



PENN STATE

CENTER FOR SPORTS SURFACE RESEARCH

From the Field: Field Hardness Impacts Head Injury Risk

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Welcome to From the Field - A Guide to Athletic Field Safety and Care.

Throughout this series, we will focus on a sometimes overlooked but critical component affecting the safety and performance for athletes of all ages – the playing surface.

Our goal is to provide you with simple, helpful tips about playing conditions that maximize both safety and performance.

There is no doubt that reducing head injuries is a major focus in football leagues across the country. While concussions are typically the result of helmet-to-helmet contact, concussions and other head injuries can also occur from the head impacting the playing surface.

Research reports, such as this [study](#), have shown that approximately 10% of concussions in football are caused by the head hitting the surface.

A properly maintained playing surface can help reduce head injury risk. Whether natural or synthetic turf, field management practices directly affect field hardness, and, in turn, risk of head injury.

As a result, monitoring field hardness is key. In fact, the NFL now requires field managers to measure surface hardness before every game.

How is playing surface hardness measured?

Surface hardness is measured by dropping a weight (often referred to as a missile) from a fixed height onto the playing surface. The missile contains an accelerometer that measures how fast the missile stops once it hits the surface. A numerical value (referred to as Gmax) is then generated.

A high Gmax value indicates the missile stopped quickly – think of this as dropping the missile onto concrete. If the missile were to be dropped onto a pillow, it would take a longer time for the missile to stop and therefore the softer surface would produce a lower Gmax value.

The NFL field testing program requires playing surface hardness of both natural and synthetic turf fields to be measured with the Clegg Impact Tester. Fields must be tested in multiple locations prior to every game and must be below 100 Gmax.

Another device that is used to measure surface hardness on synthetic turf is the F355 device. Named after the American Society for Testing and Materials (ASTM) [standard](#) that details the testing method, the concept behind this device and the Clegg Impact Tester is very similar.

However, the two devices use missiles of different weights and are not dropped from the same height. As a result, the Gmax values are not interchangeable. While the NFL uses an upper limit of 100 Gmax with the Clegg Impact Tester, [ASTM F1936](#) sets an upper limit of 200 Gmax with the F355 device.

Penn State's Center for Sports Surface Research recently hosted a round-robin testing event that included multiple testing agencies using both Clegg Impact Testers and F355 devices to measure surface hardness on 15 surfaces. The results detailing the relationship between the two devices can be found [here](#).

Additionally, more details on each device can be found [here](#) and this [video](#) further explains the devices as well as the Gmax concept in more detail.

Why do football fields get hard and what can be done to make them softer?

Natural Turf Fields

On natural turf field, the amount of water in the soil has a large influence on Gmax. The highest Gmax levels are found under dry conditions.

Additionally, natural turf fields get hard because the soil beneath them becomes compacted. As more and more football games are played on a field, the air in the pores throughout the soil gets squeezed out. As a result, the field gets harder.

Dry conditions coupled with compacted soil can result in very high Gmax values. Under these conditions, fields can reach Gmax levels of greater than 200 as measured with the Clegg Impact Tester – that is more than double the upper limit used by the NFL.

The best way to alleviate soil compaction is through mechanical aeration. Aeration involves using a machine that removes small soil cores. Aerating creates more airspace in the soil and should be done several times per year during the offseason.

Fields are often aerated after the final game of the year and then again in early spring. Highly-compacted field can be aerated more often, but it is important to avoid aerating during hot, dry weather and immediately before and during the season.

Adding compost in conjunction with aeration further helps reduce surface hardness in addition to creating better conditions for turf growth. Information about applying compost can be found in [this report](#).

Additional information on aerating can be found [here](#).

Synthetic Turf Fields

On synthetic turf fields, the infill material (crumb rubber or crumb rubber + sand) provides a cushioning effect. The more infill, the more cushioning.

Elevated surface hardness levels are almost always associated with low infill levels. It is not that the infill material is compacting like the soil does on natural turf fields. Instead, the infill is actually being removed from the field over time.

The small amount of rubber in a pair of cleats after a game may seem insignificant, but that small amount multiplied by all of the shoes on that field over time adds up and comprises what is referred to as “walk-off” crumb rubber.

This phenomenon is most evident in the high-use areas of the fields, where the majority of play occurs and, in turn, the majority of the rubber “walks off”. The result is less infill in the field and increased surface hardness.

In order to prevent this, infill levels should be measured on a regular basis and compared to the infill depth recommendations provided by your field manufacturer. You can measure infill depth using a fire-proofing depth gauge, which can be purchased for less than \$20.

When infill levels drop below the field manufacturer’s range, additional rubber should be added. This means you should have additional rubber on hand and the rubber should be the same as what is currently in the field.

You may only need to add rubber to a small area such as a lacrosse goal mouth if it is a multi-sport field. Or, the entire field may require additional rubber.

Additional information on “walk-off” crumb rubber and adding rubber to your field can be found in a previous *From the Field* column. Also, if your field is painted on a regular basis, paint can build up over time and result in elevated surface hardness values.

Painted areas should be monitored closely for Gmax and paint should be occasionally removed. The NFL suggests that paint be scrubbed and removed after approximately every four paintings on synthetic turf fields throughout the league.

How often should a field be tested?

Independent field testing agencies are available throughout the country. Your turf manufacturer can likely give you a list of testing agencies in your area.

Some field owners invest in a Clegg Impact Tester so that they can monitor their fields on a regular basis. The cost of a Clegg Impact Tester is approximately \$4500. F355 devices are much more expensive.

Ideally, synthetic turf fields should be tested once per year. If you are able to invest in a Clegg Impact Tester, you can test on a more regular basis.

Surface hardness levels of natural turf fields can vary throughout the year depending on moisture levels and field use.

As a result, testing frequency is largely dependent on your location, field use schedule, and testing budget. Routine aeration and proper maintenance practices typically result in surface hardness levels less than the 100 Gmax level (with Clegg Impact Tester) and routine testing may not be needed.