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Effects of playing surface on physical, physiological and perceptual responses to a repeated sprint ability test: natural grass versus artificial turf

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Effects of playing surface on physical, physiological and perceptual responses to a ~~performance, fatigue perception and blood markers of inflammation, muscle damage and immune function during~~repeated sprint ability test: natural grass versus artificial turf

Abstract

Purpose: The effect of playing surface on physical performance during a repeated sprint ability (RSA) test, and the mechanisms for any potential playing-surface-dependent effects on RSA performance, is equivocal. The purpose of this study was to investigate the effect of natural grass (NG) and artificial turf (AT) on physical performance, ratings of perceived exertion (RPE), feeling scale (FS) and blood biomarkers related to ~~fatigue~~anaerobic contribution [lactate (Lac)], muscle damage [creatine kinase (CK) and lactate dehydrogenase (LDH)], inflammation [c-reactive protein (CRP)] and immune function [neutrophils (NEU), lymphocytes (LYM) and monocytes (MON)] in response to a RSA test. **Methods:** Nine male professional football players from the same regional team ~~were randomly assigned to~~ completed two sessions of RSA testing (6 × 30 s interspersed by 35 s recovery) on NG and AT in a randomized order. During the RSA test, total (sum of distances) and peak (highest distance covered in a single repetition) distance covered were determined using a measuring tape and the decrement in sprinting performance from the first to the last repetition was calculated. ~~and covered, best performance and performance decrementin sprinting performance,~~ Before and after the RSA test, RPE, FS, and blood [Lac], [CK], [LDH], [CRP], [NEU], [LYM] and [MON] were recorded in both NG and AT conditions. **Results:** Although physical performance declined during the RSA ~~sprint~~ blocks on both surfaces (p=0.001), the distance covered declined more on NG (15%) compared to AT [11%; p=0.04, ES=-0.34, 95% CI (-1.21, 0.56)] with a higher total distance covered (+6 ± 2%) on AT [p=0.018, ES=1.15, 95% CI (0.16, 2.04)]. In addition, ~~This improved RSA on AT compared to NG was accompanied by~~ lower RPE [p=0.04, ES=-0.49, 95% CI (-1.36, 0.42)] and blood [Lac], [NEU] and [LYM] [p=0.03; ES=-0.80, 95% CI (-1.67, 0.14); ES=-0.16, 95% CI (-1.03, 0.72) and ES=-0.94, 95% CI (-1.82, 0.02), respectively)] and more positive feelings [p=0.02, ES=0.81, 95%CI (-0.13, 1.69)] were observed following the RSA test performed on AT compared to NG. No differences were observed in the remaining physical and blood markers. ~~There were no between playing surface differences in the other blood biomarkers (p>0.05)~~. **Conclusion:** These findings suggest that RSA performance is enhanced on AT compared to NG. This effect was ~~is enhanced on AT compared to NG, an effect thatis~~ accompanied by lower fatigue perception and blood [Lac], [NEU] and [LYM], and a more pleasurable feeling. These observations might have implications for physical performance in intermittent team sports athletes who train and compete on different playing surfaces.

Keywords: Soccer; Biochemical; Sport; Fatigue.

Introduction

It is widely accepted that ~~the~~ performance ~~of~~ in football (soccer) ~~players~~ is ~~not solely~~ affected by internal factors such as the ~~their~~ age, fitness status and cognitive abilities of the players.[1,2] ~~physical and cognitive abilities, but also by external factors.[1]such as~~ In addition, environmental factors, including the playing context ~~characteristics of the ball and~~, shoes characteristics and playing surface ~~with whichtheythe player interact~~ have been identified as important external factors that can influence football performance.[2-4] In 2005, the use of the ~~third~~ 3rd generation~~(3G)~~ artificial turf (AT) was officially approved by the Union of European Football Associations (UEFA) and the International Federation of Association Football (FIFA) as an alternative to natural grass ~~turf~~ (NG) surfaces in their official football tournaments.[5] Since this official approval, use of AT has increased exponentially for both training and competition ~~official football games or for training~~.[6-8] Accordingly, ~~this has resulted in~~ an ~~increased~~ increasing number of research studies ~~being~~ have been conducted to assess the influence of playing surface on various technical and physical components of football performance and injury risk.[9-11]

To date, studies assessing the influence of playing surface type on physical performance abilities have yielded conflicting results. During competitive games, Andersson et al.[10] observed similar running (e.g., sprint number, high-intensity running and total covered distance) and technical (e.g., standing tackles) patterns on AT compared to NG. Moreover, single sprint ~~performance~~,[11] as well as jumping and agility performances[12,13] appear to be similar on AT and NG during a soccer-simulation protocol. On the other hand, the effect of playing surface on repeated sprint ability (RSA)~~, on the other hand~~ is equivocal.[13,14] ~~However, p~~Playing surface has been shown to influence some variables, such as the peak and average speed,[15] the playing style~~,~~[10] and the change of direction ability~~,~~[11,12,14] with players also exhibiting better technical skills (e.g., fewer sliding tackles, more short passes and faster turns and direction change abilities) on AT compared to NG. These findings suggest that exercise tasks that require more direction changes might be more likely to observe a beneficial effect on AT compared to NG. However, the physiological and perceptual bases of these potential surface-dependent effects on physical and technical components of football performance are poorly defined.

Empirical research studies assessing physiological responses to exercise performed on AT compared to NG have yielded inconsistent findings.[3] Although, higher blood lactate (Lac) values at given heart rate (HR) have been observed during an incremental running test performed on AT compared to NG, [16] it has also been reported that ~~heart rate (HR)~~, Lac accumulation~~, as well as the~~ and the metabolic cost of running were not different during a football match simulation and constant-speed running ~~on~~ between NG and AT.[12,17] Stone et al.[13] were the first to assess the muscle damage response to 90 min soccer-simulation protocol (SSP) played on AT and NG and reported that blood creatine kinase (CK) concentration was similar for both surfaces immediately and up to 48 hours post-test. Since CK is just one indicator of muscle damage and two or more biomarkers are recommended to accurately infer muscle damage,[18] further studies using multiple biomarkers (e.g., CK and lactate dehydrogenase (LDH))[19,20] are required to robustly address the influence of surface-type on muscle damage responses following physical exercise. Moreover, the effect of playing surface on biomarkers of immune response [e.g., neutrophils (NEU), monocytes (MON), and lymphocytes (LYM)],[21,22] inflammation [e.g., C-reactive protein (CRP)],[23,24] metabolism (e.g., Lac and glucose (GLC)),[25] and perceptual responses during exercise has yet to be investigated.

Given that the effects of playing surface on muscle damage, and inflammatory and immune responses to physical exercise is poorly defined, and given the discrepancy in the existing literature assessing the effect of playing surface on physical performance, the purpose of this study was to assess the effect of AT ~~compared to~~ vs. NG on physical performance and perceptual and physiological responses to ~~responses in~~ a multiple direction change RSA test in football players. It was hypothesized that RSA performance would be enhanced on AT compared to NG concomitant with lower ~~physiological and~~ perceptual strain. Moreover, since previous studies suggest that physical performance can be enhanced when muscle damage and inflammatory responses to exercise are attenuated,[13,26,27] it was also hypothesized that enhanced RSA performance on AT would be accompanied by reduced acute physiological stress responses.

Methods

Subjects~~Participants~~

Nine male professional football players (mean ± SD age: 21.8 ± 1.1 years, body mass: 69.4 ± 9.8 kg, ~~stature~~height: 1.78 ± 0.62 m, body fat: 11.4 ± 2.5%) from the same regional team volunteered to participate in this study. All subjects ~~participantshad~~ had at least five years of experience in practicing ~~as a~~ football ~~player~~ and they usually trained at least three to four days per week for an average of 2 h per day ~~daily~~. To ensure an objective evaluation of the AT and to avoid any effect of adaptations,[28] subjects~~participants~~ were not accustomed to regularly training or playing on 3rd generation~~3G~~ AT. None of the subjects ~~participantshad~~ had any ~~known~~previous injury or cardiopulmonary disease and they did not ingest any antioxidant compounds or medications (e.g., anti-inflammatory agents) for six months prior to, or during,~~or six months prior to, the start of~~ the study. After receiving a thorough explanation of the possible risks and discomforts associated with the experimental procedures, subjects~~participants~~ provided written informed consent to participate in the study. The experimental procedures of the present study were approved by the University's Ethics Committee and conformed to the last version of the Helsinki Declaration.

Design

Following an initial familiarization session, subjects~~participants~~ performed two test sessions in a randomized order on AT ~~(3G surface)~~and NG which had achieved a “FIFA 1 Star” rating. A period of 72 h separated the ~~different~~ test sessions to ensure ~~the~~ full recovery ~~of the~~ for each players.[7] Test sessions were conducted in the afternoon ~~hours~~ (15:00–16:30) since this timeframe has been reported to coincide with optimal physiological responses and maximum levels of power output during different ~~forms of~~ physical exercise tests.[20,26,27] Players reported to the ~~test~~ football pitches at 14:00 to record ~~and had their~~ body mass (Tanita, Tokyo, Japan) and height ~~recorded~~ (Secastadiometer, Germany) during their first session. Before starting the physical test, subjects~~participants~~ performed a standard ~~pre-test~~ warm-up consisting of 5 min of continuous running, 5 min of articulation mobility exercises and three sprints of 30 m of increasing intensity interspersed by ~~, with a~~ 2 min recovery ~~between each test~~.[7] Upon completion of the last 30 m sprint, subjects~~participants~~ rested for 5 min before performing the RSA test and they were verbally instructed to provide maximum effort during the test. Blood samples were collected before and after the RSA test~~,~~. ~~RSA performance (i.e.,~~ From the distance recorded in each sprint, best ~~sprint~~ and total distance,~~)~~ and fatigue index were recorded ~~during each test session,~~ and ratings of perceived exertion (RPE) and feeling scale (FS) were ~~also~~ assessed after the~~each~~ RSA test. Subjects~~Participants~~ were asked to maintain their usual sleeping habits, with a minimum of 7 h of sleep the night preceding each test session. They were instructed to use the same footwear in all sessions, to maintain their habitual physical activity ~~while~~ and to avoiding strenuous exercise during the 24 h before ~~the~~ testing ~~sessions~~. They were also advised to ingest a standardized meal at least 4 h before ~~the~~each test sessions, as recommended by Bougard et al.[29], to avoid the effects of postprandial thermogenesis. The geographical proximity (i.e., Sfax, Tunisia) of the AT and NG provided similar climatic conditions (temperature: 18–22°C, humidity: 40–46% and precipitation: 19mm during February) in all tests.

Methodology

RSA test

As described by Boukhris et al.[30], the RSA test~~ing~~ consisted of six repetitions of a 30 s maximal shuttle sprint over 5 m, 10 m, 15 m and 20 m alternatively (Figure 1), interspersed by a recovery period of 35 s.[31] During each recovery period, the subject returned to the starting position.~~Total and the~~. Distance covered during the 30 s bout was recorded to the closest 1 m using a measuring tape.[31] Subsequently, peak (highest distance covered during one of the six 30 s bouts) and total (total distance covered during the six 30 s bouts) distances covered~~, as well as~~ and the percentage decline of performance (%Dec) from the first to the last repetition ~~(%Dec)~~ and the difference between the best and the worst sprint distance (%Diff) during the RSA were calculated.[31] ~~The %Diff was used as a fatigue index, as suggested by Spencer et al.~~[21]

Ratings of Perceived Exertion (RPE)

Subjects~~Participants~~ estimated their subjective exertion rating using the RPE scale. ~~were presented with an RPE scale to provide a subjective exertion rating for the RSA test.~~ The RPE scale consisted of a 15-point scale ranging from 6 (no exertion) to 20 (maximal exertion). The RPE scale is a reliable indicator of physical discomfort, has robust psychometric properties, and is strongly correlated with several ~~other~~ objective physiological measures of exertion.[32]

Feeling Scale (FS)

To measure differences in feelings of pleasure and displeasure experienced during exercise, the single-item ~~Feeling Scale (FS)~~[33] was used. The scale is presented on an 11-point continuum from -5 to +5 with negative responses indicating unpleasurable feelings, ~~and~~ positive responses suggesting pleasurable feelings and 0 corresponding to "neutral" feelings. The simplicity of the scale allows for quick administration at multiple time points during and after exercise and provides a global sense of affect; but is unable to characterize specific mood states.[33]

Blood sampling and analysis

Blood samples were collected from a forearm vein before (after 5 min of seated rest), and 3–5 min after the RSA test on ~~both the~~ AT and NG ~~sessions~~. Samples were placed in an ice bath and centrifuged immediately at 3000 rpm and 4°C for 10 min. Aliquots of the separated plasma were stored at -80°C until analysis. To eliminate inter-assay variance, all samples were analyzed in the same assay run. All assays were performed in duplicate in the same laboratory with simultaneous use of a control serum from Randox. Hematological parameters (i.e., ~~neutrophils (~~NEU~~)~~, ~~Lymphocytes (~~LYM~~)~~ and ~~Monocytes (~~MON~~)~~) were performed within 3 h in a multichannel automated blood cell analyzer [Beckman Coulter Gen system-2 (Coulter T540, Germany)]. Plasma ~~glucose (~~GLC~~)~~, ~~Lactate~~ Lac, muscle damage markers ~~(i.e., creatinine kinase (CK) and lactate dehydrogenase (LDH))~~and CRP were determined spectrophotometrically using an Architect Ci-4100-ABBOTT analyser (Abbott Deutschland, Wiesbaden, Germany).[21] CK, LDH and CRP were respectively measured with the N-acetyl-L-cysteine method, the oxidation of Lac~~lactate~~ to pyruvate method and the immunoturbidimetric method. The intra-assay coefficients of variation for these parameters ~~kit~~ were 1.3%, 0.2% and 1.16%, respectvely.[21]

Statistical analysis

~~All statistical tests were completedusing STATISTICA 10.0 Software (Stat-Soft, Maisons-Alfort, France).~~ Normality of distribution was confirmed using the Shapiro–Wilks W-test. Paired-samples *t*-tests were used to analyze the effect of surface (AT vs. NG) on best ~~performance~~ and total distance, %Dec, %Diff, RPE and FS. To analyze the effect of surface on distance covered during the six repetitions of the RSA test, a two-way repeated-measures ANOVA [surface: 2 levels (AT and NG) × sprint-block: 6 levels] was used. To analyze the effect of surface on the acute blood marker responses (pre-post values) during the RSA test, a two-way repeated-measures ANOVA [surface: 2 levels (AT and NG) × time: 2 levels (Pre and Post)] was used. Tukey's honest significance difference post-hoc tests were conducted to determine the origin of significance when a significant ~~main or interaction effects were~~*F-ratio* was observed ~~using Tukey's honest significance difference (HSD).Effect sizes were calculated as partial eta-squared (η_p^2) for the ANOVA analysis and as Cohen's d for the paired sample *t*-tests.~~ Effect size (ES) was calculated to determine the magnitude of the change score and was interpreted using the following criteria: <0.2 = trivial, 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 = large, and >2.0 = very large.[34] Confidence intervals (CI 95%) for ES were also specified. Data are presented as mean ± SD and statistical significance was set at p<0.05. All statistical tests were completed using STATISTICA 10.0 Software (Stat-Soft, Maisons-Alfort, France).

Results

RSA performance, RPE and feeling scale

There was a significant main effect for RSA sprint block (F=11.43, p=0.001~~, η_p^2= 0.62~~) with lower ~~performance~~ distance covered registered in the last sprint block compared to the first sprint block on both AT [(rate of decrease =-11±3%, ES=-1.97, 95% CI (-2.94 to -0.83)] and NG [(rate of decrease =-15±4%, ES=-1.66, 95% CI (-2.60 to -0.59)] (Figure 1). In addition, there was a main effect for surface on RSA performance (F=8.34, p=0.03~~, η_p^2=0.54~~) with a higher RSA performance on AT compared to NG only during the last three sprint blocks (i.e., 4-6) [(p=0.009; ES=0.91, 95% CI (-0.05 to 1.79); ES=0.84, 95% CI (-0.10 to 1.72) and ES=0.63, 95% CI (-0.30 to 1.50), respectively)] (Figure 2). Similarly, a significant between-surface effect was observed in the total distance covered (t(8)=2.95, p=0.018, ES=1.15, 95% CI 95% (0.16 to 2.04~~, d=1.12~~) with higher (+6±2%) distance covered on the AT (Figure 3) compared to NG. There was no significant difference between AT and NG for best

~~performance~~ distance covered and fatigue index ($p>0.05$) (Figure 3). A significant between-surface effect was observed for RPE [(t(8) =-2.31, $p=0.04$, ES=-0.49, 95% CI (-1.36 to 0.42~~d=0.50~~)] and FS [(t(8) =2.82, $p=0.02$, ES=0.81, 95% CI (-0.13 to 1.69~~d=0.83~~)] with lower RPE values (13.8±2.7 vs. 15.2±3.2) and higher FS values (1.4±1.5 vs. 0.10±1.7) on AT compared to NG. ~~(Table 1).~~

~~Physiological~~Inflammatory, immune and muscle damage responses

There was a significant main effect for time for muscle damage parameters (F=77.7, $p=0.0006$~~η_p^2=0.9~~ for CK and F=24.8, $p=0.0008$~~, η_p^2=0.8~~ for LDH, Figure 4), immune responses (F=26.4, $p=0.0007$~~, η_p^2=0.87~~ for NEU, F=113.1, $p=0.0004$~~, η_p^2=0.93~~ for LYM and F=12.33, $p=0.0009$~~η_p^2=0.61~~ for MON), Lac (F=908, $p=0.0008$~~, η_p^2=0.97~~) and CRP (F=12.5, $p=0.007$~~, η_p^2=0.6~~); but no effect for GLC ($p>0.05$) (Figure 5). CK, LDH, Lac, NEU and LYM increased immediately after the RSA test ($p=0.001$) on both AT [(ES=0.31, 95% CI (-0.58 to 1.18); ES=0.91, 95% CI (-0.04 to 1.79); ES=6.98, 95% CI (4.44 to 8.94); ES=0.61, 95% CI (-0.36 to 1.52) and ES=1.77, 95% CI (0.61 to 2.77), respectively)] and NG [(ES=0.25, 95% CI (-0.64 to 1.12); ES=0.69, 95% CI (-0.24 to 1.56); ES=5.15, 95% CI (3.17 to 6.69); ES=0.96, 95% CI (-0.06 to 1.88) and ES=3.56, 95% CI (1.95 to 4.83), respectively)], while CRP and MON increased only on AT [($p=0.0007$, ES=0.20, 95% CI (-0.74 to 1.11) for CRP and $p=0.02$, ES=1.7, 95% CI (0.57 to 2.70) for MON)]. Concerning differences between playing surfaces, Lac, Neu and LYM were higher following the RSA test on NG compared to AT [$p=0.03$; ES=-0.80, 95% CI (-1.67, 0.14); ES=-0.16, 95% CI (-1.03, 0.72) and ES=-0.94, 95% CI (-1.82, 0.02), respectively)], with no post-RSA test differences between AT and NG for the other blood biomarkers ($p>0.05$).

Discussion

The present study was designed to examine the effect of playing surface (NT vs. AT) on physical performance, RPE, FS and acute physiological responses to a RSA test. The main finding from this study is an improved physical performance on AT compared to NG, as evidenced by a higher total distance covered and lower decrement in RSA performance on AT. This improved RSA performance on AT was accompanied by improved perceptual (i.e., lower RPE scores and higher FS values) and enhancements in some physiological (i.e., lower Lac, Neu and LYM) biomarkers. These findings: 1) suggest that AT might elicit improved physical performance compared to NG; 2) improve understanding of the mechanisms which influence RSA performance on different playing surfaces; and 3) support the utilization of AT as a playing surface for football matches[8]

~~improved The main finding of the current study was that the decline in RSA was blunted on AT compared to NG. byimproved perceptual (RPE and FS) and some blood biochemistry (Lac, Neu and LYM) responses. These findings of enhanced RSA on ATand might help have implications for~~.

The influence of playing surface on certain components of football performance is equivocal.[3] While the majority of previous studies have reported similar straight-line sprint performances (e.g., distance covered and speed) on AT compared to NG,[11,12,14] it appears that performance tasks incorporating greater reliance on agility and change of direction ability are more likely to be enhanced on AT compared to NG.[11,12,35] In the present study, where the RSA test comprised repeated maximal shuttle sprints including both straight-line sprint and direction change abilities, total distance covered (but not best distance covered ~~performance,~~) was enhanced on AT compared to NG. These results suggest that physical performance ~~in~~ during a RSA test is more likely to be enhanced on AT when such tests ~~place greater reliance on~~ require greater change of direction and agility capabilities, and might help improve understanding of the previous inter-study disparities when assessing the influence of playing surface type on physical performance.[11,12,14]

In addition to best ~~sprint~~ and ~~the~~ total distance covered ~~in~~ during a RSA test, the decline ~~in maximal sprint~~ in physical performance through the match has also been identified as a determinant of football performance.[36] Therefore, recent studies have assessed the decline in physical performance during repeated sprint bouts[12-14] performed on different playing surfaces. Although RSA declined on both AT and NG in the present study, this decline in RSA was blunted on AT. This observation conflicts with findings by Hughes et al.[12] and López-Fernández et al.[14] who reported that the decline in RSA performance was similar on AT and NG, but is consistent with findings by Stone et al.[13] who observed an attenuated decline in RSA performance on AT compared to NG. These inter-study disparities might be linked to differences in the quality of the pitches used, as outlined previously.[7,13] Indeed, it has been suggested that high quality NG surfaces, which meet the criteria of FIFA's highest rating "FIFA 2 Star", offers a more comparable mechanical behavior to AT. Consequently, this results in a more homogenous physical and perceptual strain between AT and NG such that between-surface effects on physical performance are less likely.[12,14] Conversely, lower quality NG pitches, classified as "FIFA 1 Star", can alter the movement mechanics of locomotor muscles and, by extension, the amount of work performed~~done~~[37] compared to AT. This would be expected to translate into a greater physical performance disparity between NG and AT.[13,38] This might account for enhanced RSA performance observed in the present study on AT compared to NG, which only attained a "FIFA 1 Star" rating, and the previous studies which reported similar RSA on AT and NG when utilizing a "FIFA 2 Star" rated NG playing-surface.[12-14]

It is recognized that AT and NG can exhibit different stiffness characteristics.[39] Such inter-surface differences could acutely alter the ~~movement mechanics of the locomotor muscles and, by extension, the amount of work done,~~[25]~~and~~ amount of eccentric stress, muscle damage and physiological strain experienced during soccer activity on these disparate playing surfaces.[38-41] In the present study, blood Lac, NEU and LYM responses were lower on AT compared to NG~~,~~ with no-differences in CK, CRP, MON, GLC and LDH~~, compared to NG~~. These observations provide some evidence to suggest that the degree of physiological strain might be attenuated on AT compared to NG.

In the current study, RPE was lower and FS response was higher during the RSA test performed on AT compared to NG. This blunting in physical discomfort perception and the reporting of more pleasurable feelings on AT compared to NG might have contributed to the enhanced RSA ~~test~~ performance on AT. Although this improved perceptual response might have been linked to the lower physiological strain on AT, we cannot exclude the possibility that a more positive perceptual response on AT might have been linked to higher player satisfaction and better overall image impression of AT compared to NG.[42] Indeed, several researchers have documented higher user satisfaction and better user impression on AT compared with NG[43] with the first impression usually visual (i.e., overall image of the playing surface).[42] However, the present observations conflict with those of Andersson et al.[10], who reported that players perceive football activity to be more physically demanding on AT than those on NG, and Stone et al.[13] who reported that participants generally reported no difference in RPE between surfaces. Therefore, while the improved RSA performance on AT compared to NG in the current study might be linked to enhancements in aspects of physiological and perceptual responses during the RSA test, further research is required to resolve the underlying mechanisms for this surface-type-dependent effect on RSA.

The results of the present study indicated an improvement in physical performance and some physiological and perceptual responses on a 3rd generation AT compared to NG in subjects who were not accustomed to regularly training or playing on AT. Therefore, regularly training on AT might have implications for eliciting greater training adaptations.[28] However, further research is required to investigate the effect of playing surface on more physiological responses (e.g., muscle damage, inflammation, oxidative stress, metabolic demands, heart rate etc.) in groups of subjects accustomed and unaccustomed to regularly training on AT.

Practical Applications

The current study indicated that physical, physiological and perceptual markers during a RSA test, which incorporated multiple direction changes, was better on AT compared to NG. ~~This is the first study to evaluate different physiological responses (i.e., inflammation, muscle damage, immune function) to RSA test performed on third-generation AT compared to NG.The data show that the decline in RSA was blunted on AT compared to the NG. The improved RSA performance on AT was accompanied by improved perceptual (RPE and FS) and some blood biochemistry (Lac, Neu and LYM) responses.~~ Accordingly, the present observations support the use of AT for training and matches, as already recommended by sport governing bodies, as this surface might elicit superior performance compared to a traditional NG surface. Therefore, the original observations of the current study might have important implications for team sport performance on different playing surfaces.

Conclusion

This study evaluated physical performance and different physiological (i.e., inflammation, muscle damage, immune function) and perceptual (RPE and FS) responses to a RSA test performed on a 3rd generation AT and a FIFA 1 Star rated NG. The findings indicate that the decline in RSA performance was blunted on AT compared to NG. The improved physical performance on AT was accompanied by improved perceptual and some blood biochemistry (Lac, Neu and LYM) responses. ~~Sprinting performance in an RSA test, which incorporated multiple direction changes,was better on AT compared to NG in the current study.~~Although the underlying mechanisms for the surface-type-dependent effect on RSA ~~ability~~ performance is not entirely clear, the results of the present study suggest that improved RSA on AT might be a function of enhancements in certain perceptual (lower RPE and most positive feelings) and physiological (lower blood Lac,NEU and LYM) responses. ~~These observations might have implications for team sport performance on different playing surfaces.~~

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Declaration of Interest

The authors report no conflicts of interest, no relevant disclosures and no external financial support. The authors alone are responsible for the content and writing of the paper.

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Figure Captions

Figure 1: Schematic representation of repeated sprint ability test

Figure 2: Effect of surface-types on distancecovered during each 30 s block in the repeated-sprint ability test.

*: difference between artificial turf (AT) and natural grass (NG) with $p<0.05$

Figure 3: Effect of surface-types on best performance, total covered distance and fatigue index during the repeated-sprint ability test.

*: difference between artificial turf (AT) and natural grass (NG)with $p<0.05$

Figure 4: Effect of surface-typeon muscle damage biomarkers [creatine kinase (CK) and lactate dehydrogenase (LDH)] before and after the repeated-sprint ability test.

$: difference compared to pre-test with $p<0.05$

Figure 5: Effect of surface-types on blood lactate (Lac), C - reactive protein (CRP), glucose (GLC), neutrophils (NEU), lymphocytes (LYM) and monocytes (MON).

$: difference compared to pre-test with $p<0.05$
*: difference between artificial turf (AT) and natural grass (NG) with $p<0.05$

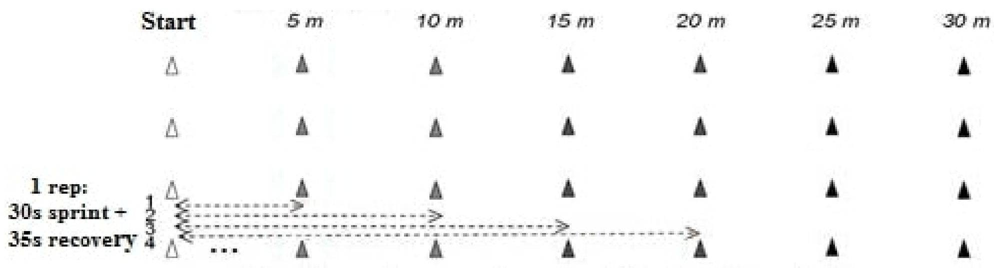

Figure 1: Schematic representation of repeated sprint ability test

179x46mm (72 x 72 DPI)

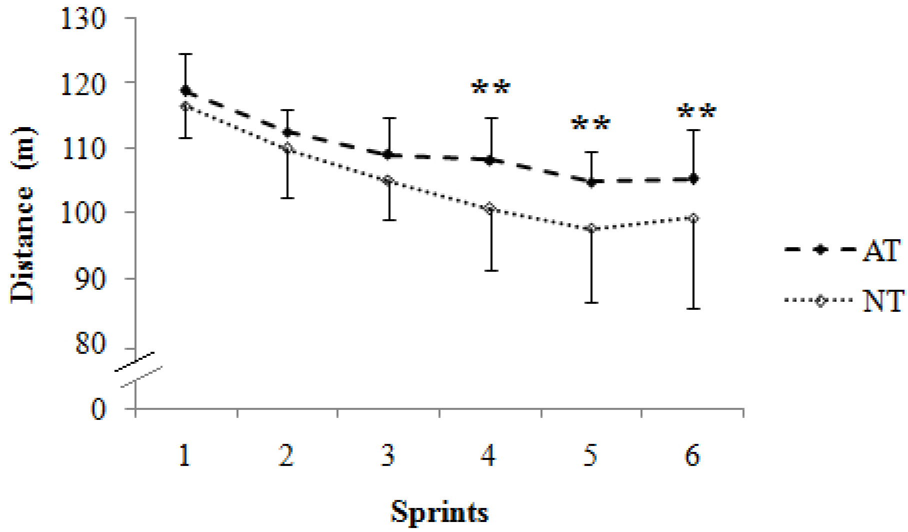

Figure 2: Effect of surface-types on distancecovered during each 30 s block in the repeated-sprint ability test.
*: difference between artificial turf (AT) and natural grass (NG) with p<0.05

122x73mm (96 x 96 DPI)

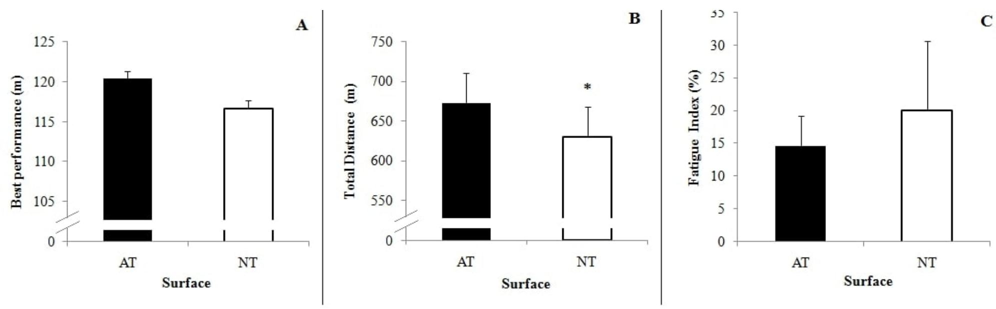

Figure 3: Effect of surface-types on best performance, total covered distance and fatigue index during the repeated-sprint ability test.
*: difference between artificial turf (AT) and natural grass (NG)with p<0.05

385x115mm (72 x 72 DPI)

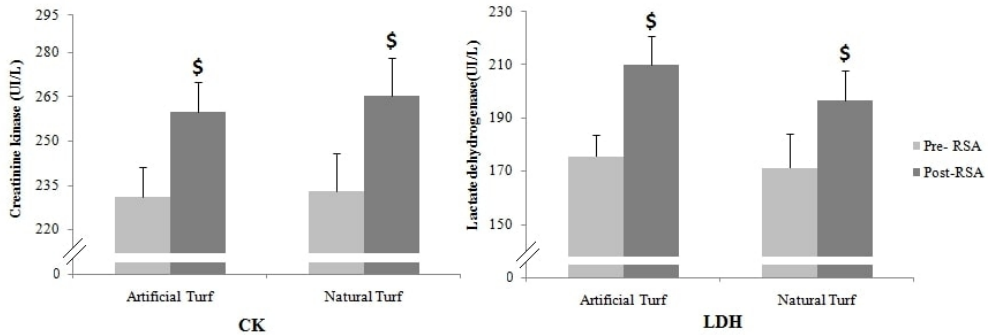

Figure 4: Effect of surface-typeon muscle damage biomarkers [creatine kinase (CK) and lactate dehydrogenase (LDH)] before and after the repeated-sprint ability test.
$: difference compared to pre-test with p<0.05

305x110mm (72 x 72 DPI)

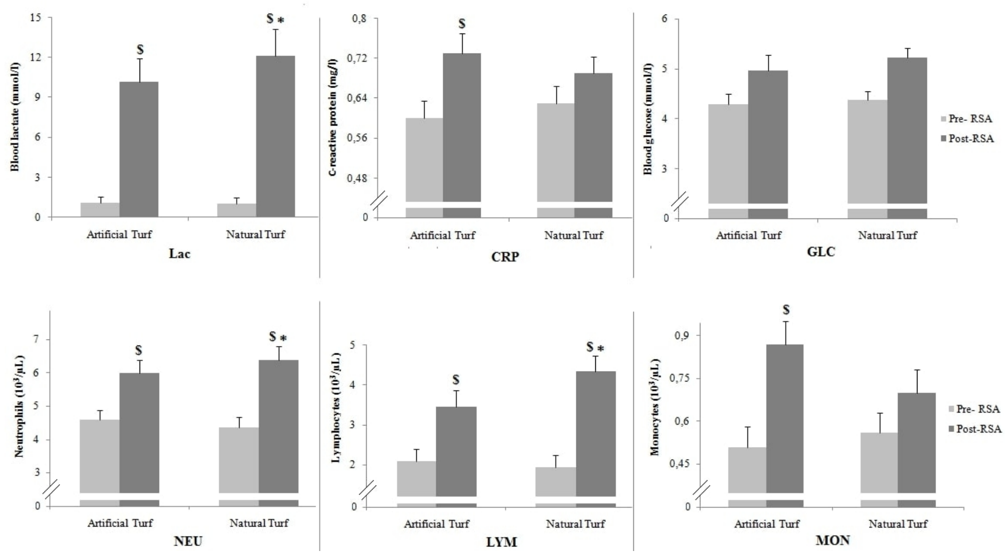

Figure 5: Effect of surface-types on blood lactate (Lac), C - reactive protein (CRP), glucose (GLC), neutrophils (NEU), lymphocytes (LYM) and monocytes (MON).
$: difference compared to pre-test with p<0.05
*: difference between artificial turf (AT) and natural grass (NG) with p<0.05

408x224mm (72 x 72 DPI)