# COMPARISON OF SHOCK ABSORBENCY ON ARTIFICIAL AND NATURAL SOCCER PLAYING SURFACES USING TWO IMPACT TEST ANALYSIS APPROACHES

Muhammad Shaleh Mazuki
Faculty of Sports Science and Recreation, Universiti Teknologi MARA

Shariman Ismadi Ismail
Faculty of Sports Science and Recreation, Universiti Teknologi MARA

Norasrudin Sulaiman
Faculty of Sports Science and Recreation, Universiti Teknologi MARA

Rahmat Adnan
Faculty of Sports Science and Recreation, Universiti Teknologi MARA

他

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# COMPARISON OF SHOCK ABSORBENCY ON ARTIFICIAL AND NATURAL SOCCER PLAYING SURFACES USING TWO IMPACT TEST ANALYSIS APPROACHES

Muhammad Shaleh Mazuki[1], Shariman Ismadi Ismail[1], Norasrudin Sulaiman[1], Rahmat Adnan[1], Hiroyuki Nunome[2], Filip Gertz Lysdal[3], Motohide Arayama[4], and Mohamad Nizam Nazarudin[5]

[1]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Shah Alam, MALAYSIA, [2]Faculty of Sports and Health Science, Fukuoka University, JAPAN, [3]Centre for Health, University College Absalon. Roskilde. Denmark. University College Absalon. Roskilde. Denmark, [4]Dream GP Inc., JAPAN, [5]Faculty of Education, Universiti Kebangsaan Malaysia, Bangi, MALAYSIA

Corresponding author: shariman_ismadi@uitm.edu.my

**Abstract:** *This study aimed to examine the shock absorbency properties of two different soccer playing surfaces, namely the artificial turf (AT) and natural turf (NT), using a bespoke impact test aligned with the FIFA Advanced Artificial Athlete (AAA) testing standard. Measurements were collected using an accelerometer sensor to quantify peak impact force to calculate the shock absorbency property across five field locations, with each location consists of four trials of impact test at the same spot (T1 – T4). Two data analysis methods were compared: (1) using only the first trial (T1) and (2) averaging four consecutive trials (AVG) in determining the impact properties of the two surfaces. Results showed significant differences in shock absorbency on the NT surface between T1 and AVG ($p < 0.05$), while no significant difference was found on AT ($p > 0.05$). This suggests that NT surfaces exhibit greater variability due to environmental and structural inconsistencies, whereas AT surfaces offer more uniform mechanical properties of multiple impact tests. The rubber infill in AT likely contributed to its reduced compressibility and consistent shock response. These findings highlight the importance of considering surface type and test methodology when evaluating playing surface performance. In conclusion, the study emphasizes that analysis methods and surface characteristics substantially influence shock absorbency measurements. A standardized and surface-specific approach is essential for accurate assessment.*

**Keywords:** Soccer; Surface; Shock Absorbency; Mechanical Test; FIFA

## 1. INTRODUCTION

Soccer, widely regarded as the world's most popular sport, boasts an impressive 275 million players across the globe [1]. Its global appeal is largely driven by the game's exciting and dynamic nature, which features countless spontaneous movements. During match play, players frequently execute directional changes, primarily between 0° and 90°. Defenders complete approximately 700 turns per match, while midfielders and strikers perform around 500 and 600 turns respectively. Notably, midfielders and strikers tend to make more turns between 270° and 360° [2].

It is well established that an effective force generation from surface-athlete interaction is vital for executing sport-specific movements [3]. Previous studies showed that soccer players execute quick changes of direction motion which include several movements (sprinting, running, and cutting), and the player-playing surface interaction involving high-impact force during cutting maneuver can be manipulated by altering the playing surface mechanical properties [4,5].

With regards to the playing surface, playing on artificial turf has been associated with increased physical effort and more difficulty in ball control [6,7], whereas natural turf has been reported to impose a higher relative load during cutting movements [8]. Other studies indicate that contact time during cutting maneuvers in sports like soccer and rugby is significantly shorter on artificial turf, possibly due to differences in ground reaction forces and quicker force attenuation [9]. The type of playing surface also influences variables such as shooting accuracy, plantar loading during agility tasks, and game speed, with harder surfaces being associated with faster play [10].

Investigation on these forces and impact attenuation-related variables are commonly measured using an IMU sensor or accelerometer—a device that measures acceleration or movement by humans and in mechanical tests to evaluate playing surface properties [11,12].

According to the FIFA Quality Concept Standard, the shock absorption of a soccer-playing surface is measured using the Advanced Artificial Athlete (AAA) device. The FIFA protocol involves conducting three impact tests and calculating the average value [12]. However, some recent studies have adopted different approaches. For example, one study used the average of the fourth and fifth impact trials to assess the effect of foamed shock pad designs on energy absorption [13]. Others have reported using average values from all trials [14], only the highest recorded value [15], or the average peak impact force from five separate, untouched test sections [16]. Furthermore, studies using human subjects have incorporated accelerometers placed on the head and lower leg to assess impact properties across fields with different structural configurations [17].

One such study also explored the correlation between human-measured impact data and shock absorbency as measured by the AAA device, using the average of the second and third impact trials for analysis. Despite the establishment of a standardized testing protocol by FIFA, current practices in impact test analysis remain inconsistent. Various studies employ differing data analysis methods ranging from averaging all trials to selecting only the highest or selected subset of values, highlighting a lack of consensus.

Therefore, the objective of this study was to examine the shock absorption properties of two different soccer playing surfaces using a customized impact test based on the FIFA Quality Programme Standard (AAA). Two data analysis methods were proposed and compared: one using the average value from only the first trial, and the other using the average of four trials. It was hypothesized that the selection of the data analysis method would significantly affect the measured shock absorbency of the soccer turf.

*Figure 1: Artificial turf and Natural turf*

## 2. METHODS

A total of five locations within a 2m x 6m area of two soccer turfs (AT and NT) were selected for data collection (Figure 1). The impact force for each location (P1 – P5) was measured using a bespoke impact tester for four trials on each exact location for both the AT and NT soccer turf (Figure 2). There was a one-minute interval rest between each trial conducted to allow the turf surface elastic component to return to its original state after the impact force had deformed the turf's surface.

In this study, a bespoke surface impact test was used to measure the soccer mechanical properties, namely the surface peak impact force and surface shock absorbency (SA). The bespoke surface impact test (based on AAA FIFA standard) is a test used to replicate impact ground reaction from vertical force and contact time from heel strike in sports performance. The test foot was hung at 90mm from the soccer turf surface (Figure 3) and was released onto the test surface by using the release lever to generate impact to the test AT and NT surface (Figure 1: a and b). An initial test was conducted to verify the bespoke device met the FIFA standard of maximum impact force (reference force) at 6760N when tested on a hard-solid flooring surface according to the FIFA standard.

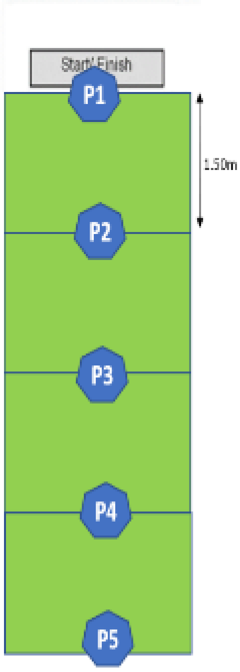


*Figure 2: impact test location on test sides for both natural and artificial turf (Five location: P1-P5).*

An accelerometer is a device that can be used to measure the force of an impact (Figure 4). The device is used as a surface impact tester sensor (based on the AAA FIFA

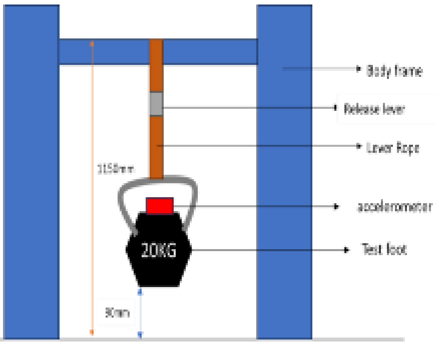


*Figure 3: Prototype bespoke impact tester (based on AAA FIFA standard).*

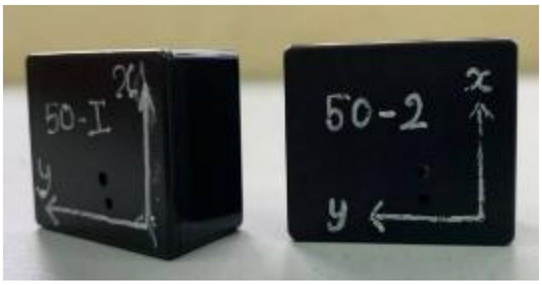


*Figure 4: Accelerometer device (3-axis 50G at 200Hz used in this study, produced by 4-assist Inc., Japan*

standard) on two soccer fields: artificial and natural turf utilized in this study. The accelerometer was placed on top of the test foot. The first impact force test was conducted on hard-solid flooring to measure Fref according to FIFA standards. Next, an impact test was conducted for the soccer field to measure Fmax and shock absorbency properties for the artificial and natural turf. On each playing surface, measurement of the impact test was conducted at five locations (P1 – P5) as shown in Figure 4. Average data from these five locations was used to calculate the measure of Fmax and shock absorbency properties for the artificial and natural turf. The calculation reference used in this study was based on the FIFA (Test Manual I – Test Methods: 2015 Edition- FIFA Quality Programme for Football Turf), as shown in the calculation below:

- Shock absorption calculation $F_{max} = (m \times g \times G_{max}) + m \times g$
- $F_{max}$, is the peak force, expressed in Newton (N)
- $G_{max}$, is the peak acceleration during the impact, expressed in multiples of the acceleration due to gravity (g)
- $m$, is the falling mass, which is the kettlebell weight
- $g$, is the gravity value at the accelerometer
- on the calculation for shock absorption $SA = \left[1 - \frac{F_{max}}{F_{ref}}\right] \times 100$
- SA is the shock absorption on %
- $F_{max}$, is the force max measured on the sports surface, in N.
- $F_{ref}$ is the reference force value of each surface (artificial and natural) value for a concrete floor 6760N

**STATICAL ANALYSIS**

A normality test was conducted using IBM SPSS Statistics 27.0.1 which uses Levene's Test for Equality of Variances, Skewness Values, and Kurtosis values. In addition, an independent t-test was conducted to compare trial 1 (T1) and the average bespoke impact test at two different playing surfaces (AT and NT) using IBM SPSS Statistics 27.0.1.

## 3. RESULTS

The results and data analysis are shown below:

Table 1 Levene's Test for Equality

| Levene's Test for Equality of Variances | | | |
|---|---|---|---|
| | f | Sig. | df |
| AT | 1.279 | 0.291 | 8 |
| NT | 0.709 | 0.424 | 8 |

The results of Levene's Test for Equality of Variances are presented AT and NT in Table 1. For the AT impact force F (1,8) 1.279, p=0.291. For NT impact force, F (1,8) = 0.709, p = 0.424.

Table 2 Skewness Values

| Skewness | | |
|---|---|---|
| | Statistic | Std. Error |
| AT | -0.990 | 0.687 |
| NT | 0.096 | 0.687 |

Skewness values were calculated for the variables AT and NT. The skewness of AT was found to be -0.990 (SE = 0.687), indicating a negative skew, while the skewness of NT was 0.096 (SE = 0.687), suggesting a near-normal distribution.

Table 3 Kurtosis values

| | Kurtosis | |
|---|---|---|
| | Statistic | Std. Error |
| AT | 1.388 | 1.334 |
| NT | -0.953 | 1.334 |

Kurtosis values were calculated for the variables AT and NT. The kurtosis for AT was 1.388 (SE = 1.334), indicating a moderately peaked distribution, while the kurtosis for NT was -0.953 (SE = 1.334), suggesting a relatively flat distribution compared to a normal distribution.

Independent t-test

Table 4 Independent t-tests

| | t | df | Sig. |
|---|---|---|---|
| AT | -1.119 | 8 | 0.296 |
| NT | -4.021 | 8 | 0.004 |

Independent t-tests were conducted to compare the means of SA property between T1 and AVG for both AT and NT. For AT, t (8) = -1.119, p=0.296 indicating no significant difference. For NT, t (8) = -4.021, p = 0.004, suggesting a statistically significant difference.

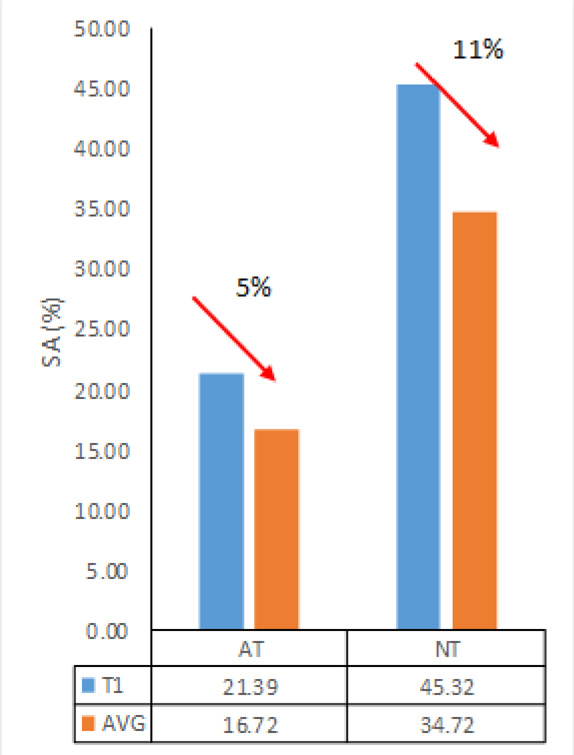


*Figure 5 Shock Absorption (SA) at AT and NT field*

The graph shows shock absorption (SA) compares the T1 and AVG impact tests on AT and NT playing surfaces. AT showed a T1 value of 26.08 and NT T1 was 17.84. The value of AVG at AT was 27.69 and NT was 21.41. Differences in the shock absorption component between T1 and Avg value at AT was 5% and NT recorded changes of 11%.

## 4. DISCUSSION

The purpose of this study was to examine the impact test measurements of soccer surfaces. Two different playing surfaces were tested using a bespoke impact test based on the FIFA Quality Programme for the Advanced Artificial Athlete (AAA). Two surfaces (AT and NT) were used in this study, and their hardness at specific locations was measured using the bespoke impact test based on the AAA FIFA standard. It was hypothesized that there would be a significant difference in shock absorbency of the two soccer turfs (AT and NT) when analysed using two different analysis methods.

The study results demonstrated a significant difference on the NT surface compared to the AT surface in impact tests at T1 and AVG. The NT impact test values ($p<0.05$) showed a significant difference in the mean effect of impact resistance, hardness, or shock absorption (reduction of shock absorbency at 11%). Meanwhile, the AT values ($p>0.05$) suggest consistency in the AT-engineered material, such as the rubber infill and synthetic fiber, which provide uniform impact resistance, resulting in less variability across tests (reduction of shock absorbency at 5% only). The results from the independent t-tests indicate that the impact force of the soccer surface is according to the specific turf type. For artificial turf (AT), the force value T1 was 5313.49N and the Average force value was 5629.08N, natural turf (NT) was 3695.62N for T1 and 4412.34N for average force value.

In addition, previous studies showed that the NT was significantly influenced by environmental factors such as rain, heat, and insects as compared to the AT [18,19]. Unlike AT, the natural grass will absorb water through its roots and this may influence the soil's mechanical properties [20]. This condition may facilitate AT to maintain its soil's structural integrity under intense weather inconsistency. Furthermore, AT playing surfaces typically possessed a much more consistent and even surface throughout the fields when compared to a natural grass soccer field [19]. This condition would likely have influenced the outcome of this study.

Meanwhile, the lower changes in the SA property of AT as compared to NT may be contributed by the property of the rubberized infill used in the AT playing surface. Styrene-butadiene rubber (SBR) is commonly used as a performance infill material due to its performance levels and low cost. It was previously demonstrated that SBR was found to be less compressible than other organic materials under high normal loading [20]. Therefore, it is also likely the AT surface tested in this study was also less compressible when being impacted more than once at the same spot as compared to the NT surface which would be much more compressible and more compact after four trials of impact test.

Nevertheless, there was a previous study that has challenged this conclusion. One study found that there were no substantial performance differences between natural and high-quality hybrid turfs, suggesting that maintenance practices, such as irrigation and grass length, play a pivotal role in the performance of natural turf [21]. The significant result observed in this study may reflect specific testing conditions (e.g., dry versus wet turf) or variations in turf wear, which can influence the playing characteristics of the surface [22].

## 5. LIMITATION

This study was conducted at only one specific location (2 width x 3 length) on the soccer turf. To obtain a more comprehensive and representative understanding of the surface's overall condition, it is recommended that similar tests be conducted at multiple locations across the entire field. Meanwhile, the maintenance of the soccer field should be documented and considered as a significant influencing factor. The manufacturing quality of the artificial grass used in the soccer turf is a critical factor that must be assessed [23]. The characteristics of the infill material used in the artificial turf, such as its composition, granule size, elasticity, and distribution, should also be examined and considered as factors that may influence the study outcome.

## 6. CONCLUSIONS

In this study, it was successfully demonstrated that AT playing surfaces were likely less affected by multiple impact tests conducted on the same spot on the surface, potentially due to its mechanical property and turf construction as compared to an NT playing surface. These results highlight the importance of considering a test approach based on the type of playing surface or its mechanical property and construction specification.

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**REFERENCES**

[1] Kirkendall, Donald T. "Evolution of Soccer as a Research Topic." Progress in Cardiovascular Diseases, vol. 63, no. 6, 1 Nov. 2020, pp. 723–729, www.sciencedirect.com/science/article/abs/pii/S0033062020301341?via%3Di hub, https://doi.org/10.1016/j.pcad.2020.06.011. Accessed 1 Feb. 2024.

[2] Lake MJ. Determining the protective function of sports footwear. Ergonomics. 2000 Oct 1;43(10):1610-21

[3] Bloomfield, Jonathan, et al. "Physical Demands of Different Positions in FA Premier League Soccer." Journal of Sports Science & Medicine, vol. 6, no. 1, Mar. 2007, p. 63, pmc.ncbi.nlm.nih.gov/articles/PMC3778701/. Accessed 15 Apr. 2025.

[4] Mazuki, Muhammad Shaleh, et al. "The Influence of Soccer Boots Insole's Surface Roughness and Hardness on Short-Sprint and Change of Direction 132 Performance." Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES), vol. 10, 17 Oct. 2024, pp.42–47.

[5] Wannop, John W, et al. "Influence of Artificial Turf Surface Stiffness on Athlete Performance." Life, vol. 10, no. 12, 10 Dec. 2020, pp. 340–340, www.mdpi.com/2075-1729/10/12/340, https://doi.org/10.3390/life10120340.

[6] Kaalund, Søren, and Pascal Madeleine. "Effects of Shock-Absorbing Insoles during Transition from Natural Grass to Artificial Turf in Young Soccer Players." Journal of the American Podiatric Medical Association, vol. 104, no. 5, 1 Sept. 129 2014, pp. 444–450, pubmed.ncbi.nlm.nih.gov/25275731/, https://doi.org/10.7547/0003-0538-104.5.444.

[7] Sassi, Aldo, et al. "The Cost of Running on Natural Grass and Artificial Turf Surfaces." Journal of Strength and Conditioning Research, vol. 25, no. 3, 1 Mar. 2011, pp. 606–611, journals.lww.com/nscajscr/fulltext/2011/03000/The_Cost_of_Running_on_Natural_Grass_and.5.aspx, https://doi.org/10.1519/jsc.0b013e3181c7baf9.

[8] Ford, Kevin R, et al. "Comparison of In-Shoe Foot Loading Patterns on Natural Grass and Synthetic Turf." Journal of Science and Medicine in Sport, vol. 9, no. 6, 1 Dec. 2006, pp. 433–440, www.sciencedirect.com/science/article/abs/pii/S1440244006000430, https://doi.org/10.1016/j.jsams.2006.03.019.

[9] Strutzenberger, Gerda, et al. "Player–Surface Interactions: Perception in Elite Soccer and Rugby Players on Artificial and Natural Turf." Sports Biomechanics, 2020, www.tandfonline.com/doi/abs/10.1080/14763141.2020.1720279.

[10] Mathew, Sithin, et al. "Grasses for Sports Grounds and Its Influence on Playing Quality: A Review." ~ 17 ~ Journal of Pharmacognosy and Phytochemistry, vol. 10, no. 2, 2021, www.phytojournal.com/archives/2021/vol10issue2S/PatA/S-10-1-107-713.pdf.

[11] Liu, Beiying, et al. "A Wearable Motion Capture Device Able to Detect Dynamic Motion of Human Limbs." Nature Communications, vol. 11, no. 1, 5 Nov. 2020, www.nature.com/articles/s41467-020-19424-2, https://doi.org/10.1038/s41467-020-19424-2.

[12] FIFA. "FIFA Quality Programme for Football Turf." Fifa.com, 2020, www.fifa.com/technical/football-technology/standards/football-turf/fifaquality-programme-for-football-turf

[13] Hiroyuki Nunome, et al. "A Novel Comparison between Standard and New Testing Procedures to Assess Shock Absorbency of Third Generation Artificial Turfs." Sports Engineering, vol. 17, no. 2, 14 Dec. 2013, pp. 103–112, link.springer.com/article/10.1007/s12283-013-0146-7, https://doi.org/10.1007/s12283-013-0146-7. Accessed 10 Apr. 2025.

[14] Sproule, D. W., Campolettano, E. T., & Rowson, S. (2017). Football helmet impact standards in relation to on-field impacts. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 231(4), 317–323. https://doi.org/10.1177/1754337117703019

[15] Nigg, B. M., & Yeadon, M. R. (1987). Biomechanical aspects of playing surfaces. Journal of Sports Sciences, 5(2), 117–145. https://doi.org/10.1080/02640418708729771.

[16] Allgeuer, Thomas, et al. "Study of Shockpads as Energy Absorption Layer in Artificial Turf Surfaces." Sports Technology, vol. 1, no. 1, Jan. 2008, pp. 29–33, https://doi.org/10.1080/19346182.2008.9648448. Accessed 7 Dec. 2020

[17] Sánchez-Sánchez, Javier, et al. "Influence of the Structural Components of Artificial Turf Systems on Impact Attenuation in Amateur Football Players." Scientific Reports, vol. 9, no. 1, 23 May 2019, www.nature.com/articles/s41598-019-44270-8, https://doi.org/10.1038/s41598-019-44270-8.

[18] Stiles, V. H., James, I. T., Dixon, S. J., & Guisasola, I. N. (2008). Natural Turf Surfaces. Sports Medicine, 39(1), 65–84. https://doi.org/10.2165/00007256-200939010-00005

[19] Burgers, R. (2015). A study on improving the comfort of artificial grass in sports. https://doi.org/10.13140/RG.2.1.3969.2963

[20] Kamal, Masud. "(PDF) Natural Grass vs Synthetic Surfaces for Recreation and Sports: An Evidence Review." ResearchGate, 2019, www.researchgate.net/publication/342852314_Natural_grass_vs_synthetic_surfaces_for_recreation_and_sports_An_evidence_review, https://doi.org/10.13140//RG.2.2.20840.08969. Accessed 26 May 2025.

[21] McGowan, H., Fleming, P., James, D., McMahon, J., Pak, J.-H., & Forrester, S. (2025). Investigating normal stress effects on the shear and traction characteristics of performance infill materials used in artificial turf surfaces. Sports Engineering, 28(1). https://doi.org/10.1007/s12283-025-00489-5

[22] Roberts, Jonathan R, et al. "Elite Players' Perceptions of Football Playing Surfaces: A Qualitative Study." Research Quarterly for Exercise and Sport, vol. 91, no. 2, 24 Oct. 2019, pp. 239–251, pubmed.ncbi.nlm.nih.gov/31647370/, https://doi.org/10.1080/02701367.2019.1660757.

[23] Serin H, Şahin Y. A Research on Obstecles Originating from The Management Departments About Quality Improvement and Development. (IEICES) Vol.3(2017): 31-34.