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Compaction analysis in three low-performance soccer fields: a case study

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Abstract

Football fields are the stage for major sporting competitions and essential for the practice of the sport, however, the intense traffic players during matches and training causes soil compaction. Compaction on soccer fields can damage the development of grass, affect the health of athletes, increasing the risk of injuries, and impairing gameplay. The present work aimed to identify the spatial distribution of compaction in low-performance soccer fields. Three soccer fields were selected, composed predominantly of potato grass (*Paspalum notatum*), which were divided into three sectors: S1- goalkeeper area (composed by the small and large area); S2–laterals (composed by the lateral ends of the field) and S3 - midfield (composed by the central interval between the large areas). Subsequently, the soil mechanical resistance to penetration (RMP) in the soil profile of 0–0.20m in each of the sectors was determined and the data obtained were submitted to analysis of variance. It was found that there is a presence and variation of soil compaction in the different sectors of the three soccer fields studied, with averages varying between 654.62kPa and 3788.58kPa. Compaction levels were identified in certain sectors that can be limited to the development of potato grass and harmful to the health of athletes. Thus, it is recommended to carry out decompaction and/or aeration operations in the fields to improve the physical conditions of the soil.

Keywords: turfgrass, sports field, *paspalum notatum*

Introduction

Football fields are classified according to the quality of the playing surface, which can be low, intermediate or high performance. The quality of turf is determined according to the resources available for the construction and maintenance of the field, factors that can influence the performance of the match.[1]

In this context, in general, low-performance fields belong to amateur clubs or are fields for community use,[2] which have limited resources and opt for more rustic grasses such as Bahia grass (*Paspalum notatum*), species that requires less maintenance, tolerates drought and low fertility soils, but is susceptible to shading and is relatively tolerant to half-shade.[3,4]

As for the soil, in this type of field, there is no "topsoil" and the lawn is often directly implanted in the soil present in the field, without decompaction and correction of fertility taking place. Furthermore, irrigation or drainage systems are rarely present in these fields, the playing surface presents irregularities and the occurrence of holes and weeds is common.[5,6]

On soccer fields, the quality of the grass surface is essential for the gameplay to be as efficient as possible. However, on low-performance fields due to intense trampling by players and low maintenance of the field, the process of compression in the grass and soil particles occurs, affecting soil aeration and triggering compaction, which in turn reduces the permeability of the site and increases the resistance of the soil to penetration.[7]

According to the US Department of Agriculture,[8] compaction decreases porosity as soil bulk density increases. This process can be attributed to environmental conditions, grass species, soil texture, management practices, amount of use, and field location.[9]

Compaction on the soil surface can be a limiting physical condition that restricts the availability of oxygen, the absorption of water and nutrients, impairing plant development.[10] Consequently, these factors affect the quality of the turf and provide a greater risk of injury to athletes.[11] According to Mateus et al.[12] and Wannop et al.[13] compaction in sports fields is a factor that maximizes the risk of knee and ankle injuries, requiring that sports surfaces have low rotational traction, to reduce the joint load on the lower limbs, preserving the physical integrity of the players.

Thereby, it is essential to evaluate the compaction of sports fields, especially those with low performance, because they have less maintenance and are more likely to harm the game. And one way to measure this data is through the analysis of mechanical resistance to soil penetration, which allows the evaluation of compaction in different layers of the profile, and with this, essential quality standards can be established in soccer fields, for turf development and athlete safety.

Thus, the objective of this study was to evaluate the conditions and variability of compaction on the surface of soccer fields in a municipality in northwestern São Paulo.

Material and methods

Characterization of study areas

The present study was carried out during January 2017, in the city of northwestern São Paulo. The evaluated lawns are part of sports complexes in the city (Figure 1), the fields were studied: Field (A) - Estádio Municipal Frei Arnaldo Castilho; Field (B) - Parque Mantiqueira; Field (C) Centro de Treinamento Premisa. All fields evaluated had lawns composed of potato grass (*Paspalum notatum*) directly implanted in the local soil, classified as Dystroferric Red

Latosol (LVd).[5] None of the fields had a drainage system and the present irrigation system was by sprinkler, activated only in dry periods.

In the field maintenance history, there are no decompaction practices or lawn aeration. The cutting maintenance takes place through rotary cutting equipment, carried out every 15 days during the summer season to level the height of the grass at approximately 0.05m.

The frequency of use of the fields is on average three times a week, being used for training municipal teams and local championship games.

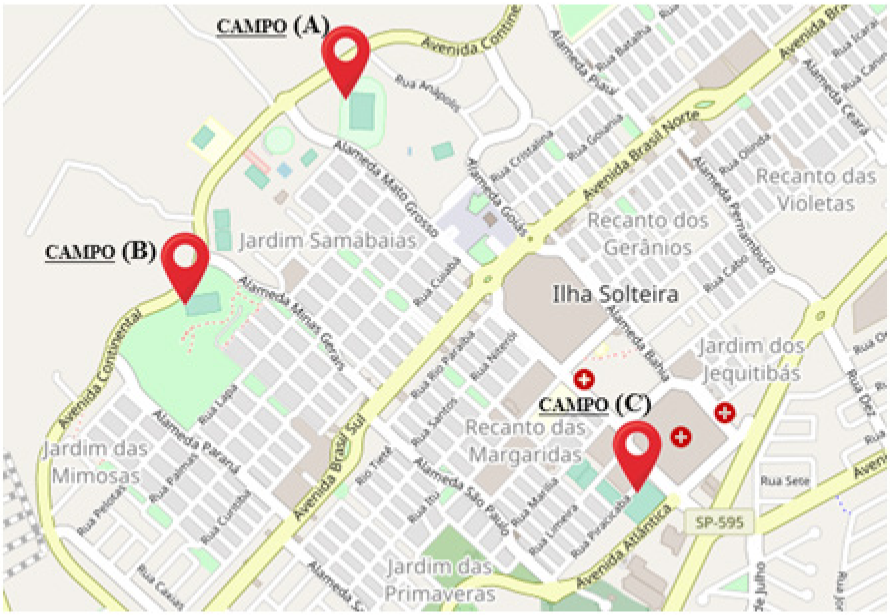

Figure 1 Location of soccer fields in the city.

Source: Adapted from Cidade Brasil.[28]

Evaluation

Before the evaluations, each field was divided into 3 sectors (Figure 2): S1- goalkeeper area (composed of a small and large area); S2–laterals (composed by the lateral ends of the field), and S3 - midfield (composed by the central interval between the large areas).

Subsequently, the soil mechanical resistance to penetration (RMP) was determined using an Electronic Penetrometer (PenetroLOG PLG 1020 from Falker®). The equipment works by inserting a conical metal rod into the ground, which allows for carrying out and storing RMP measurements at every centimeter in the soil profile.

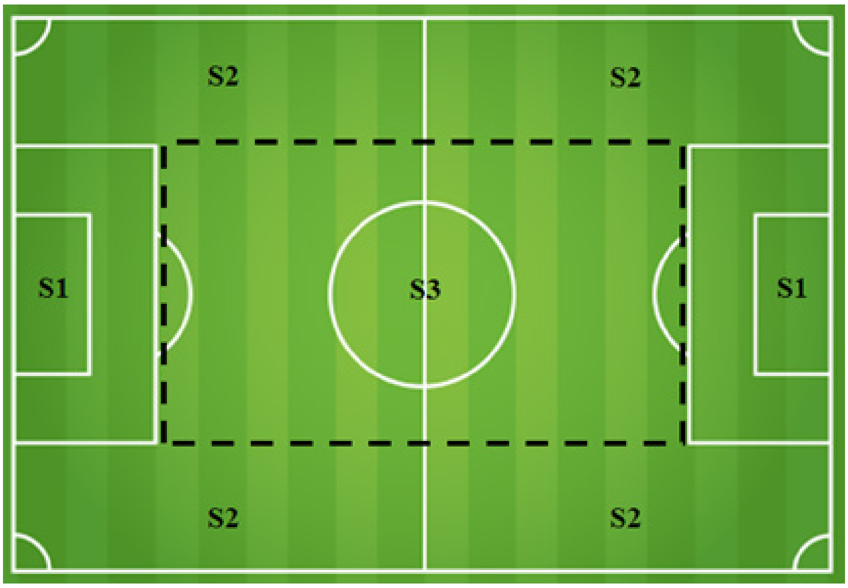

Figure 2 Illustrative image of the division of football fields into sectors.

Source: Author himself (2020).

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For the RMP evaluations, six sampling points were determined within each one of the sectors, on both sides of the soccer fields, being distributed in a representative way of the concentration areas. The fields were evaluated on 06/01/2017, respecting two days after the last precipitation, to rule out the influence of this factor in the measurements.

The collected data were subjected to analysis of variance and, subsequently, the means were compared by the LSD test at 5% significance. The computer program: System for Analysis of Variance – SISVAR[14] was used.

Results and discussion

Table 1 shows the results of mechanical resistance to penetration collected in the different sectors of Campos (A) evaluated.

According to the data shown in Table 1, there is no interaction between the area and depth factors in any of the RMP values (mean, minimum and maximum), but there is a significant difference in these factors evaluated separately.

Table 1 RMP values in the different sectors of the Field (A)

Sectors	Soil mechanical resistance to penetration (RMP)		
	Mean	**Minimum**	**Maximum**
	---------- Kpa ----------------		
Sector 1	2087,93 a	1455,25 a	2739,54 a
Sector 2	1431,77 b	654,62 b	2321,86 a
Sector 3	2174,92 a	1464,79 a	2925,21 a
DMS	645,54	529,71	756,78
Depth (m)			
P1: 0-0,05	41,46 c	0,0 b	214,06 c
P2: 0,05-0,10	1078,17 b	209,56 b	2080,78 b
P3: 0,10-0,15	2900,72 a	1988,3 a	3817,56 a
P4: 0,15-0,20	3572,46 a	2576,28 a	4536,44 a
DMS	745,41	611,65	873,86
F area	3,170*	6,167**	1,334ns
F depth	38,061**	35,107**	39,050**
F AxP	0,567ns	2,060ns	0,279ns
CV (%)	58,9	76,99	49,23

Means followed by the same letter in the column do not differ by the LSD test at 5% significance. ** - Significant at 1%; * - Significant at 5%; ns–Not Significant

Assessing the values of the sector factor, no significant difference was observed between the three sectors for maximum RMP. As for the average and minimum RMP, the values indicate that sectors S1 and S3 do not differ from each other, but they differ significantly from sector S2, which present the lowest values of RMP. This behavior may be related to the disposition of soccer players on the field, sector S2 because it is on the sides of the field, it is the sector that receives less traffic flow from athletes during a match compared to other sectors.[15] This happens because the full-backs and corners are sporadic situations during the game, moments when the ball crosses the lines that delimit the field, allowing the opposing team to have the ball in a set-piece play.

Although in maximum RMP there is no significant difference between the sectors, all of them obtained values that exceed 2000Kpa, indicated by Silva et al.[16] as harmful to root growth and shoot development of plants.

Table 1 showed the depth factor, there was a significant difference between the mean and maximum RMP values with the same behavior, P1 differed significantly from the others and being the lowest RMP value, followed by P2 with intermediate RMP values that differ from the others other depths and P3 and P4 that did not differ from each other, but differ significantly from P1 and P2.

According to Flitcroft et al.[17] studies with sports fields found that values above 3990Kpa are limiting, requiring decompaction and aeration measures in highly compacted specifics. Thus, the mean RMP value of P4 is close to what is considered limiting and the maximum RMP value of P4 extrapolates this value, indicating intervention with maintenance measures to leave the field in ideal conditions.

Assessing the minimum RMP values in Table 1, P1 and P2 show the least RMP values and do not differ from each other, but they differed significantly from P3 and P4, which also did not differ from each other. An effect similar to that observed by Li et al.[18] where soil compaction gradually increases in-depth, making it difficult for the roots to expand, causing them to concentrate in the 0-0.05m surface layer, called the "damping effect", resulting from the rhizomatous growth habit of the emerald grass that produces roots and rhizomes that completely cover the soil surface.[19]

The RMP values in Table 2 suffered, in addition to the individual action of each factor (area and depth), an interaction between these factors in minimal RMP. Thus, it appears that in this variable, the high values found at depth P4 are directly related to sectors S1 and S3. According to de Brooks et al.[20] studying heat mapping of the origin of passes in Spanish football (La Liga), indicate that these sectors, especially the S3 sector, have a greater flow of passes during the match, consequently, greater player traffic. Heavy traffic is considered the main cause of turf grass deterioration, causing aerial part wear and soil compaction.[21,22]

Table 2 RMP values in the different sectors of the Field (B)

Sectors	Soil mechanical resistance to penetration (RMP)		
	Mean	**Minimum**	**Maximum**
	---------- Kpa ----------------		
Sector 1	2559,98 ab	1506,67 a	3556,79 ab
Sector 2	1846,08 b	832,50 b	2945,67 b
Sector 3	2755,95 a	1728,17 a	3788,58 a
DMS	545,54	364,13	826,08
Depth (M)			
P1: 0-0,05	58,01 d	0,00 c	273,28 d
P2: 0,05-0,10	1299,09 c	267,56 c	2367,17 c
P3: 0,10-0,15	3251,73 b	2109,67 b	4318,72 b
P4: 0,15-0,20	4682,85 a	3045,89 a	6362,22 a
DMS	629,93	42,046	953,87
F Area	5,596**	13,135**	2,131*
F Depth	84,890**	97,280**	59,930**
F AXP	1,101^{ns}	4,761**	0,592^{ns}
CV (%)	40,71	46,51	42,96

Means followed by the same letter in the column do not differ by the LSD test at 5% significance. ** - Significant at 1%; * - Significant at 5%; ns–Not Significant

Note that for the area factor, the average RMP value in sector S2 was significantly different from that found in sector S3, while sector S1 did not differ from both sectors (S2 and S3). Despite this change, the minimum RMP values in Field (B) are considerably higher than the values found in the same variable in Field (A), which may indicate a lower maintenance frequency or even an excessive number of games in this field.

The maximum RMP values had the same behavior regarding the significant differences between sectors, sector S2 differs from sector S3 and sector S1 does not differ from the others. However, the RMP values found in all sectors are above 2000Kpa, which, as described above, provide a restrictive condition in the soil, preventing ideal turfgrass development.

Regarding the depth factor, it is shown in Table 2 that all mean and maximum RMP values differ from each other in each of the depths. An effect similar to that found between the minimum RMP values, where only P1 and P2 did not differ but differed in relation to the other depths. It is observed that for all RMP (mean, minimum and maximum) of the depth factor, P3 and P4 that corresponds to the range of 0.10-0.15m and 0.15-0.20m, respectively, obtained the highest values of Soil RMP, being higher than the values found by Laureda et al.[23] in equestrian polo fields, where for the same depth range the RMP values varied between 2438-2528Kpa. Indicating serious and significant restrictions to turf grass roots and rhizomes.

The results shown in Table 3, obtained from the indices of mechanical resistance to soil penetration, showed that there was no interaction between areas and depths, showing that each of these factors acts individually.

Table 3 RMP values in the different sectors of the Field (C)

Sectors	**Soil mechanical resistance to penetration (RMP)**		
	Mean	**Minimum**	**Maximum**
	---------- **Kpa** ----------------		
Sector 1	2341,32 ab	1513,38 a	3233,33
Sector 2	1738,02 b	794,25 b	2856,83
Sector 3	2478,52 a	1660,54 a	3343,83
DMS	735,51	551,79	989,40
Depth (m)			
P1: 0-0,05	55,51 d	0,00 d	261,33 d
P2: 0,05-0,10	1258,81 c	246,5 c	2373,56 c
P3: 0,10-0,15	3053,99 b	2046,50 b	4221,72 b
P4: 0,15-0,20	4375,52 a	2997,88 a	5222,05 a
DMS	849,30	637,15	1142,46
F area	2,296*	5,648**	0,533ns
F depth	40,480**	40,987**	34,152**
F AxP	0,559ns	2,018ns	0,132ns
CV (%)	58,27	72,24	54,49

Means followed by the same letter in the column do not differ by the LSD test at 5% significance. ** - Significant at 1%; * - Significant at 5%; ns–Not Significant

For the area factor, the mean RMP values were significantly different, similar to the behavior observed in Field (B) for the same variable, being sector S2 different from sector S3 and both sectors did not differ from sector S1. Regardless of the sector, all values found are close to or above 2000Kpa, indicating the need to maintain the physical conditions of the soil in the field.

The minimum RMP values of the area factor followed the same behavior as in Fields (A and B), where only sector S2 differed significantly from sectors S1 and S3 and in general, the pattern of other fields was maintained, where sector S2 obtained the lowest RMP values, indicating the influence of space occupation and player traffic on the results found. Another fact that corroborates this statement is the values obtained for maximum RMP, which, although not significantly different from each other, show turfgrass compaction rates.

Assessing the depth factor, it was noted in Table 3 that the RMP values (mean, minimum and maximum) manifested themselves in the same way, differing significantly from each other at all depths, a behavior that suggests a trend of increased compaction along with the increased depth.

Analyzing the compaction in the evaluated fields (A, B and C), it was identified that there is compaction variability within the same field, with different levels of compaction according to the sector and depth evaluated. According to studies carried out by Straw et al.[11] and Aldahir, the variability present in football fields occurs due to factors: player traffic, the species of grass, weather, maintenance management, construction and field structure.

According to Reinert et al.[24] and Canarache[25] compaction levels above 2,000Kpa may be limited to root growth. Thus, the spatial distribution of compaction in the fields had similar behavior in the three fields, with limiting compaction levels identified from 0.10 m in depth, being obtained in the areas of the goalkeeper and midfield. In these sectors, it is essential to carry out soil decompaction and/or aeration operations, a process carried out by drilling with pins, which provides for the reduction of the RMP and soil density, improving the conditions for root development and frequently carried out on sports fields of high performance.[26,27]

The sector of the sides of the field (S2), in the three fields (A, B and C) was the sector with the lowest levels of compaction. This fact may be related to a lower flow of athletes in this sector, resulting in a lower frequency of impacts that promote the compaction of soil particles.[28–30]

Conclusion

It was found the presence of soil compaction in limiting levels to the development of the turf and harmful to the health of the athletes in the three evaluated soccer fields.

There was the variability of soil compaction according to the sectors of the fields and the depths evaluated. The goalkeeper area (S1) and the midfield (S3) are the sectors most affected by this phenomenon and with the highest levels of compaction detected at a depth of 0.15-0.20m.

Based on the information obtained, it soil decompaction and/or aeration operations in the goalkeepers' areas and the midfield, for better turf grass development conditions is recommended to carry out and provide a non-harmful playing surface for athletes.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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