelies on sports ground etc).

The other related matters that are considered in the JLT checklists are weather conditions and the correct padding of goal structures.
Whilst outside the ambit of this particular report, a focus statement related to first aid should be included on the form and could read:

There are appropriate first aid personnel, equipment and phone contact with emergency services should it be required.

**Safety Kit**

To enable rectification of these types of hazard, a kit comprised of sand, soil, (in sufficient volume) rake, shovel, gloves, wheel barrow and rubbish tin should be available at the ground.

**Suggested focus of best practice match day and training session checklist**

Figure 29 provides a suggested focus for a modified match day and training session checklist.

<table>
<thead>
<tr>
<th><strong>YES</strong></th>
<th><strong>NO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The ground is free from debris (glass, stones, faeces, windrows, etc)</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>Sprinkler heads and taps are covered and level with surrounds</td>
<td>☐</td>
</tr>
<tr>
<td>If NO what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>The ground is free from holes or uneven sections that could cause trips and falls</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>The padding of goal (and point) structures is adequate</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>The weather conditions are safe for play to commence</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>The perimeter fencing and signage is safe and secured</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
<tr>
<td>There are no other hazards that create danger for players</td>
<td>☐</td>
</tr>
<tr>
<td>If NO, what action was taken?----------------------</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 29. Suggested focus for a match day and training checklist**

Recommended inspection notes (to be included on the reverse side of the match day and training checklist) are given below.
Debris
This is an obvious hazard but requires a careful visual inspection. Glass, aluminium cans that have been mown over, rocks and general rubbish are often littering sports grounds. Other debris includes syringes, faeces and windrows of mown grass that can cause tripping injuries.

Sprinklers
Recessed sprinkler heads on sports grounds are normally made safe by a cover. Erosion of the surrounds of the sprinkler caused by water pressure should be made level with the surrounding ground. A player should be able to run across this area and directly place a foot on the top of the sprinkler area with no disruption to the stride pattern or gait.

Holes and uneven surfaces
Potholes, divots and depressions are hazards that arise for many reasons on sports grounds. They are easily repaired by adding sand or soil and should be tamped to provide a stable surface. Uneven surfaces typically arise through differential wear patterns (e.g. goal square) and around cricket pitch areas where loose soil has a different drainage pattern to the adjacent areas and uneven, rippled surfaces can arise. Bare patches of earth with clumped grass or weeds can also lead to uneven surfaces. An inspection of a suspect uneven surface by walking across it with eyes shut such that it makes the person feel very unsure about their footing indicates that this area requires repair.

Padding
Padding should be on all upright goal posts to a height of 2.5 m. It should be a minimum of 35 mm thickness, be in good condition and securely fixed to the upright (goal, behind structures).

Weather conditions
The major and serious risks arising from hazardous weather conditions relate to the prospect of localised lightning, the combination of wind, rain and cold leading to hypothermic conditions and conditions of extreme heat. Where appropriate, the weather situation as it relates to player safety should be considered in an ongoing manner throughout match day.

Perimeter fencing
Perimeter fencing should be checked for protruding wire, pipes, bolts and loose and damaged signage. The sitting of signage should also be considered and placed as far from the boundary line as possible. At all times the appropriate safety distance from boundary line to the fence (Australian Rules football=5m, cricket and soccer=9m back and sides 6m) should be considered.

Other hazards
From time to time abnormal situations are created that cause hazardous conditions for players. These could be man-made (e.g. vandalism by drivers doing wheelies on ground), structural (e.g. burst water main) or natural (e.g. flooding, snow etc). Common sense should be used and player safety considered first and foremost. When particular hazards cannot be eliminated consideration should be given (as in golf) to creating an Out of Bounds area where no play is possible.

It is recommended that the checklist be provided as a single sheet, two-sided document and, if required, could be made sport specific. An example of this is included in Appendix 5.
TIER TWO: GOOD PRACTICE SPORTS GROUND INSPECTION

Elsewhere in this report, our analysis of the DSM of Sports Ground Inspection indicated that there were a number of major shortcomings both in terms of the areas inspected and the scoring system used in this inspection format. This assessment of the DSM was undertaken to highlight the need for developmental work on this model, rather than to criticise it. In the near future, it is highly likely that it will be possible to validate aspects of the DSM in terms of its capacity to relate to objective measures. It will also be necessary to develop new measures for both objective and subjective processes. This will lead to affordable, viable mimic measures of some objective aspects of assessing sports ground suitability for play being developed, validated and trialled.

At this stage, it is not possible to recommend the DSM for wholesale adoption across LGAs. However, the current evidence suggests that if it were used, then no harm would be done, in that the system of scoring and the areas measured would not produce false positives ratings of grounds. In this context, a false positive rating would lead to a declaration that a sports ground was safe for play when, in fact, it was unsafe. Furthermore, there is the overriding statement on the DSM Inspection sheet that any one observation may render the sports ground unsafe for play.

What follows is an examination of the DSM (2006) format against the focus areas that should be considered from the material presented in this report. This “good practice” system, which is drawn from aspects of the DSM, is neither complete nor accompanied with a scoring system. Whilst based on current best practice, it is indicative of work in progress and requires validation. This validation will be undertaken over the 2007 football season.

The proposed approach is both subjective and qualitative as there are currently no objective approaches available in checklist format in the literature in common practice. After examination of each aspect, the person(s) inspecting the ground would be required to make a subjective decision, based on their observations as to whether the ground is safe for play or unsafe.

This suggested model requires the person(s) inspecting the ground to firstly describe the conditions related to the area under observation, next to analyse those conditions and finally to make a decision related to the safety. As stated above, this model incorporates some aspects of the DSM observations. At all times, it is recognised that timely remedial action can render a ground safe.

This second tier of sports ground inspection would therefore involves LGAs, in conjunction with individual clubs if possible, conducting a visual inspection of their sports ground. This should be conducted weekly and, at the conclusion of the inspection, a statement about the ground suitability for play should be available. The dimensions to be considered are:

- surface evenness (as it relates to player stability)
- grass cover (as it relates to evenness and traction)
- shock absorbency (as it relates to hardness)
- grip (as it relates to traction and slipperiness)
- other known hazards (similar to match day checklist).

These areas are explained in detail below.
Surface evenness dimension

The surface evenness dimension of the Good Practice Sports Ground Inspection process is summarised in Table 41. The sports ground surface should be level, flat and even. This should be considered at two levels: whole of ground and parts of ground. Uneven and denuded areas created by sport dimension markings can be hazardous. Uneven ground surfaces are evident in the form of patches of bare ground and tufted grass, holes and undulations, a raised cricket table with unstable filling of different composition to the surrounds are all examples of potential hazards in terms of unevenness.

Table 41. The surface evenness dimension of the Good Practice Sports Ground Inspection process

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are bare areas at such different levels to the grass surrounds to cause stability or tripping hazards?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Are there holes, undulations, worn areas and sprinkler areas that might cause players to trip, or fall?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Are there variations between the cricket wicket area and the surrounds</td>
<td>Yes / No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Not significant</th>
<th>Very significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any YES response to the above observations means problems exist. Review your responses and indicate how significant this aspect of the ground safety is. Remember that aspects of ground safety can be less than ideal, but still safe for play.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECISION</th>
<th>Safe</th>
<th>Unsafe</th>
</tr>
</thead>
<tbody>
<tr>
<td>In terms of overall ground surface safety the evenness of the field is such that conditions for players and officials is</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For a whole of ground evaluation, the person(s) inspecting the ground seeks to conclude that the overall sports ground surface is even and there are not undulations, holes, tussocks or other raised surfaces that present a tripping or falling hazard to players and officials. As stated in the match day and training checklist observation notes, this hazard is evaluated through a visual scan. This can be assisted by an inspection of a suspect uneven surface by walking across it with eyes shut such that if it makes the person feel very unsure about their footing this would indicate that this area requires repair.

Grass cover dimension

The grass cover dimension of the Good Practice Sports Ground Inspection process is summarised in Table 42. Ideally, sports grounds should have a 100% grass cover. It should be noted that as the percentage of bare area increases, the associated injury risk potentially increases as well. The safety issues relate to bare patches being at a different level to the grassed surface causing an uneven surface and the different traction characteristics as players move from one area to another. Weeds, tussocks and tufts of different grasses can also lead to an undulating and uneven surfaces. Tripping and jarring injuries are the likely consequences.
### Table 42. The grass cover dimension of the Best Practice Sports Ground Inspection process

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>The percentage of grass cover is estimated at</th>
<th>&lt;25%</th>
<th>&lt;50%</th>
<th>&lt;75%</th>
<th>&gt;75%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Does the percentage of grass cover present a</td>
<td>hazard to players and officials?</td>
<td>Yes/ No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are there weeds, tussocks or bare patches that</td>
<td>could cause stability problems for players?</td>
<td>Yes / No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the grass length (or variations ) likely to cause a</td>
<td>player to trip?</td>
<td>Yes / No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANALYSIS</td>
<td>Any YES response to the above observations means</td>
<td>problems exist. Review your responses and indicate</td>
<td>Not significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>how significant this aspect of the ground is.</td>
<td>Remember that aspects of ground safety can be less</td>
<td>Very significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remember that aspects of ground safety can be less</td>
<td>than ideal, but still safe for play.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DECISION</td>
<td>In terms of ground surfaces safety the grass cover of</td>
<td>the field is such that conditions for players and</td>
<td>Safe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>officials is</td>
<td>Unsafe</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Shock absorbency

The shock absorbency dimension of the Good Practice Sports Ground Inspection process is summarised in Table 43. Shock absorbency is the extent to which a surface absorbs the impact of a player running on the surface. Sportsgrounds can feel soft, firm or hard. Shock absorbency is influenced by soil moisture, soil type and grass cover. Extremely hard surfaces may lead to soft tissue injuries caused by falling and to joint injuries caused by compressive forces.

### Table 43. The shock absorbency dimension of the Good Practice Sports Ground Inspection process

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>Are the ground conditions in terms of softness, firmness and hardness an issue for player safety?</th>
<th>Yes/ No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is this condition uniform over all the ground?</td>
<td>Yes / No</td>
</tr>
<tr>
<td></td>
<td>Are there cracks in the sports ground surface?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>ANALYSIS</td>
<td>Any YES response to the above observations means problems exist. Review your responses and indicate how significant this aspect of the ground condition is. Remember that aspects of ground safety can be less than ideal, but still safe for play.</td>
<td>Not significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very significant</td>
</tr>
<tr>
<td>DECISION</td>
<td>In terms of ground surfaces safety the shock absorbency of the field is such that conditions for players and officials is</td>
<td>Safe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unsafe</td>
</tr>
</tbody>
</table>
Grip

The grip dimension of the Good Practice Sports Ground Inspection process is summarised in Table 44. Both slip resistance and traction are important characteristics of sports ground surfaces and the interaction with players through their footwear. A player must experience enough grip on the surface to accelerate and decelerate at will. If there is insufficient grip a player may slip which can result in loss of stability and balance and result in ligament and muscle damage. Conversely, too much grip can entrap a body part such as a foot whilst other parts move differentially leading to ankle, knee and hip injuries. The playing surface must also allow players sufficient traction to change direction at will.

Table 44. The grip dimension of the Good Practice Sports Ground Inspection process

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there sections of the ground with different surface characteristics (bare patches, sandy sections)?</td>
<td></td>
</tr>
<tr>
<td>Is travelling from grassed to ungrassed sections likely to cause either slipping or grip problems?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Not significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any YES response to the above observations means problems exist. Review your responses and indicate how significant this aspect of the ground is. Remember that aspects of ground safety can be less than ideal, but still safe for play.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECISION</th>
<th>Safe</th>
</tr>
</thead>
<tbody>
<tr>
<td>In terms of ground surfaces safety the grip of the field is such that conditions for players and officials is</td>
<td></td>
</tr>
</tbody>
</table>

Other hazards

The other hazards dimension of the Good Practice Sports Ground Inspection process is summarised in Table 45. Aspects of the Match day and Training checklists are used here to highlight particular hazards known to increase the likelihood of player injury.

Table 45. The other hazards dimension of the Good Practice Sports Ground Inspection process

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ground is free from debris (glass, stones, faeces, windrows, etc)?</td>
<td></td>
</tr>
<tr>
<td>Sprinkler heads and taps are covered and level with the surrounds?</td>
<td></td>
</tr>
<tr>
<td>The perimeter fencing and signage is safe and secured?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Not significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any NO response to the above observations means problems exist. Review your responses and indicate how significant this aspect of the ground is. Remember that aspects of ground safety can be less than ideal, but still safe for play.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECISION</th>
<th>Safe</th>
</tr>
</thead>
<tbody>
<tr>
<td>In terms of ground surfaces safety the hazards on the field are such that conditions for players and officials is</td>
<td></td>
</tr>
</tbody>
</table>
Ground profile assessment

A ground profile assessment (Figure 30) should be produced when the person(s) inspecting the sports ground have to make a judgement whether, overall and on balance, the ground is safe for play. The decisions made for individual ground components are aggregated. For a ground to be considered unsafe for play there must be clear evidence for this, and a strong belief that the likelihood and consequences of the surface conditions creating unreasonable risk for players and officials, is evident. It is important that ground managers and sports officials are able to say that a ground is closed for safety reasons, not aesthetics or horticultural standards. The concept of asset protection may indeed lead to ground closure, but this should not be disguised as safety.

<table>
<thead>
<tr>
<th>OBSERVATION FOCUS</th>
<th>SAFE OR UNSAFE</th>
<th>Remedial action required to enable play</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface evenness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock absorbency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other hazards</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ground surfaces at--------------------------- has been reviewed by LGA representative------
--------------------------------- and Club representative--------------.

We believe that that the ground is currently safe / unsafe for play.

We recommend the following maintenance action on the ground

Signed       Date-----------------------
-------------- LGA rep
------------- Club rep

Figure 30. Good Practice Ground Profile Assessment

A possible format for the Good Practice Sports Ground Inspection checklist and ground profile assessment is given in Appendix 6.

SUMMARY

This Chapter has provided a suggested format for good practice adoptions of match day and training session checklists and ground inspection processes. At this stage it is not possible to assign scoring systems, nor weights, to them because they have not been validated in the real-world context. However, such validation will be undertaken over the 2007 football season in a sample of regional football venues. For LGAs and SSAs without current assessment practices, adoption of these proforma (as given in Appendices 5 and 6) would be an important start to any ongoing and future grounds assessment practices.
REFERENCES


