The interaction between an athlete and the playing surface is based on traction and field hardness. Measuring these characteristics, researchers are paving the way for improved field conditions across the country.

SAFE AT ANY SPEED

The primary objective of experiments conducted at Penn State University was to advise high school athletic field managers of ways to improve playing field conditions. The conclusions were not surprising.

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An athletic field's quality is assessed differently by players, coaches and fans. Viewers judge it by appearance. However, a dark green field with 100 percent turf cover doesn't guarantee player performance or safety. For players and coaches, quality is a function of performance and safety.

Interactions between player and surface are based on traction and field hardness. To measure these characteristics, researchers use equipment designed to evaluate turf surfaces.

- *Traction*, the relationship between a player's foot and the playing surface, can be quantitatively assessed with a device known as a shear vane, which simulates the action of cleats pressed into the ground. The measurement is made by rotating the shear vane until the turf or ground breaks loose. Similar devices pressed onto but not into the surface have also been used.

- *Hardness* is a measure of the surface shock-absorbing properties. It can be determined using accelerometers attached to weighted objects that simulate a player's falling or running on the surface. By dropping the objects from a constant height and using a constant mass, different surface hardnesses can be compared.

Study results

Good maintenance practices and good field conditions were generally associated with lower impact values, which indicates more softness. Higher impact values were found for fields with lower moisture contents, greater bulk densities and less turf cover. It became apparent that, in football field maintenance and renovation programs, the center of a field requires the most attention.

And in general, higher shear resistance values were found for game fields and outside hashmarks, where greater vegetation had a more apparent effect than bulk density and moisture values, which would have favored low shear resistance.

The volunteers

Twelve volunteer Pennsylvania high schools with 24 athletic fields were evaluated five times each between November 1986 and November 1987. Evaluations were done to include as many different environmental conditions as possible, both inside and outside the hashmarks at the 35-yard lines.

School representatives provided

information regarding fertilization, cutting height, weed control, aeration, liming and irrigation. The information included both past and present management practices.

Average hardness data for position and field type for all recording periods are shown in Table 1. With a heavier object, there was a significant difference in hardness between areas inside and outside the hashmarks. Impact values were higher inside the hashmarks throughout the study. These higher values were associated with less turf cover, drier soil and/or more compact soil. The least amount of differences were in March measurements. This was attributed to the greater amount of frost heaving on the inside areas, which were bare or less densely covered with turf than the outside areas. The soil was loosened, causing lower impact values. As the year progressed, the differences increased.

With the heavier object, impact values for game fields were lower than for practice fields. The greatest differences were in November, following football season. Greater differences between field types as the year progressed were attributed to more intensive practice field use.

Impact values for the lighter hammer followed the same patterns.

In general, the lowest values reflected a combination of dense turf, low soil bulk density and high soil moisture.

And artificial turf?

As observed in Table 2, values obtained at various times on a new artificial turf field fell within the range of the natural high school fields. A practice field that had frozen was much harder than either artificial or natural unfrozen turf. Values for floor surfaces in a home were higher than values for the high school fields. It should be noted that variation would also be expected for different artificial turf surfaces or floor surfaces in homes.

Values for shear resistance (traction) are shown in Table 3. On each measurement date, these values were lower—although not always significantly lower—for practice fields and positions inside the hashmarks (except for November, 1987).

Turf or soil giving way under foot would be associated with lower shear values. Certain impacts between players might make it better for the soil or turf surface yield than a player's joints. From the standpoint of efficiency of play, the variation in footing, as indicated by a range of shear values for the same field, could affect performance as players move from one area of the field to another.

Maintenance levels

It is unfortunate that practice fields, used more than game fields, received less maintenance. Such findings indicate that in turfgrass management decisions, game field appearance may receive more attention than playing quality of both practice and game fields. Fortuately, much of the maintenance work aimed at appearance also improves the playing surface. However, a need to educate field managers on the role of turfgrass management in providing a good playing

Field hardness was most significant between hashmarks, a result of less turf cover, drier soil and/or more compact soil.

TABLE 1.

Hardness values for field type and position, November 1986-November 1987.

Field type and position	Hardness: 2.25 kg hammer				
	Nov 86	Mar 87	Jun 87	Aug 87	Nov 87
	gmax				
Game	65**	57	79	76	76**
Practice	80	59	90	94	94
Inside	85**	60**	90**	92**	98**
Outside	60	56	78	77	72
	Hardness: 0.5 kg hammer				
	Nov 86	Mar 87	Jun 87	Aug 87	Nov 87
	gmax				
Game	102**	78	105	96*	120**
Practice	123	82	127	125	157
Inside	137**	85**	132**	120*	166**
Outside	89	76	99	101	110

* Significantly different at the 5% level.
** Significantly different at the 1% level.
gmax = maximum deceleration.

Source: The authors

TABLE 2.

Impact values for high school fields vs. impact values for other surfaces.

Surface	Hammer 0.5 kg	Hammer 2.2 kg
	gmax	
High school fields	50-286	33-167
Artificial turf	109-172	60-91
Frozen practice field	404	303
Tiled, concrete basement floor	1,440	1,280
Carpet and pad on tiled concrete floor	260	190
Carpet and pad on hardwood floor	86	134

gmax = maximum deceleration.

Source: The authors

TABLE 3.

Traction (shear resistance) values for field type and position, November 1986-November 1987.

Field type and position	Traction (shear resistance)				
	Nov 86	Mar 87	Jun 87	Aug 87	Nov 87
	kPa				
Game	69	68	80*	62	82
Practice	68	62	68	58	78
Inside	67	57**	68**	55**	82
Outside	70	73	80	64	78

* Significantly different at the 5% level.
** Significantly different at the 1% level.
kPa = kilopascals (1 kPa = 0.145 lb in2)

Source: The authors

surface still exists.

Game fields were in better condition than practice fields. They had lower bulk densities, fewer weeds and more turf cover. Differences indicated that areas inside the hashmarks had more wear.

None of the fields in the study had modified soil. Native soils were all medium- to fine-textured loam, silt loam, silty clay loam and clay loam.

Variables

Variables were calculated in five categories: overall, game, practice, inside hashmarks and outside hashmarks. In general, an overall correlation existed between maintenance practices and vegetative variables. Fields receiving the best maintenance had the lowest weed cover and highest total turf cover. The correlation of N fertilization and aeration indicated that when one of these important maintenance inputs was intensified, so was the other.

A positive correlation was found between soil moisture and aeration levels. (Increased moisture probably reflects greater infiltation and less runoff on aerified fields.) There was slight correlation between field hardness and maintenance practices (As aeration and fertilization levels increased, field hardness decreased.)

Field hardness seemed to be affected most by percentage of soil moisture. In general, soil moisture correlated better with hardness as measured by the lighter hammer. In addition, an increase in bulk density was asociated with an increase in a field's impact value. Correlations between hardness and bulk density were not as great as those between hadness and percentage of soil moisture.

In general, then, when soil nutrient levels, N fertilization, core cultivation and weed and turf cover varied to indicate better maintenance practices, that variation accompanied a decrease in hardness.

For the most part, shear resistance values were not significantly correlated with maintenance practices, but for positions inside the hashmarks there was some indication that shear values decreased as weed cover increased. Weed populations were observed to be higher on worn areas where the turfgrass root system would be insufficient to create a high shear resistance. Field hardness and shear resistance relationships were both variable and slight.

Correlation between dates of the measured characteristics (hardness, traction, moisture, bulk density and weed cover) was variable. **LM**