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Influence of the structural components of artificial turf systems on impact attenuation in amateur football players

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The purpose of this research was to evaluate the influence of the structural components of different 3rd generation artificial turf football field systems on the biomechanical response of impact attenuation in amateur football players. A total of 12 amateur football players (24.3 ± 3.7 years, 73.5 ± 5.5 kg, 178.3 ± 4.1 cm and 13.7 ± 4.3 years of sport experience) were evaluated on three third generation artificial turf systems (ATS) with different structural components. ATS were composed of asphalt sub-base and 45 mm of fibre height with (ATS1) and without (ATS2) elastic layer or compacted granular sub-base, 60 mm of fibre height without elastic layer (ATS3). Two triaxial accelerometers were firmly taped to the forehead and the distal end of the right tibia of each individual. The results reveal a higher force reduction on ATS3 in comparison to ATS1 (+6.24%, CI95%: 1.67 to 10.92, ES: 1.07; $p < 0.05$) and ATS2 (+21.08%, CI95%: 16.51 to 25.66, ES: 2.98; $p < 0.05$) elastic layer. Tibia acceleration rate was lower on ATS3 than ATS1 (-0.32 , CI95%: -0.60 to -0.03 , ES: 4.23; $p < 0.05$) and ATS2 (-0.35 , CI95%: -0.64 to -0.06 ; ES: 4.69; $p < 0.05$) at 3.3 m/s. A very large correlation ($r = 0.7$ to 0.9 ; $p < 0.05$) was found between energy restitution and fibre height in both head and tibial peak acceleration and stride time. In conclusion, structural components (fibre height, infill, sub-base and elastic layer) determine the mechanical properties of artificial turf fields. A higher force reduction and lower energy restitution diminished the impact received by the player which could protect against injuries associated with impacts compared to harder artificial turf surfaces.

Football is a sport characterized by high-intensity periods and recovery phases alternating with frequent accelerations and sudden changes of directions¹. The development of new technologies in this sport has allowed the detection of the influence of external variables on the performance in these actions and the safety of the players². In this way, the sport surface has been identified as an external factor that affects football players' performance and risk of injury^{3,4}. Several studies have analysed the differences between natural and artificial turf in football^{5,6}. However, Sánchez-Sánchez *et al.*⁷, revealed a mechanical heterogeneity between the different 3rd generation systems of artificial turf. In fact, previous studies showed that the differences between various systems of artificial turf can be even higher than those between natural grass and artificial turf⁸.

The evolution of the structural components of 3rd generation football fields has resulted in a great diversity of structural combinations between the type of fibre, the filling material, the elastic layer installed, or the selected sub-base⁹. In this sense, previous studies have shown that these structural combinations influence on the mechanical behavior, the response to the intensity of use and the level of maintenance required^{10,11}. Within the support structure, the type of sub-base selected significantly determines the vertical loads and the properties of impact absorption, energy of restitution and standard vertical deformation of the playing surface^{11–15}.

The systems of artificial turf composed by a sub-base of compacted gravel without a shockpad have proven a force reduction and vertical deformation below the limits specified in the normative^{9,12,16}. On the other hand,

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Author Contributions

Conceptualization: J.S.-S. and A.E.-M.; methodology: J.S.-S., A.M.G.-G., A.G.-G. and A.E.-M.; software: J.S.-S., A.G.-G. and A.E.-M.; formal analysis: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; investigation: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; resources: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; data curation: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; writing- original draft: J.S.-S., A.M.G.-G., A.G.-G. and A.E.-M.; Writing- review and editing: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; supervision: J.S.-S., A.M.G.-G., A.G.-G., J.A.S.-S. and A.E.-M.; project administration: J.S.-S. and A.E.-M.

Additional Information

Competing Interests: The authors declare no competing interests.

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