HIGH-LOADING ABSORPTION CHARACTERISTICS OF NATURAL AND ARTIFICIAL TURFS

Hiroyuki Nunome[1], Koichiro Inoue[2] and Yasuo Ikegami[3]

[1]Research Centre of Health, Physical Fitness and Sports, Nagoya University, Nagoya, Japan
[2]Faculty of Human Development, Kokugakuin University, Yokohama, Japan
[3]Faculty of Health and Medical Sciences, Aichi Shukutoku University, Nagakute, Japan

The present study was designed to illustrate shock attenuation characteristics of natural turf as a target property for long pile artificial turf (3-g turf) and to compare the property with that of existing 3-g turf systems. A recently proposed new high loading test was conducted to detect the initial state of shock attenuation property of natural turfs with two different bases (sod and sand base) and of 3-g turfs with three different infills (sand, rubber and sand/rubber). Clear differences between these turfs were observed as the natural turfs are having a higher impact damping and a larger hysteresis with plastic surface deformation. Those features would be beneficial in lowering a high load imparted to the human body but might limit player's performance.

KEY WORDS: new test, third generation turf, initial state.

INTRODUCTION: Use of artificial turf is becoming very common for sports that are usually played on natural lawn, in particular for Soccer and Rugby. After alternations of artificial turf generation, it seems that third generation long pile (3-g) artificial turf generated a more "natural turf" like appearance and acceptable properties, such as: ball-surface interaction. In contrast to a report on an earlier generation of artificial turf (Árnason, Gudmunsson & Johannsson, 1996), several cohort studies reported no clear differences for injury risk (Ekstrand, Timpka, Hägglund, 2006; Fuller, Clarke & Molloy, 2010; Fuller, Dick, Corlette & Schmalz, 2007; Fuller, Dick, Corlette & Schmalz, 2007; Steffen, Andersen & Bahr 2007) and player movement pattern (Anderesson, Ekblom & Krustrup, 2008) between newer 3-g artificial surfaces and natural turf. However, there is still concern and anxiety among coaches and players that some mechanical characteristics of artificial sports surfaces may be linked to acute or chronic sports injuries. Soccer players still had negative overall impression and felt they required greater physical efforts when they play on 3-g artificial turf (Anderesson et al, 2008). There is a possibility that some specific property of 3-g artificial turf might be linked to that impression from players.

Of various aspects required for sports surface, cushioning property is an important feature. Although that characteristic of natural turf could have been a good target for newer artificial turfs, the information on how much 3-g artificial turf mimics that property of natural turf has been very limited. Recently, Nunome, Inoue, Shinkai, Kozakai, Suito & Ikegami (2014) proposed a new testing procedure, which more precisely reflects the acute loading that would be experienced by human sports actions. The construction of this test also allowed measuring the shock absorbency of turfs in on-field situations. It is evident that the shock absorbency performance of natural turf would provide significant insight for improving or fine-tuning the property of conventional 3-g artificial turf.

The present study, therefore, has two aims: (1) to illustrate the shock absorbency performance of natural turf and (2) to compare the shock absorbency characteristics between natural turf and 3-g artificial turf.

METHODS: Three types of 3-g artificial turf tray (90×90 cm) with different infill components: sand [3-g SAND], rubber [3-g RUB] and sand/rubber composite [3-g R/S] were prepared. Each tray was designed to have the same infill depth (35 mm). On the other hand, to obtain initial characteristic of natural turf, two types of natural turf field were specially made for the present study: natural turf with 40 mm depth sod base was transplanted [N SOD] and with 40 mm depth sand base, in which grass seeds was sowed over [N SAND].

An accelerometer and a rotary encoder were installed to the testing rig (Figure 1). The accelerometer produced acceleration –time profiles from the action of the impact head against the sample surfaces. The rotary encoder also measured the angular motion of the impact head through impact to detect loaded surface deformation of the tested samples (Nunome, et al, 2014).

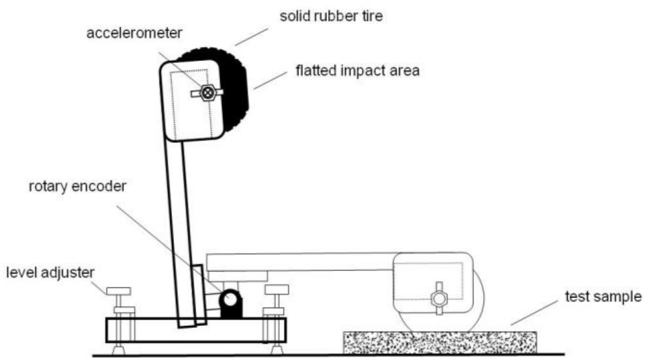

Figure 1: A simplified schema of experimental set up of the current test.

Before testing, the linearity between the changes of acceleration measured from the surface and that of loading force measured from underneath force platform has been verified ($R^2 > 0.9897$) (Figure 2).

The new test was repeated five times at different un-touched, 'fresh' sections of all the turfs. The raw, unsmoothed signal output from the accelerometer and rotary encoder were amplified and fed simultaneously through an analog/digital data conversion system (Power-Lab, ADInstruments Ltd, New Zealand), sampling at 10 kHz and stored in a laptop computer. The test was conducted in indoor (for3-g turfs) and on-field situation (natural turfs).

RESULTS: Figure 3 shows the average acceleration-time curves of two types natural turfs (left panel) and three types 3-g artificial turfs (right panel). Overall, the natural turfs showed apparently lower peak magnitudes (N SOD=50.4±2.5 (g); N SAND=70.8±3.0 (g)) than those of the 3-g artificial turfs (3-g SAND=122.2±1.3 (g); 3-g RUB=83.2±2.3 (g); 3-g R/S= 93.6±2.0 (g)). Differences of the acceleration slope were also evident among all types of turf. It can be seen that there is a distinct change of the acceleration slope for the natural turfs while the 3-g artificial turfs maintained a constant acceleration slope through the on-loading phase.

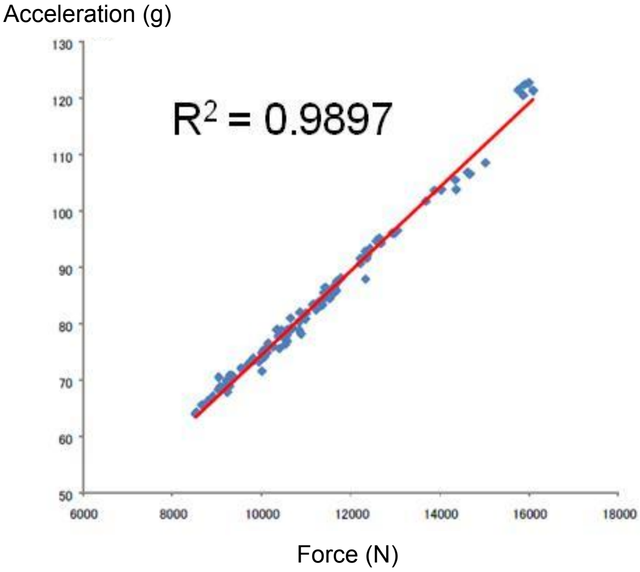

Figure 2: Linearity verification of between the peak acceleration and peak loading force during testing.

The average acceleration-deflection (stress-strain) curves of the natural turfs (left panel) and the 3-g artificial turfs (right panel) are shown in Figure 4. There were distinctive differences between the natural turfs and the 3-g artificial turfs for the stress-strain relationship. The natural turfs tend to deform by less stress than the 3-g artificial turfs during on-loading phase and there was little self-recovering during off-loading phase. It can be seen that apparent surface deformation still exists on both the natural turfs after the impact load was removed. Also there was a distinct difference for the amount of resultant surface deformation between the natural turfs with different base constitutions (N SAND vs. N SOD).

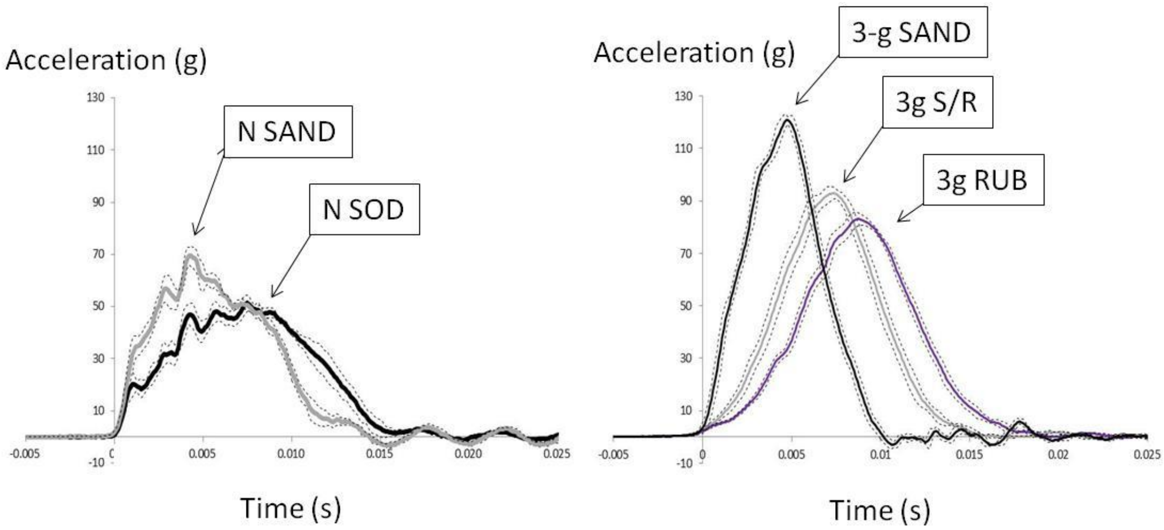

Figure 3: The average (±SD) time series impact acceleration profiles of natural (left panel) and 3-g artificial turfs (right panel).

DISCUSSION: In the present study, a novel attempt was made to illustrate the nature of shock absorbing property of natural turf and those characteristics were compared with that of conventional 3-g artificial turf systems. Using a new testing procedure which was designed to reproduce a similar peak impact load by humans during a hard landing, the present study has clearly demonstrated the differences of the time-acceleration profile and the stress-strain relationship. As a result, the natural turfs tested in the present study were characterized by more absorbed acceleration peaks, variable acceleration slopes, and larger hysteresis with plastic surface deformations.

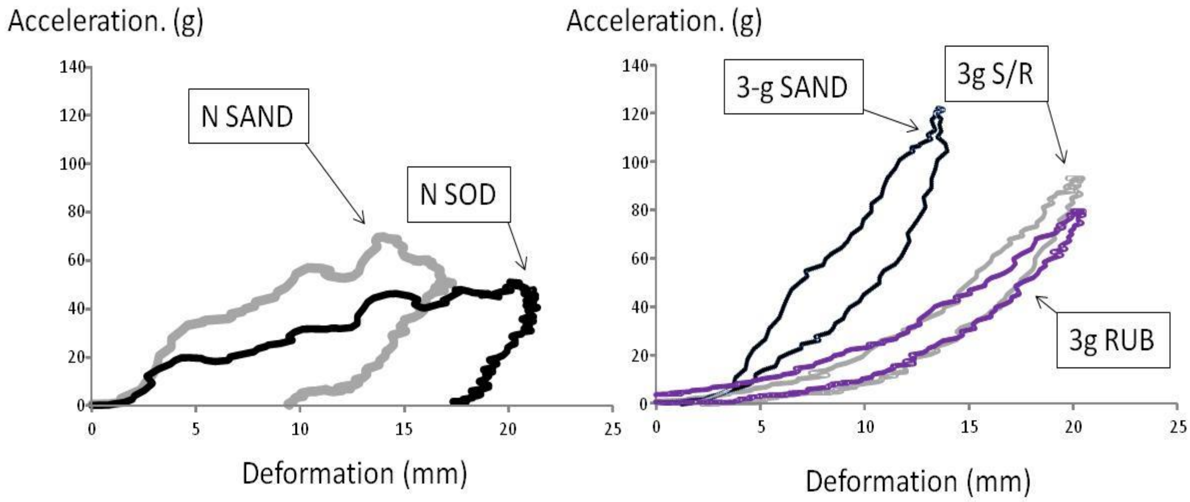

Figure 4: The average acceleration-deflection profiles of natural (left panel) and 3-g artificial turf (right panel).

From a human safety perspective, soft surface profiles have been thought to be beneficial in lowering associated injury risks and specific sports injuries have been considered as a direct consequence of surfaces that are very hard (Dixon, Batt & Collop, 1999; Williams, Hume &

Kara, 2011). The results of this study highlighted that the natural turfs still pose a clear advantage for this aspect when the turfs are in their initial state. Varied acceleration slopes observed in the natural turfs also suggests that the bases of natural turfs are composed with different materials of various densities. It can be assumed that these materials included in turf bases react to the given load sequentially thereby producing a unique, non-linear shock absorbing property. On the other hand, the results of the 3-g turfs suggested that the hardness of 3-g turfs can be varied drastically by changing infill components. It can be assumed that even though sand infills typically used for earlier generation of artificial turf yields a distinctive stress-strain relationship, the 3-g turfs with rubber and rubber/sand infills are producing stress-strain relationships that are closer to the natural turfs.
Conversely, excessive softness would induce a large energy loss thereby reducing a players' performance. The high absorbing property of the natural turfs observed in the present study might be considered as more susceptible to limit player's performance or to cause excessive fatigue on players. Regarding this aspect, the current results do not support the fact that soccer players felt greater physical efforts were required when they play on 3-g artificial turf (Anderesson et al, (2008). However, in the present study, all the turfs were tested in a very high load condition only, thus, further studies are needed to examine the effect of playing surface on players' performance using a lower force magnitude comparable to running or sprinting. A multiple loads test may be warranted to examine the two opposing requirements of sports surface properties.

CONCLUSION: The current investigation succeeded in obtaining shock attenuation property of natural turf and demonstrating clear differences in the characteristics between natural turf and long pile artificial turf. Natural turf was characterized by a higher impact damping and a larger hysteresis with plastic surface deformation.

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