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Incidence, Mechanisms, and Severity of Match-Related Collegiate Women's Soccer Injuries on FieldTurf and Natural Grass Surfaces

A 5-Year Prospective Study

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Background: Numerous injuries have been attributed to playing on artificial turf. Over the past 2 decades, however, newer generations of synthetic turf have been developed to duplicate the playing characteristics of natural grass. Although synthetic turf has been determined to be safer than natural grass in some studies, few long-term studies have been conducted comparing match-related collegiate soccer injuries between the 2 playing surfaces.

Hypothesis: Collegiate female soccer athletes do not experience any difference in the incidence, mechanisms, and severity of match-related injuries on FieldTurf and on natural grass.

Study Design: Cohort study: Level of evidence, 2.

Methods: Female soccer athletes from 13 universities were evaluated over 5 competitive seasons for injury incidence, injury category, time of injury, injury time loss, player position, injury mechanism and situation, primary type of injury, injury grade and anatomic location, field location at the time of injury, injury severity, head and lower extremity trauma, cleat design, turf age, and environmental factors. In sum, 797 collegiate games were evaluated for match-related soccer injuries sustained on FieldTurf or natural grass during 5 seasons.

Results: Overall, 355 team games (44.5%) were played on FieldTurf versus 442 team games (55.5%) on natural grass. A total of 693 injuries were documented, with 272 (39.2%) occurring during play on FieldTurf and 421 (60.8%) on natural grass. Multivariate analysis per 10 team games indicated a significant playing surface effect: $F_{2,690} = 6.435$, $P = .002$, $n - \beta = .904$. A significantly lower total injury incidence rate (IIR) of 7.7 (95% confidence interval [CI], 7.2-8.1) versus 9.5 (95% CI, 9.3-9.7) ($P = .0001$) and lower rate of substantial injuries, 0.7 (95% CI, 0.5-1.0) versus 1.5 (95% CI, 1.2-1.9) ($P = .001$), were documented on FieldTurf versus natural grass, respectively. Analyses also indicated significantly less trauma on FieldTurf when comparing injury time loss, player position, injury grade, injuries under various field conditions and temperatures, cleat design, and turf age.

Conclusion: Although similarities existed between FieldTurf and natural grass during competitive match play, FieldTurf is a practical alternative when comparing injuries in collegiate women's soccer. It must be reiterated that the findings of this study may be generalizable to only collegiate competition and this specific artificial surface.

Keywords: artificial surface; knee; head; trauma

For over 40 years, a greater risk and incidence of articular and concussive trauma have been attributed to playing on artificial turf when compared with natural grass.[15,26] Over the past 2 decades, newer generations of synthetic surface such as FieldTurf, which is composed of a polyethylene fiber blend stabilized with a graded silica sand and cryogenically ground rubber infill, were developed to duplicate the playing characteristics of natural grass. Although FieldTurf has been recommended as a practical option to natural grass in the prevention of American football injuries,[32,33] minimal research has been conducted comparing match-related collegiate women's soccer injuries between the 2 playing surfaces over several seasons of competition.[8,12]

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More than 1 million athletes play competitive soccer in the United States.[36,37] The number of injuries is rising, and their cost of treatment and rehabilitation is reaching into the millions of dollars each year.[14,17,35,52] Coupled with this is the psychological trauma and setbacks in training and the potential for long-term degenerative changes typically experienced by athletes after a significant injury.[2,34,58] As such, efforts to address ways to minimize the predisposition to injury are warranted.[6] Therefore, the purpose of this study was to quantify the incidence, mechanisms, and severity of match-related collegiate women's soccer injuries on FieldTurf and natural grass. It was hypothesized that collegiate female athletes would not experience differences in the incidence, mechanisms, and severity of match-related injuries between FieldTurf and natural grass.

MATERIALS AND METHODS

Population

A total of 13 universities, classified as Division IA by the United States National Collegiate Athletic Association (NCAA) governing body, were evaluated for match-related collegiate women's soccer injuries sustained while playing on both FieldTurf and natural grass during a 5-year period from 2007 to 2011. The specific schools were selected based on the availability of both playing surfaces during the competitive season, uniformity of skill level, and presence of a full-time certified athletic training (ATC) staff, minimizing the potential for injury-reporting bias.[6,32,33,45] This resulted in a total of 797 matches over the 5-year period played on either FieldTurf (n = 355) or natural grass (n = 442).

To quantify the history and potential influence of prior injuries, all athletes underwent preparticipation physical examinations under the care of their respective team physician/orthopaedic surgeon. Criteria for exclusion included (1) any known pre-existing congenital or developmental factor that predisposed an athlete to a potential injury and (2) the acknowledgment, complaint, or observed evidence of any medical or orthopaedic problem severe enough to compromise an athlete's performance or endanger her health as determined by self-response, medical history, and interview.[32,33]

Procedures

Based on paradigms suggested in prior research,[2,27,31,56] it was decided that a multifactorial approach that encompassed teams playing on both surfaces during the same time period, using definitive but brief injury surveillance, would provide several advantages. These include gaining a greater comparison of the nuances of each surface's influence on injury, avoiding limitations in data collection (eg, seasonal variation, participant randomization by surface), and minimizing difficulties in analyses and interpretation of findings that former studies have had.[2,44] For this prospective cohort study, the previously developed 2-sided, single-page injury surveillance form (available as an Appendix at http://ajsm.sagepub.com/content/32/7/1626/suppl/DC1) was modified for soccer based on prior criteria recommended and previously described in the literature.[19,27,32,39] The form includes the following: athletic identification number; athletic trainer; date of injury; athlete's weight; university; type of playing surface; surface quality; surface age; temperature at match time; cleat design; year/skill level of athlete; where the injury occurred; weather/field conditions; injury category; injury classification; injury time loss; position played at the time of injury; injury mechanism; injury situation; personnel determining the injury; injury site location; principal body part; primary type of injury; grade of injury; occurrence of external bleeding; injury because of illegal action; head, knee, shoulder, and thoracic/abdominal diagnosis; elective imaging and surgical procedures; and musculoskeletal, joint, or organ location of injury.

The injury surveillance form was initially e-mailed to the head ATCs during the preceding summer before the start of the soccer season. At this time, we provided all ATCs with an overview of the purpose, procedures, benefits, time demands, and importance of the study. They were also provided with copies of the injury surveillance form and detailed instructions for completion to avoid the potential for performance and detection biases.[8,44,45] After a full explanation, all ATCs agreed to participate in the data collection. Informed consent was voluntarily obtained from the appropriate reporting staff, institutional review board permission was granted, and the study was conducted in accordance with the guidelines for the use of human participants. Continual communication was maintained to discuss potential concerns and to ensure accuracy of the collection, comprehensiveness of information, and ease of application.

All regular-season conference and nonconference matches and postseason tournament matches were included. Injury data were recorded after match completion, with additional support from ATC notes to avoid lapses in memory leading to inaccuracy or response distortion.[44,56] All match-related injuries were evaluated by the attending head athletic trainer and team physicians on site and subsequently in the physician's office when further follow-up and treatment were deemed necessary. Any sport trauma that occurred toward the end of the competitive schedule was monitored beyond the player's specific season to determine the date of recovery and functional return to play.[6,8,32]

Completed injury surveillance forms were faxed to us within 7 working days after a match and were entered in the database before the next week. A follow-up telephone call was used to obtain any additional information pertaining to any changes or additions in the diagnosis, treatment, or time to return to play. To avoid the potential for on-the-field detection bias,[32,45] a single-blind outcome approach was maintained throughout the study period, with total data collection, compilation, and analyses limited to the data coordinator.

Definitions

Although any definition of injury and level of trauma lacks universal agreement and has its shortcomings,[2,22,39,44] we attempted to define an injury based on a combination of functional outcome, observation, and treatment.[32,33,39] A *reportable injury* was defined as any game-related soccer trauma that resulted in (1) an athlete missing all or part of a match, (2) time away from competition, (3) any injury reported or treated by the athletic trainer or physician, and (4) all cranial/cervical trauma reported. Although some authors have recommended omitting minor injuries,[39,44] others have expressed a need to quantify and track these typically overlooked minor traumas to avoid the underreporting of injuries and to monitor those injuries that may turn into chronic or overuse problems.[7,19,59] Prior studies have also revealed that 42% to 60% of competitive trauma results in minimal time loss and medical cost.[33,56] Therefore, we felt that a definition that included functional outcome, observation, and treatment on all injuries would more clearly quantify the unique nuances or trauma observed with each playing surface and reduce the individual and player biases that allegedly influence injury reporting based solely on time loss.[32,44]

Injury time loss was based on the number of days absent from practice or match competition and was divided into 0, 1 to 2, 3 to 6, 7 to 9, 10 to 21, and ≥22 days of recovery time. Not surprisingly, a review of the literature revealed high subjectivity in the determination of what constitutes a moderate or severe injury. Whereas any injury resulting in a time loss of approximately 7 to 28 days has been considered moderate trauma and a time loss range of 21 to 28 days has been defined as severe,[8,56] others have defined a severe injury as trauma resulting in ≥7 days of time loss.[19,27,42] Furthermore, what constitutes a moderate injury in one athlete (eg, elbow injury in a midfielder) may be considered severe when diagnosed in the throwing arm of a goalkeeper.[3,59] Therefore, we chose to define any trauma that required 0 to 6 days of time loss as a *minor injury*, an injury that required 7 to 21 days of time loss resulting in the athlete being unable to return to play at the same competitive level as a *substantial injury*, and trauma that required ≥22 days of time loss as a *severe injury*.[32,33] The delineation and subsequent analysis of minor, substantial, and severe injuries are similar to earlier criteria established in soccer[18,43] and primarily served to minimize the potential time loss bias.[32]

Injury category was quantified by player-to-player collision, player-to-turf collision, player-to-ball impact, player-to-object collision, injuries attributed to shoe-surface interaction during player contact, injuries attributed to shoe-surface interaction without player contact, and muscle-tendon–related overload.[6,32] Regarding injury classification, *acute trauma* was delineated from recurrent and overuse injury according to criteria previously published,[29,32] with acute trauma linked to an incidence that specifically occurred during a competitive match versus *repetitive exposure*, which resulted in symptoms and an injury to the same location during the season (recurrent). An *overuse injury* was defined as repetitive exposure resulting in trauma and sequelae with no definitive onset.[32]

To enhance optimal cell size and interpretation, player positions in soccer were condensed and analyzed by offensive and defensive as well as analyzed individually (goalkeeper, center back/sweeper/libero, fullback, wingback, defensive midanchorman, attacking midfielder, wide midfielder, winger, center striker, dual/deep-lying striker). *Mechanism of injury* was defined as occurring while a player was dribbling/shielding; heading; passing/receiving a pass; shooting; attempting a slide tackle; being tackled from the side/behind; blocking a shot/pass; scrambling for a loose ball; goalkeeping; making contact with the playing surface; being stepped on, fallen on, or kicked; sprinting/running/jumping with no player contact; or by heat illness or overuse. *Injury situation* was defined as trauma occurring during a specific play or event such as warm-up; kickoff; offensive direct play; possession build-up; offensive counterattack; defensive high pressure, middle pressure, or low pressure; kicks (penalty, corner, direct, indirect); dropped ball; or throw-in.

To optimize analyses, *primary type of injury* was combined into the following categories: surface/epidermal (abrasion, laceration, puncture wound), contusion, concussion, inflammation (bursitis, tendinitis, fasciitis, synovitis, capsulitis, apophysitis), ligament sprain, ligament tear, muscle-tendon strain/spasm/tear, cartilage tear, hyperextension, neural (burner, brachial plexus), subluxation/dislocation, and fracture (standard, epiphyseal, avulsion, stress, osteochondral). Injuries were also defined according to grade (1, 2, or 3).

Because of increasing concerns of rising medical costs,[35] the potential for long-term articular changes,[2,58] and perceived higher incidence of articular trauma while playing on artificial turf,[60] elective imaging procedures (computed tomography, magnetic resonance imaging, radiography, ultrasound) and the number of in-season and postseason surgical procedures were documented. *Anatomic location of injury* was combined from 40 physical areas and analyzed by cranial/cervical, upper extremity, thoracic, and lower extremity trauma and further analyzed by type of tissue injured (bone, joint, muscle, neural, other). *Cranial/cervical trauma* included grade 1 to 3 concussions, hematomas, postconcussions and second-impact syndromes, neurological sequelae (eg, stingers/burners, transient quadriplegia), vascular or dental injuries, or associated fractures, sprains, and strains.[32] *Neural trauma* was restricted to any injury involving only concussions, associated syndromes, and neurological sequelae. Because of growing concerns addressing excessive head, knee, and lower extremity trauma in sports,[14,44] these areas were specifically identified for further analyses.

Because studies have indicated a variation in peak pressure, torque, and in-shoe foot-loading patterns resulting from the shoe-surface interaction,[11,23,28,57] the type of cleat design (studded removable cleats, combination of molded conical with either cleats or blades) was documented. In addition, there has been minimal information on factors such as weather conditions and the effect of playing under surface conditions that influence injury frequency.[14,33] Therefore, environmental factors such as field conditions and temperature were obtained before match time by each team's respective ATC and/or through the local airport climatic data center to ascertain the potential influence on injury from changes in weather throughout the season.[32] Finally, based on injury concerns from the wear-and-tear and aging of artificial surfaces, data on the field location of injury (goal box, penalty box, third and midfield halves) and turf age (new, 1-3, 4-7, ≥8 years) were gathered for surface comparison, areas not previously documented in the literature.

Statistical Analyses

Tabular frequency distributions were computed for data in each category using the Statistical Package for Social Sciences (version 10.0, SPSS Science Inc, Chicago, Illinois) software. Because most universities schedule a similar number of matches each season, exposure to injury was defined in terms of team matches, as previously recommended.[32,33,56] Using this definition, the injury incidence rate (IIR) was expressed using injuries per 10 team matches = (number of injuries/number of team matches) × 10. The 95% confidence intervals (95% CIs) for IIRs were determined as described elsewhere.[47]

To achieve a more thorough understanding beyond traditional frequency analyses and to eliminate the possibility of irrelevant sources of error,[31,54] after the season, data were numerically recoded, grouped by playing surface (FieldTurf, natural grass), and subjected to multivariate analyses of variance (MANOVAs) and the Wilks λ criteria using general linear model procedures.[32,54] Data screening was conducted to ensure no violations of multivariate normality, linearity, outliers, homogeneity of variance, multicollinearity, or singularity.[54] When significant main effects were observed, univariate post hoc procedures were performed within each dependent variable based on the total percentage of injuries reported on each playing surface. An experiment-wise type I error rate of .05 was established a priori, and least squared means procedures were required because of the uneven number of observations on which to compare differences between variables.

RESULTS

Injury Incidence

A total of 797 collegiate matches were evaluated for game-related soccer injuries sustained while playing on FieldTurf or natural grass during the 2007-2011 seasons (Table 1). Overall, 355 (44.5%) team matches were played on FieldTurf versus 442 (55.5%) team matches played on natural grass. A total of 693 injuries were documented, with multivariate analysis indicating a significant playing surface effect across the level of injury ($F_{2,690}$ = 6.435; P = .002). Post hoc analysis indicated a significantly lower incidence of total injuries (P = .0001) occurring during play on FieldTurf (n = 272; IIR, 7.7; 95% CI, 7.2-8.1) as compared with playing on natural grass (n= 421; IIR, 9.5; 95% CI, 9.3-9.7) as well as a significantly lower (P = .001) incidence of substantial trauma on FieldTurf (IIR, 0.7; 95% CI, 0.5-1.0) than reported on natural grass (IIR, 1.5; 95% CI, 1.2-1.9).

The majority of trauma comprised acute injuries on both FieldTurf (IIR, 6.7; 95% CI, 6.2-7.2) and natural grass (IIR, 8.1; 95% CI, 7.7-8.4). Only 34 of 272 (IIR, 1.0; 95% CI, 0.7-1.3) injuries reported on FieldTurf and 64 of 421 (IIR, 1.4; 95% CI, 1.2-1.8) injuries reported on natural grass were classified as recurrent trauma or complications from a prior injury.

TABLE 1
Incidence of Match-Related Collegiate Women's Soccer Injuries Between FieldTurf and Natural Grass Surfaces[a]

Variable	FieldTurf	Natural Grass	Total/Mean
Matches evaluated			
n (%)	355 (44.5)	442 (55.5)	797 (100.0)
All injuries			
n (%)	272 (39.2)	421 (60.8)	693[e] (100.0)
IIR (95% CI)	7.7 (7.2-8.1)	9.5 (9.3-9.7)	8.7
Minor injuries[b]			
n (%)	237 (87.1)	326 (77.4)	563 (81.2)
IIR (95% CI)	6.7 (6.2-7.1)	7.4 (6.9-7.8)	7.1
Substantial injuries[c]			
n (%)	24 (8.8)	68 (16.2)	92[f] (13.3)
IIR (95% CI)	0.7 (0.5-1.0)	1.5 (1.2-1.9)	1.2
Severe injuries[d]			
n (%)	11 (4.0)	27 (6.4)	38 (5.5)
IIR (95% CI)	0.3 (0.2-0.5)	0.6 (0.4-0.9)	0.5

[a]IIR = (number of injuries/number of team matches) × 10. IIR, injury incidence rate.
[b]Minor injury = 0 to 6 days of injury time loss.
[c]Substantial injury = 7 to 21 days of injury time loss.
[d]Severe injury = ≥22 days of injury time loss.
[e]P = .0001.
[f]P = .001.

Head and Knee Trauma

As shown in Table 2, there was no significant main effect ($F_{6,886}$ = 1.523; P = .168) between surfaces by head injury when combined with all sources of trauma. There were a substantially greater number of posttraumatic headaches after head impact, however, documented on natural grass (n = 15; IIR, 0.3; 95% CI, 0.2-0.6) than reported on FieldTurf (n = 2; IIR, 0.1; 95% CI, 0.0-0.2).

A similar nonsignificant main effect ($F_{11,681}$ = 0.796; P = .644) between surfaces by knee injury was also observed. The majority of knee trauma involved patellar tendinopathies/syndromes on both FieldTurf (IIR, 0.5; 95% CI, 0.3-0.7) and natural grass (IIR, 0.5; 95% CI, 0.4-0.8), followed by ACL and associated tissue injuries combined ranging from 26% to 29% on both surfaces.

Injury Category and Injury Time Loss

As shown in Table 3, multivariate analysis indicated no significant playing surface effect by injury category ($F_{6,686}$ = 1.554; P = .158). With regard to injury time loss, findings indicated a significant playing surface effect ($F_{5,687}$ = 3.879; P = .002). Subsequent post hoc analysis (Table 3) revealing a significantly lower incidence of injuries resulting in a 7- to 9-day time loss (P = .0001) was

TABLE 2
Frequency and Rate of Match-Related Collegiate Women's Soccer Injuries Between FieldTurf and Natural Grass Surfaces by Head and Knee Trauma[a]

	FieldTurf (n = 355)			Natural Grass (n = 442)		
Variable	n	IIR	95% CI	n	IIR	95% CI
Head injury						
1st-degree cerebral concussion	15	0.4	0.3-0.7	15	0.3	0.2-0.6
2nd-degree cerebral concussion	4	0.1	0.0-0.3	9	0.2	0.1-0.4
3rd-degree cerebral concussion	0	0.0	0.0-0.0	0	0.0	0.0-0.0
Posttraumatic headache	2	0.1	0.0-0.2	15	0.3	0.2-0.6
Postconcussion syndrome	0	0.0	0.0-0.0	1	0.0	0.0-0.1
Second-impact syndrome	1	0.0	0.0-0.2	0	0.0	0.0-0.0
Epistaxis	7	0.2	0.1-0.4	14	0.3	0.2-0.5
Concussion injuries combined	19	0.5	0.3-0.8	24	0.5	0.4-0.8
Knee injury						
Medial collateral ligament	3	0.1	0.0-0.2	9	0.2	0.1-0.4
Lateral collateral ligament	0	0.0	0.0-0.0	3	0.1	0.0-0.2
ACL	4	0.1	0.0-0.3	8	0.2	0.1-0.4
ACL and associated tissue	5	0.1	0.1-0.3	5	0.1	0.0-0.3
PCL and associated tissue	1	0.0	0.0-0.2	0	0.0	0.0-0.0
Arcuate-popliteal complex	0	0.0	0.0-0.0	1	0.0	0.0-0.1
Lateral/medial meniscus	2	0.1	0.0-0.2	1	0.0	0.0-0.1
Patellar tendinopathies/syndromes	16	0.5	0.3-0.7	24	0.5	0.4-0.8
ACL injuries combined	9	0.3	0.1-0.5	13	0.3	0.2-0.5

[a]IIR = (number of injuries/number of team matches) × 10. ACL, anterior cruciate ligament; IIR, injury incidence rate; PCL, posterior cruciate ligament.

reported on FieldTurf (IIR, 0.2; 95% CI, 0.1-0.4) versus natural grass (IIR, 1.0; 95% CI, 0.8-1.3).

Position Played at Time of Injury

Although the CIs indicated lower incidences of offensive injuries on FieldTurf ($P < .05$) (Table 3), from a multivariate standpoint, there was no significant playing surface effect by overall player position, that is, offense and defense ($F_{1,691} = 1.130$; $P = .288$). Multivariate analysis, however, indicated a significant main effect by specific position ($F_{10,682} = 2.715$; $P = .003$), with a significantly lower incidence of trauma ($P = .003$) experienced by dual/deep-lying strikers on FieldTurf (IIR, 0.4; 95% CI, 0.2-0.7) versus natural grass (IIR, 1.1; 95% CI, 0.8-1.4).

Environmental Factors

The attempt to quantify environmental conditions at the time of injury revealed that the majority of injuries occurred during dry weather (Table 4). With regard to field conditions, there was a significant main effect ($F_{3,689} = 7.055$; $P = .0001$) between surfaces, with a significantly lower incidence of injuries during no precipitation/wet field conditions ($P = .0001$) reported on FieldTurf (IIR, 0.5; 95% CI, 0.3-0.8) versus natural grass (IIR, 1.7; 95% CI, 1.4-2.1) as well as a significantly lower incidence of injuries during all adverse weather conditions combined ($P = .0001$) reported on FieldTurf (IIR, 1.0; 95% CI, 0.8-1.4) versus natural grass (IIR, 2.4; 95% CI, 2.0-2.8).

When analyzing data by cold days (ie, ≤69°F) as compared with hot days (ie, ≥70°F) as suggested by others,[31-33] there was a significant main effect ($F_{1,691} = 10.517$; $P = .0001$) between surfaces by environmental temperature. On hot days, a significantly lower incidence of injuries ($P = .0001$) was also reported on FieldTurf (IIR, 3.9; 95% CI, 3.4-4.4) versus natural grass (IIR, 6.0; 95% CI, 5.6-6.5).

Cleat Design and Player Weight

The effect of the type of shoe-surface interface with playing surface has become an increasing concern within the medical community. Results of this investigation indicated a significant main effect ($F_{5,687} = 5.496$; $P = .0001$) between surfaces by cleat design (Table 5). A significantly lower incidence of injuries ($P = .0001$) was reported while wearing a combination of molded conical/cleat design on FieldTurf (IIR, 4.5; 95% CI, 4.0-5.1) versus natural grass (IIR, 6.6; 95% CI, 6.1-7.0). No significant differences in studded cleats or combination of molded conical/blade cleat design were observed.

When addressing the anecdotal concerns on the influence of player weight on cleat release and the concomitant potential for injury, findings indicated no significant main effect ($F_{5,687} = 0.924$; $P = .464$) between surfaces by player weight (Table 5). The CIs, however, indicated a significantly lower incidence of trauma among players weighing from 100 to 120 lb ($P < .05$), as was reported on FieldTurf (IIR, 0.8; 95% CI, 0.5-1.1) when compared with competing on natural grass (IIR, 1.4; 95% CI, 1.2-1.8).

TABLE 3
Frequency and Rate of Match-Related Collegiate Women's Soccer Injuries Between FieldTurf and Natural Grass Surfaces by Injury Category, Injury Time Loss, and Player Position[a]

	FieldTurf (n = 355)			Natural Grass (n = 442)		
Variable	n	IIR	95% CI	n	IIR	95% CI
Injury category						
Player-to-player collision	120	3.4	2.9-3.9	162	3.7	3.2-4.1
Player-to-turf collision	48	1.4	1.0-1.7	65	1.5	1.2-1.8
Player-to-ball/object impact	19	0.5	0.3-0.8	46	1.0	0.8-1.4
Shoe surface (contact)	34	1.0	0.7-1.3	72	1.6	1.3-2.0
Shoe surface (noncontact)	21	0.6	0.4-0.9	26	0.6	0.4-0.8
Muscle-tendon overload	30	0.8	0.6-1.2	50	1.1	0.9-1.5
Injury time loss, d						
0	143	4.0	3.5-4.5	181	4.1	3.6-4.6
1-2	48	1.4	1.0-1.7	75	1.7	1.4-2.1
3-6	46	1.3	1.0-1.7	70	1.6	1.3-2.0
7-9	7	0.2	0.1-0.4	44	1.0	0.8-1.3[b]
10-21	17	0.5	0.3-0.8	24	0.5	0.4-0.8
≥22	11	0.3	0.2-0.5	27	0.6	0.4-0.9
Position played at time of injury						
Defense	137	3.9	3.4-4.4	193	4.4	3.9-4.8
Goalkeeper	23	0.6	0.4-1.0	44	1.0	0.8-1.3
Center back/sweeper/libero	35	1.0	0.8-1.3	58	1.3	1.0-1.7
Fullback	26	0.7	0.5-1.1	28	0.6	0.4-0.9
Wingback	31	0.9	0.6-1.2	43	1.0	0.7-1.3
Midanchorman	22	0.6	0.4-0.9	22	0.5	0.3-0.7
Offense	135	3.8	3.3-4.3	228	5.2	4.7-5.6[c]
Attacking midfielder	46	1.3	1.0-1.7	91	2.1	1.7-2.5
Wide midfielder	29	0.8	0.6-1.1	32	0.7	0.5-1.0
Winger	14	0.4	0.2-0.7	12	0.3	0.2-0.5
Center striker	32	0.9	0.6-1.2	44	1.0	0.8-1.3
Dual/deep-lying striker	14	0.4	0.2-0.7	47	1.1	0.8-1.4[d]

[a]IIR = (number of injuries/number of team matches) × 10. IIR, injury incidence rate.
[b]$P = .0001$.
[c]$P < .05$.
[d]$P = .003$.

TABLE 4
Frequency and Rate of Match-Related Collegiate Women's Soccer Injuries Between FieldTurf and Natural Grass Surfaces by Environmental Factors[a]

	FieldTurf (n = 355)			Natural Grass (n = 442)		
Variable	n	IIR	95% CI	n	IIR	95% CI
Field conditions						
No precipitation/dry field	235	6.6	6.1-7.1	315	7.1	6.7-7.5
Rain	19	0.5	0.3-0.8	32	0.7	0.5-1.0
Snow/sleet	1	0.0	0.0-0.2	0	0.0	0.0-0.0
No precipitation/wet field	17	0.5	0.3-0.8	74	1.7	1.4-2.1[b]
Adverse conditions combined	37	1.0	0.8-1.4	106	2.4	2.0-2.8[b]
Temperature						
Cold days (≤69°F)	134	3.8	3.3-4.3	155	3.5	3.1-4.0
Hot days (≥70°F)	138	3.9	3.4-4.4	266	6.0	5.6-6.5[c]

[a]IIR = (number of injuries/number of team matches) × 10. IIR, injury incidence rate.
[b]$P = .0001$.
[c]$P = .001$.

TABLE 5
Frequency and Rate of Match-Related Collegiate Women's Soccer Injuries Between FieldTurf and Natural Grass Surfaces by Cleat Design, Player Weight, and Turf Age[a]

	FieldTurf (n = 355)			Natural Grass (n = 442)		
Variable	n	IIR	95% CI	n	IIR	95% CI
Cleat design						
Studded removable cleats	26	0.7	0.5-1.1	21	0.5	0.3-0.7
Combination of molded conical/cleats	161	4.5	4.0-5.1	291	6.6	6.1-7.0[b]
Combination of molded conical/blade	85	2.4	2.0-2.9	109	2.5	2.1-2.9
Player weight, lb						
100-120	27	0.8	0.5-1.1	64	1.4	1.2-1.8[c]
121-140	155	4.4	3.9-4.9	219	5.0	4.5-5.4
141-160	78	2.2	1.8-2.7	115	2.6	2.2-3.0
161-180	11	0.3	0.2-0.5	20	0.5	0.3-0.7
181-200	1	0.0	0.0-0.2	3	0.1	0.0-0.2
Turf age, y						
New	31	0.9	0.6-1.2	61	1.4	1.1-1.7
1-3	99	2.8	2.3-3.3	96	2.2	1.8-2.6
4-7	117	3.3	2.8-3.8	152	3.4	3.0-3.9
≥8	25	0.7	0.5-1.0	112	2.5	2.2-3.0[b]

[a]IIR = (number of injuries/number of team matches) × 10. IIR, injury incidence rate.
[b]P = .0001.
[c]$P < .05$.

Age of Playing Surface

As existing artificial surfaces continue to mature, there has been conjecture as to the influence of age of the playing surface on injuries. In this study, there was a significant main effect ($F_{3,689}$ = 13.719; P = .0001) by age of surface (Table 5). Findings indicated a significantly lower incidence of injury (P = .0001) reported on ≥8-year-old FieldTurf (IIR, 0.7; 95% CI, 0.5-1.0) versus natural grass (IIR, 2.5; 95% CI, 2.2-3.0). Findings on newer surfaces, however, indicated no significant playing surface differences in injury incidence when competing on new, 1- to 3-, or 4- to 7-year-old FieldTurf versus natural grass of a similar age.

Injury Mechanism and Situation

As shown in Appendix Table A1 (available online at http://ajsm.sagepub.com/supplemental), no significant main effect was observed ($F_{19,673}$ = 1.100; P = .345) between surfaces by injury mechanism. A similar nonsignificant main effect was noted ($F_{12,680}$ = 1.314; P = .187) between surfaces by injury situation.

Primary Type of Injury and Injury Grade

As shown in Appendix Table A2 (available online), no significant main effect ($F_{13,678}$ = 0.992; P = .457) by primary type of injury was noted between the 2 surfaces. The CIs, however, indicated a significantly lower incidence of contusions ($P < .05$) reported on FieldTurf (IIR, 2.4; 95% CI, 2.0-2.9) versus natural grass (IIR, 3.4; 95% CI, 3.0-3.9). Although there was a lower incidence of ligament sprains and tears combined reported on FieldTurf (IIR, 1.9; 95% CI, 1.6-2.4) when compared with natural grass (IIR, 2.6; 95% CI, 2.2-3.1), the CIs, however, indicated no significant differences between FieldTurf and natural grass. There were also no significant differences in ligament, cartilage, and muscle tears combined while playing on FieldTurf (IIR, 0.3; 95% CI, 0.1-0.5) as compared with natural grass (IIR, 0.4; 95% CI, 0.3-0.6).

There was a significant main effect ($F_{2,690}$ = 8.305; P = .0001) between surfaces by injury grade (Appendix Table A2). A significantly lower incidence of second-degree injuries (P = .0001) was reported on FieldTurf (IIR, 0.6; 95% CI, 0.4-1.0) versus natural grass (IIR, 1.7; 95% CI, 1.3-2.0).

Elective Imaging and Surgical Procedures

With regard to elective medical care (Appendix Table A2), there was no significant difference in the total number of imaging procedures conducted as a result of injuries attributed to playing on FieldTurf (IIR, 1.3; 95% CI, 1.0-1.7) versus playing on natural grass (IIR, 1.7; 95% CI, 1.4-2.1). There were twice as many radiographs performed, however, after injuries occurring on natural grass (n = 46; IIR, 1.0) when compared with radiographs after injuries reported on FieldTurf (n = 23; IIR, 0.6). There were also no significant differences observed in the number of in-season/postseason surgeries documented after trauma on FieldTurf (IIR, 0.3; 95% CI, 0.2-0.6) when compared with playing on natural grass (IIR, 0.4; 95% CI, 0.2-0.6).

Anatomic Location and Type of Tissue Injured

Regarding the anatomic/regional location of injury (Appendix Table A2), there was no significant playing surface effect ($F_{3,689}$ = 0.789; P = .501) as well as no significant main effect by specific location of body trauma ($F_{30,662}$ = 1.459; P = .056) between surfaces (Appendix Table A2). The CIs, however, indicate a lower incidence of lower extremity injuries ($P < .05$) reported on FieldTurf (IIR, 5.3; 95% CI, 4.7-5.8) versus natural grass (IIR, 6.4; 95% CI, 6.0-6.9).

There was no significant main effect ($F_{4,688}$ = 0.904; P = .461) between surfaces by tissue type. The CIs, however, indicated a lower incidence of muscle injuries ($P < .05$) reported on FieldTurf (IIR, 3.8; 95% CI, 3.3-4.3) versus natural grass (IIR, 4.9; 95% CI, 4.4-5.4).

There was no significant main effect ($F_{30,662}$ = 1.459; P = .056) in the specific location of body trauma (Appendix Table A3, available online) found between playing surfaces. There was, however, a higher incidence of shoulder girdle injuries reported on natural grass (IIR, 0.5; 95% CI, 0.3-0.7) when compared with trauma occurring on FieldTurf (IIR, 0.1; 95% CI, 0.1-0.3).

When analyzing by specific lower extremity trauma (Appendix Table A4, available online), there was no significant playing surface effect ($F_{14,678}$ = 0.710; P = .765) by specific joint injured, nor was there a significant playing surface effect ($F_{8,684}$ = 0.469; P = .878) by specific muscle trauma. Although there was a lower incidence of muscle trauma to the lower leg and foot on FieldTurf (IIR, 1.3; 95% CI, 1.0-1.7) when compared with natural grass (IIR, 1.8; 95% CI, 1.4-2.1), no significant differences in trauma incidence existed between the 2 surfaces.

DISCUSSION

The purpose of this prospective cohort study was to quantify the incidence, mechanisms, and severity of match-related collegiate women's soccer injuries on FieldTurf versus natural grass. It was hypothesized that collegiate female athletes would not experience any difference in the incidence, mechanisms, and severity of match-related injuries between FieldTurf and natural grass. Although numerous similarities did exist between FieldTurf and natural grass, unique differences in sport trauma were observed between the 2 playing surfaces.

Injury Incidence

Over the 5-season study, 693 match-related injuries, or 3.6 injuries per university per season, were recorded among 13 universities competing on both surfaces. This is consistent with the number of injuries observed in prior studies ranging from 2.4 to 15.7 injuries per school per season.[3,32,33,44] The incidence of acute injury (86.0%) was similar to findings in earlier studies, ranging from 71% to 94%.[8,31,32,36] The overall incidence of substantial (8.8%-16.2%) and severe trauma (4.0%-6.4%) recorded in this study is also consistent with prior seasonal trauma reported in soccer[7] but substantially lower than observed in professional female soccer.[10] Although the large variation in injury definition among these studies prevents an accurate comparison, both the total number and the number of minor, substantial, and severe injuries recorded in this study still reflect the typical level of trauma observed at the collegiate level of play. The lower overall incidence of trauma on FieldTurf is consistent with prior studies in football[32] but is in contrast to other findings between surfaces in soccer,[8,9] which may be reflective of assessing injuries on single versus multiple artificial infill surfaces.

In addition to acute injuries, repetitive or recurrent trauma is considered a major contributor to future trauma.[32] The incidence of recurrent cases over 5 seasons in this study ranged from 11.1% on FieldTurf to 12.4% on natural grass, similar to the 11% to 17% of recurrent trauma reported in other studies in high-contact field sports.[12,32,33,53] Whether recurrent trauma was observed over the same surface in all studies is not known. The increased interest but paucity of studies that address recurrent trauma prevents further discussion at the collegiate level of play.

With regard to foul play, the incidence (13.0%) of injuries attributed to illegal actions was minimal. This is higher than the 0.5% to 5.7% occurrence reported in collegiate and high school football[15,32,33,36] but is in far contrast to the 23% to 62% reported among professional female soccer and other intercollegiate and senior sports.[7,10,42] In summary, the lower rate of overall injuries documented on FieldTurf may be attributed to the lower incidence of substantial and severe trauma on the artificial surface when compared with natural grass.

Head and Knee Trauma

Although there were no significant differences in head or knee trauma between the 2 surfaces, when compared with other high-contact field sports,[32,33] the greater incidence of posttraumatic headaches on natural grass is a concern and further reiterates the overall level of potential head trauma observed during collegiate women's competition (Table 2).[5] Consistent with prior studies,[12,13] however, a minimal number of head trauma cases (14%) were attributed to player-turf impact in this study. With the prevalence of head trauma with subsequent posttraumatic conditions taking center stage in sport,[1] other factors need to be considered besides playing surface. Interestingly, of the 18% (n = 124) of total injuries reported to the head, neck, face, and mouth (Appendix Table A1), none of these athletes were wearing mouthguard protection. Although evidence is equivocal on the role of mouthguard use in the prevention of concussions, studies have indicated a reduction in head acceleration and a protective effect against orofacial trauma while wearing some form of mandibular orthotic.[20,38] Whether sports medicine education can override tradition in soccer remains an area for future investigation.

The nonsignificant playing surface effect on the incidence of knee trauma is consistent with prior findings,[16] with the incidence of joint derangement on both surfaces similar to previous reports in women's collegiate and elite-level soccer.[6,8] Although there is no clear consensus, the high incidence of patellar tendinopathies/syndromes reported in this study is consistent with earlier findings and may be attributed to several factors independent of playing surface.[16] These include weak knee extension strength, overuse, inadequate patellar tracking, and lower extremity malalignment.[16,24] Others have indicated a higher incidence of patellofemoral pain syndrome among women when compared with men with similar medical preparticipation status.[4] Continued efforts to delineate the physical influence from playing surface effect in the incidence of knee trauma are warranted.

Injury Category and Injury Time Loss

Results of this study indicate no significant differences between playing surfaces across injury categories. This is consistent with studies indicating similar nonsignificant findings between artificial and natural grass surfaces in soccer and football.[7,12,32]

As similarly noted when discussing the severity of injury, the significantly lower incidence of substantial injuries requiring 7 to 21 days of time loss on FieldTurf versus natural grass is in contrast to findings assessing injuries across various artificial infill systems.[8,9] Although not significant, a possible concern is the 2-fold greater incidence of injuries involving ≥22 days of time loss associated with competing on natural grass. Prior studies on natural grass at both the high school and collegiate levels of competition in other high-contact field sports have found an increased incidence of injuries resulting in extensive time loss (>22 days).[32,33] Whether these findings with the natural grass surface are a function of decreasing turf quality with high temperatures and low moisture content,[40,55] lower surface compliance and a higher coefficient of restitution observed after noncontact injuries on natural grass,[42] excessive wear because of multipurpose use,[55] or simply the lack of resiliency of natural grass as the season progresses is not clear and is beyond the scope of this study.

Position Played at Time of Injury

When grouped by generalized positions, that is, offense and defense, multivariate analyses indicated no significant effect of playing surface at the time of injury. Prior studies, however, have expressed concerns with the greater impact forces and incidence of injuries among offensive positions, for example, running backs handling the football, while competing on natural grass surfaces.[32,33] When assessing specific player positions in this study, results are consistent with earlier studies that indicated a greater incidence of trauma among midfielders followed by strikers and goalkeepers.[13] Findings also indicated a significantly greater incidence of trauma associated with offensive play and among dual strikers while competing on natural grass. Unfortunately, at this time, the limited frequency of injury among most player positions in this study prevented further in-depth analyses and discussion of potential injury differences and position susceptibility.

Environmental Factors

Limited attention has been directed toward the potential influence of weather conditions on injury during competition.[15,32,33,40] In this study, the majority of play and injuries occurred during conditions of no precipitation, therefore minimizing the opportunity to thoroughly ascertain possible influences under various field conditions. The significantly lower incidence of injury on FieldTurf during play on wet fields, as well as all adverse conditions combined, may reflect the more consistent surface that the turf provides during inclement weather. The significantly lower incidence of injuries on FieldTurf when temperatures remained ≥70°F is consistent with trauma observed in college football[32] but is in contrast to prior findings previously reported on other surfaces,[33,40] although those surfaces were either an earlier type of turf or natural surfaces under drier conditions when compared with today's highly managed collegiate grass surfaces.

Contrary to prior studies on the original artificial turf surfaces, the significantly greater incidence of injury during hot days on natural grass supports prior findings that indicated enhanced shoe-surface interaction potentiating articular trauma with increasing turf temperature as well as reports of a greater frequency of knee trauma with higher temperatures.[40] In summary, these findings are of clinical concern and warrant further investigation for optimal natural grass management practices.[51]

Cleat Design and Player Weight

With the exception of the combination of molded conical/cleat style, the majority of cleat designs associated with injuries in this study did not reflect a significant shoe-surface influence. This is consistent with prior work assessing in-shoe foot-loading patterns, where no significant differences between grass and artificial turf were observed in sprint time with maximal effort in male high school athletes.[11] The significantly lower incidence of trauma on FieldTurf while wearing the conical/cleat pattern may reflect a more optimal cleat release on artificial turf during both linear and rotational movements when compared with blade or strictly removable cleat patterns.

The overall nonsignificant influence of player weight on either playing surface, at this time, does not support anecdotal concerns of player weight on cleat release and potentiating injury. The lower incidence of trauma to players weighing 100 to 120 lb on FieldTurf reflects only 10% of the total trauma and will require further examination. In summary, more studies are warranted to quantify the interaction of cleat design, player weight, and playing surface on injury.[11]

Age of Playing Surface

Limited information has been provided in the literature concerning the influence of playing surface age on injuries[32,33,40] primarily because of the limited but growing number of newer generations of artificial surfaces being installed as well as the challenges of delineating variable interactions on natural grass surfaces under continual transition and various management systems.[51] The lower incidence of injuries reported on newly installed FieldTurf surfaces, when compared with new natural grass fields, is consistent with prior summaries pointing to less opportunities for trauma with greater surface uniformity and optimal vertical deformation, shock absorption, and rotational resistance.[2,32,41,61]

The significantly lower number of injuries reported on ≥8-year-old FieldTurf may be a reflection of the consistent surface quality of FieldTurf over time as well as the decreasing quality of natural grass as the season progresses.[55] Further analyses as to factors contributing to surface age and sport trauma may more firmly establish these observations.

Injury Mechanism and Situation

Although prior authors have surmised that the more consistent artificial composition enhances the speed of the game[3,32] but allows for a greater opportunity for an injury because of overextension and a greater fatigue potential of muscles and a greater rate of acceleration, in-shoe loading patterns, and torque,[11,23,29,33] there were no significant differences in the injury mechanism or injury situation between playing surfaces in this study (Appendix Table A1). Risk factors repeatedly mentioned in the literature have included pivoting, change of direction, direct contact with an opposing player, deceleration, unfortunate mishaps, or being jolted during an uncontrolled or compromised movement.[2,3,32,49,61] Others have identified equipment (eg, shoe/cleat design), the abrasive nature and variations in playing surfaces, and various anatomic, metabolic, and biomechanical influences.[2,3,30,46,51] Although these factors were consistently observed during match play, resulting trauma could not be significantly attributed to either playing surface.

Primary Type of Injury and Injury Grade

We found no significant surface effect on the primary type of trauma in this study. Other studies have found a lower incidence of lower extremity strains on artificial turf,[9,32] which may be related to the lower shoe-surface traction usually associated with a more consistent, compliant surface,[32] concurring with earlier summations noting an inverse relationship between the incidence of ligament trauma and surface compliance.[61] Although others have reported greater shoe-surface peak torque and rotational stiffness with artificial surfaces,[28,57] these studies were conducted under noncompetitive, laboratory conditions utilizing traditional mechanical simulations that lacked environmental variability, player contact, and the anatomic and neuromuscular complexities during actual sport performance, thus limiting comparison to on-the-field sport activity.[21,22] Further investigation into the biomechanics of the shoe-surface interaction beyond the laboratory setting will be necessary to elucidate more definitive causes.

The significant lower incidence of second-degree injuries on FieldTurf (Appendix Table A2) is consistent with trauma documented in college football[32] but is in contrast to nonsignificant findings on similar surfaces during high school football and soccer competition,[33,50] a level of play in which the degree of speed, power, and subsequent impact trauma is lower than observed at the collegiate or professional level of sport.[3,32] Findings may more clearly reflect the higher impact in attenuation/shock absorbency of the more compliant turf surface at this level of play.[9,32]

Elective Imaging and Surgical Procedures

With increasing health care costs and equivocal sport injury findings, surprisingly, the tracking of elective imaging and surgical procedures has not been addressed in prior injury risk studies. The nonsignificant differences in the use of posttraumatic imaging procedures, as well as the incidence of surgeries required after an injury while playing on either surface over 5 competitive seasons, are not in juxtaposition with suggestions of more serious injuries on artificial surfaces.[60] The future reporting of medical procedures beyond the playing field would add pertinent insight on the incidence and severity of trauma across various surfaces.

Anatomic Location and Type of Tissue Injured

Regarding the anatomic location and specific location of body trauma (Appendix Tables A2 and A3), the nonsignificant differences between playing surface are consistent with earlier studies addressing cranial/cervical, upper extremity, and thoracic trauma at the collegiate level of play.[9,32] The overall lower incidence of lower extremity injury on FieldTurf in this study, however, was also similar to previous reports among collegiate athletes[32] but is in contrast to earlier findings indicating no significant differences between surfaces.[9,12,50] Differences in results may be reflective of the various artificial infill surfaces studied or simply the type of sport.[3,8]

When assessing the type of tissue injured, the lower incidence of muscle injuries reported on FieldTurf (Appendix Table A2) is consistent with earlier summations indicating an inverse relationship between the incidence of muscle trauma and surface compliance.[2,30,32,61] This study did not establish the coefficient of restitution or degree of rebound; however, when compared with the polyethylene/cryogenic rubber composition of FieldTurf, lower extremity findings on natural grass seemed to reflect a less compliant surface and lower energy absorption at ground impact. The energy of impact is subsequently transferred back, in this case to the lower extremity region, increasing the potential for trauma.[61] This may be reflected in the higher incidence of tibiofemoral and distal tibiofibular joint derangements on natural grass when compared with FieldTurf (Appendix Table A4).[32] Although others have reported a greater incidence of ankle sprains combining data derived from 8 to 12 different brands of artificial turf,[8,9] the authors did not control for length and time of collection or variation in turf type or quality—methodological concerns that may have benefitted from further analyses.

Limitations

There were several potential limitations to the study that may have influenced the type and number of injuries reported. These included the inability to determine and control the inherent random variation in injuries typically observed in high-collision team sports[3,31,32]; the strength and conditioning status of the athletes and variations in the type of equipment used[2,3,19,25,29]; the weather conditions and variations in field conditions[32,33]; the differences in postural/joint integrity, musculoskeletal structure, and biomechanics of movement[2,25,30,48]; the time of year[9,25]; the coaching style and experience and player management[2,3,15,21,29,30]; the quality of officiating and foul play[2,32,57]; the player's position and actual versus average time to exposure to injury[3,19,21]; the skill level, intensity of play, and fatigue level at the time of injury[6,14,21,25]; the athlete's ephemeral response to the risk potential, injury, and subsequent pain[2,29,30,34,44]; the unreported congenital/developmental factors predisposing an athlete to additional injuries[2,3,25,29,48,50]; or simply any unforeseen mishap.[3,31,33] Also, there is always the opportunity for an injury to go unreported despite the comprehensive nature of any reporting system.[3,8,29]

Key strengths of the study included the opportunity to follow several as well as identical universities competing at a high level during the 5-year period. This prevented confounding interteam seasonal injury fluctuations and individual team effect, which enhanced the ability to identify differences and trends in surface effect.[8,12] This is also the first study on injury risk factors that addressed elective imaging and surgical procedures on both surfaces as well as field location, cleat design, and age of the playing surfaces at the time of injury. In addition, the combined method of assessing functional outcome, time loss, direct observation, and treatment records, as well as the daily interactions of ATCs and players evaluated in this study, minimized the potential for transfer bias and unreported injuries throughout the season.[32,33] The daily evaluation and follow-up telephone calls also increased the opportunity to quantify and track typically overlooked minor indices that often evolve into chronic or overuse problems.[8,32,56]

Note that the percentage of influence from risk factors other than simply surface type cannot be overlooked. Because of the inherent challenges of collecting data on multiple indices and on numerous teams and players over an extended period of time, the degree of influence from these risk factors remains a limitation that can only be acknowledged at this time.[8,21,31] The prospective-cohort multivariate design did enhance the sample size, result in randomization of play on both surfaces, control for seasonal and team variation, and allow for greater insight into both significant and subtle differences between a new generation of artificial turf and natural grass.

Finally, the lack of a universally accepted definition of a sport injury will continue to be a challenge and subsequent influence on injury interpretation.[16,32,39] With the concomitant difficulty in subjectively determining a plethora of surface conditions and quality of natural grass,[32,39] any attempt to interpret the injury-surface interaction with any degree of accuracy will continue to pose concerns.

CONCLUSION

Although numerous similarities did exist between FieldTurf and natural grass over the 5-year period of competitive match play, there were significant differences in injury incidence, severity of injury, injury time loss, grade of injury, injuries under various field conditions and temperature, cleat design, and age of playing surface. No significant differences in head or lower extremity trauma, however, were observed between playing surfaces. Both surfaces, from a statistical and clinical standpoint, exhibited unique injury causes that need to be addressed to reduce the number of match-related collegiate women's soccer injuries. The hypothesis that collegiate female athletes would not experience any difference in the incidence, mechanisms, and severity of match-related injuries between FieldTurf and natural grass was only partially supported. In conclusion, FieldTurf is a practical alternative to natural grass when comparing injuries in collegiate women's soccer. It must be reiterated, however, that the findings of this study may be generalizable to only this level of competition and specific artificial surface.

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