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REVIEW

NATURAL GRASS VS ARTIFICIAL TURF FOR INJURY PREVENTION IN YOUTH SPORTS: A SCOPING REVIEW

John Nyland[1], Jonathon Lewis[2], Jarod Richards[1], Ryan Krupp[3]

[1] Division of Sports Medicine, Department of Orthopaedic Surgery, University of Louisville, Louisville, USA
[2] School of Medicine, University of Louisville, Louisville, USA
[3] Louisville Institute of Orthopaedics, Louisville, USA

Corresponding author's e-mail: john.nyland@louisville.edu

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ABSTRACT

Background: Studies of elite adult athletes have generally shown similar injury patterns on artificial turf (AT) and natural grass (NG). Since widely ranging physical, mental, cognitive, behavioral, and social development occurs during childhood and adolescence, we propose that the influence of playing surfaces on childhood and adolescent athlete injury characteristics might differ.

Objective: This scoping review compared childhood and adolescent athlete sport injuries on NG and AT to determine which surface was favored based on study conclusions.

Eligibility Criteria: A broad range of studies were included with a requirement that mean participant age was between 9-25 years and that evaluated musculoskeletal or concussion injuries having occurred on either NG or AT.

Sources of Evidence: The PubMedD, Embase, and Web of Science databases were searched using the search terms "adolescent and sports injury and natural grass or artificial turf". Only English language studies were included. Review and meta-analysis, clinical, biomechanical, training performance/physiology, dissertations and theses, meeting abstracts, case reports, case series, editorials/commentaries/letters to the editor were excluded. The primary investigator reviewed each study that was identified as having involved childhood or adolescent-age athletes.

Charting Methods: Publication year, country of origin, subject number, age, gender, study purpose, study methods, key study findings, study conclusion, and whether or not NG or AT was favored information was extracted.

Results: After screening, 46 studies contributed to this review. Overall, 26 studies (56.5%) favored NG, eight studies favored AT, and 12 reported no differences between playing surfaces. From the late childhood to young adulthood developmental period, study conclusions suggest that a NG surface was favored for reducing sports injury risk.

Conclusions: Athletes who perform on NG from late childhood to late adolescence may experience better musculoskeletal and concussion injury prevention.

KEYWORDS

Playing surface, synthetic turf, child development, injury prevention

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INTRODUCTION

With a high sports injury incidence, particularly at the lower extremities, childhood and adolescent sports participation has an element of danger from a musculoskeletal and concussion injury perspective[1]. The playing surface upon which practices and competitions occur may contribute to the onset of many of these injuries[2]. Studies, such as the report by Ekstrand et al.[3], have described overall equivalence between injuries sustained by elite athletes on artificial turf (AT) and natural grass (NG) with no injury rate differences even when the playing surface changed[4]. Injury epidemiology studies, however, that focus more on older, elite professional athletes may not accurately reflect how playing surfaces may affect younger developmentally vulnerable childhood, adolescent, and young adulthood athletes[5].

During childhood and adolescence athletes experience unique physical, mental, cognitive, behavioral, and social stressors, making them particularly susceptible to injuries[6]. Given the rapid growth of elite-level training, sport specialization, and "professionalism", therefore, improving our understanding of the influence of different playing surfaces on sports injuries could be of value[7,8]. With this in mind, this scoping review aimed to compare childhood and adolescent athlete musculoskeletal and concussion sport injuries on NG and AT across studies of subjects between 9-25 years of age (between late childhood and young adulthood)[9,10] based on study conclusions.

METHODS

A scoping review was performed to evaluate a diverse range of injury studies related to the influence of NG or AT playing surfaces on musculoskeletal or concussion injuries among childhood and adolescent athletes. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (https://www.prisma-statement.org/scoping). To be included in this review, studies had to demonstrate that the subject population consisted primarily of late childhood to young adult athletes (9-25 years of age)[9,10] involved in sports practice or competitions on AT or NG.

The primary investigator searched the PUBMED, EMBASE, and WEB OF SCIENCE (core collection) databases using the search terms "adolescent and sports injury and natural grass or artificial turf". The primary investigator then reviewed each study to confirm that the primary study group consisted of athletes between 9-25 years of age. No year of publication limits were set, except Web of Science, which was only reviewed over the last 5 years. This was done to decrease the number of redundant, flagged articles and to focus more on the most recent studies. Only English language studies were included. Review and meta-analysis, clinical, biomechanical, training performance/ physiology, dissertations and theses, meeting abstracts, case reports, case series, and editorials/ commentaries/ letters to the editor were excluded. The study inclusion and exclusion processes that were used are shown in *Figure 1*. The diverse study content that was excluded from scoping review inclusion are shown in *Figure 2*. A total of 46 unique studies contributed to this review. The following information was extracted by the primary investigator and confirmed by the senior author (RK) for each accepted study: author, country of origin, publication year, study design, subject number and age, gender, primary study purpose, methods, key findings, conclusion, and whether or not NG or AT was favored (Appendix). Late childhood-to-early adolescence, middle adolescence, late adolescence and young adulthood were respectively defined as 9-14 years of age, 15-17 years of age, 18-24 years of age, and approximately 25 years of age. When participant average age was not specifically mentioned in a study, middle school athletes were considered to be between 9-14 years of age (bridging late childhood and early adolescence), high school athletes were considered to be between 15-18 years of age (bridging middle and late adolescence), and National Collegiate Athletic Association (NCAA) athletes were considered to be between 19-25 years of age (bridging late adolescence and young adulthood) *(Fig. 3)*.

After extraction, a different study co-author (JR) screened each paper for data collection accuracy. A formal bias assessment was not performed since the study inclusion criteria ensured a broad range of relevant studies that enabled comprehensive, representative mapping of current literature for this 9-25 years of age group. The initial review of potential studies for quality and relevance was conducted by the primary investigator during the

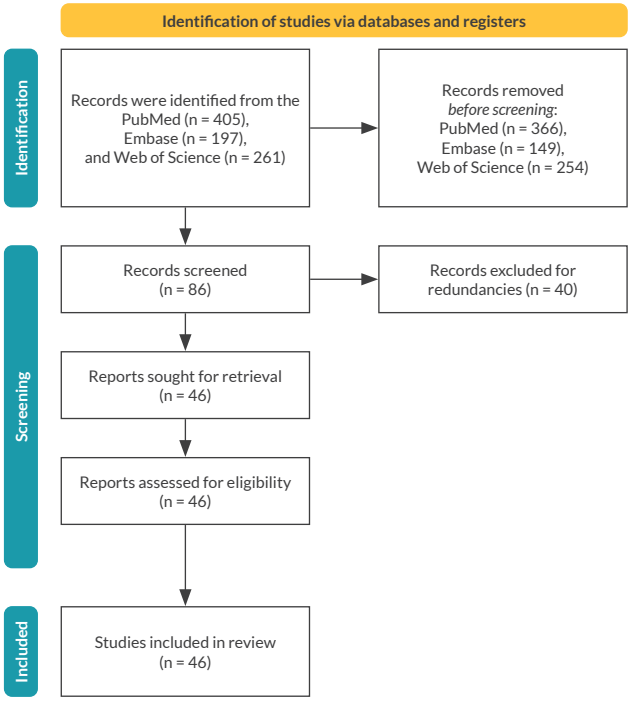


Figure 1. *Systematic study selection process for this scoping review, following PRISMA guidelines. This flow diagram provides a transparent step-by-step breakdown of the study selection process, ensuring reproducibility and clarity in how studies were chosen and filtered for inclusion in the review.*



Figure 2. *The PubMed, Web of Science and Embase database search process leading up to the final 46 articles that were included in this review.*

screening and data abstraction process. To better control for selection bias, however, a co-investigator (RK) also reviewed each potential study to determine whether it should be included. Where any disagreements existed after reviewing the study, a third co-author (JR) made the final decision regarding study inclusion. Lastly, accepted studies were designated as favoring NG, favoring AT, or identifying no difference between playing surface types. Studies were then compared by participant age group based on accepted childhood, adolescent, and young adult age sub-divisions[9,10] and gender. When reviewer disagreements arose, the senior author (RK) made the final decision.

Statistical analysis

Descriptive statistical analysis was performed using specialized software (IBM-SPSS version 29.0, Chicago, IL, USA). Chi-square or Fisher's exact tests were used to compare categorical variables. An alpha level of $p \leq 0.05$ was used to indicate statistical significance.

RESULTS

PubMed, Embase, and Web of Science database searches identified 405, 197, and 261 records, respectively. Three studies evaluated athletes during the late childhood to early adolescence period (9-14 years of age) with each favoring NG[11-13]. Three studies evaluated athletes during middle adolescence (15-17 years of age) with two studies favoring NG[14,15] and one study reporting no difference between playing surfaces[16]. Six studies evaluated athletes during late adolescence (18-24 years of age) with four studies favoring NG[17-20] and 2 studies reporting no difference between playing surfaces[21,22]. Four studies evaluated athletes during early to mid-adolescence with two studies favoring NG[23,24] and two favoring AT[25,26]. Six studies evaluated athletes during mid-to-late adolescence with five studies favoring NG[27-31] and one study reporting no difference between playing surfaces[32]. Seventeen studies evaluated athletes from late adolescence-to- young adulthood with seven studies favoring NG[33-39], five studies

Late Childhood - Early Adolescence 9-14 years of age	Middle Adolescence 15-17 years of age	Late Adolescence 18-24 years of age	Young Adulthood ≈ 25 years of age
Middle School ≈ 9 to 14 years of age	High School = 15 to 18 years of age	College = 19 to ≈25 years of age	

Figure 3. *Age group classifications used in this scoping review to categorize adolescent and young adult athletes. The framework aligns developmental stages with corresponding school levels, ensuring consistency in study comparisons.*

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Study	Favored artificial turf	Age group	No difference	Age group	Favored natural grass	Age group
Arnason A, et al.[11]					X	Early adolescence
Alles WF, et al.[27]					X	Middle-to-late adolescence
Aoki H, et al.[23]					X	Middle adolescence
Błażkiewicz A, et al.[14]					X	Middle adolescence
de Putter CE, et al.[50]					X	Early-to-late adolescence
Dragoo JL, et al.[33]					X	Late adolescence-to-young adulthood
Dragoo JL, et al.[34]					X	Late adolescence-to-young adulthood
George E, et al.[35]					X	Late adolescence-to-young adulthood
Guskiewicz KM, et al.[55]					X	Middle adolescence-to-young adulthood
Hagel BE, et al.[36]					X	Late adolescence-to-young adulthood
Hägglund M, et al.[24]					X	Early adolescence-to-middle adolescence
Hunt KJ, et al.[37]					X	Late adolescence-to-young adulthood
Iacovelli JN, et al.[38]					X	Late adolescence-to-young adulthood
Immonen V, et al.[17]					X	Late adolescence
Ingram JG, et al.[28]					X	Middle adolescence-to-late adolescence
Iraqui-Rato I, et al.[18]					X	Late adolescence
Kaalund S, et al.[15]					X	Middle adolescence
Kristenson K, et al.[52]					X	Young adulthood
Loughran GJ, et al.[39]					X	Late adolescence-to-young adulthood
Mears AC, et al.[19]					X	Late adolescence
Miyamori T, et al.[20]					X	Late adolescence
Ngatuvai MS, et al.[29]					X	Middle adolescence-to-late adolescence
Paliobeis A, et al.[30]					X	Middle adolescence-to-late adolescence
Ramirez M, et al.[31]					X	Middle adolescence-to-late adolescence
Rössler R, et al.[12]					X	Early adolescence
Sokka T, et al.[13]					X	Early adolescence
Harris L, et al.[25]	X	Early adolescence-to-middle adolescence				
Heinzelmann MM, et al.[56]	X	Late adolescence				
Howard M, et al.[40]	X	Late adolescence-to-young Adulthood				
Meyers MC, et al.[43]	X	Late adolescence-to-young adulthood				
Meyers MC, et al.[41]	X	Late adolescence-to-young adulthood				
Meyers MC[42]	X	Late adolescence-to-young adulthood				
Meyers MC[44]	X	Late adolescence-to-young adulthood				
O'Kane JW, et al.[26]	X	Early adolescence-to-middle adolescence				
Babwah TJ[45]			X	Late adolescence-to-young adulthood		
Bjørneboe J, et al.[46]			X	Late adolescence-to-young adulthood		
Bianchi FP, et al.[21]			X	Late adolescence		
Ekstrand J, et al.[54]			X	Young adulthood		
Fujitaka K, et al.[22]			X	Late adolescence		
Fuller CW, et al.[47]			X	Late adolescence-to-young adulthood		
Fuller CW, et al.[48]			X	Late adolescence-to-young adulthood		
Hägglund M, et al.[24]			X	Young adulthood		
Meyers MC, et al.[32]			X	Middle adolescence-to-late adolescence		
Ross LK, et al.[49]			X	Late adolescence-to-young adulthood		
Soligard T, et al.[51]			X	Early adolescence-to-late adolescence		
Steffen K, et al.[16]			X	Middle adolescence		

Table 1. *Studies that favored artificial turf (AT), natural grass (NG) or reported no difference.*

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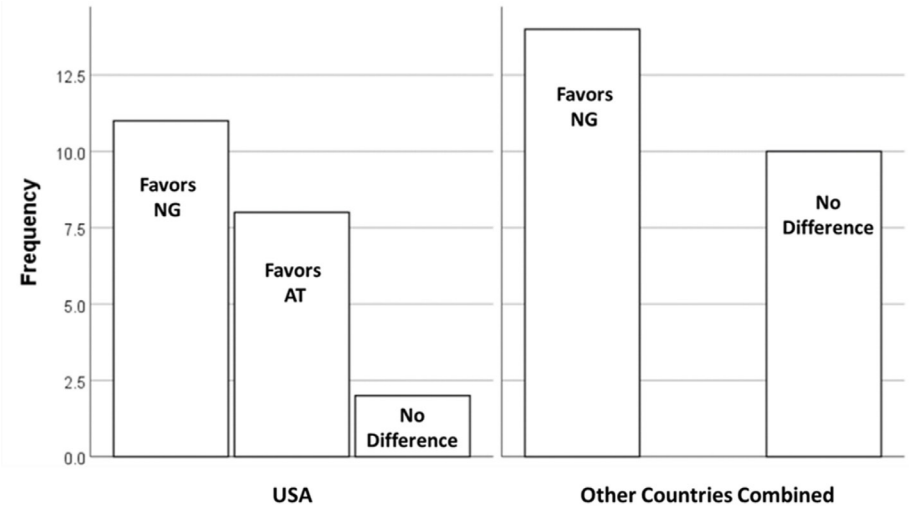


Figure 4. *The USA was the only country with studies supporting AT as being superior to NG among athletes between late childhood and young adulthood.*

favoring AT[40-44], and five studies reporting no difference between playing surfaces[45-49]. Two studies evaluated athletes from early-to-late adolescence, with one study favoring NG[50] and one reporting no difference between playing surfaces[51]. Three studies evaluated athletes during young adulthood (approximately 25 years of age) with one study favoring NG[52] and two studies reporting no difference between playing surfaces[53,54]. One study evaluated athletes from middle adolescence-to-young adulthood, favoring NG[55].

Overall, from an injury prevention perspective, 26 studies favored NG[11-15,17-20,23,24,27-31,33-39,50,52,55], eight studies favored AT[12,25,26,40-44,56], and 12 studies reported no differences between playing surfaces[16,21,22,32,45-49,51,53,54] *(Table 1)*. Most studies only evaluated males (n = 27, 6.7%) [11,14,15,17,18,21-23,31,33,34-39,41-44,46,50,52,53-56]. Although 14 studies evaluated both males and females[12,13,19,20,25,27-30,40,47-49,51]. Only five studies evaluated females separately[16,24,26,43,45]. Overall, 21 studies were performed in the USA (45.7%, 21/46)[25-29,31-35,37-44,49,55,56] and 25 were conducted in the rest of the world[11-14,15-20-24,30,36,45-48,50-54]. The USA (n = 9) displayed a greater than predicted number of studies that favored AT[25,26,32,40,41-44,56] compared to other countries (n = 0)(p = 0.003), while other countries displayed a greater than predicted favoring of NG or reporting no difference between playing surfaces (n = 14)[11,12,14,15,17-20,23,24,30,36,50,52] *(Fig. 3)*. The USA had more studies that evaluated participants from late adolescence-to-young adulthood (n = 12)[33-44,49] than other countries (n = 5)[36,45-48] (p <0.001).

DISCUSSION

From the perspective of the late childhood-to-late adolescence developmental period, the results of this scoping review suggest that a NG surface was favored for reducing musculoskeletal and concussion sports injury risk. This was the case when the study population consisted of participants between late childhood and early adolescence (9-14 years of age), during middle adolescence (15-17 years of age), late adolescence (18-24 years of age), or from early-to-late adolescence (14-24 years of age). These findings suggest that younger athletes up to late adolescence may possess differing musculoskeletal and concussion injury prevention needs compared to athletes from late adolescence-to-young adulthood (18 to approximately 25 years of age).

Most studies that compared the influence of NG and AT playing surfaces on musculoskeletal and concussion injury epidemiology focused on the late adolescent-to- young adulthood age (18-25 years of age), a period when both training and competition are near peak levels[57] In this group, a similar number of studies favored NG (n = 7) and AT (n = 5), with other studies (n = 3) finding no difference between playing surfaces. For this age group, either playing surface may possess similar musculoskeletal and concussion injury protection characteristics. However, results from studies of younger, early, middle, and even late adolescent age athletes suggest that NG may be more effective for musculoskeletal and concussion injury prevention. This may possibly be important during early athletic movement motor skill[58], core and neuromuscular control development[59,60], as the young athlete would likely get more natural and variable sensory feedback from NG.

Recent evidence suggests that during childhood and early adolescence, more rapid skeletal maturation may be occurring with the medical and public health communities attempting to better understand which factors may be contributing to earlier epiphyseal fusion timing[61,62] and increased bone mineral density levels[63,64], particularly when nutrition is optimal[65], Although this phenomenon is likely multifactorial, it emphasizes that much more needs to be learned about the specific needs of this developmentally vulnerable population[66].

Interestingly, compared to other countries, studies conducted in the USA were more likely to favor AT, with greater focus on participants during late adolescence or during late adolescence-to-young adulthood. This suggests potentially greater focus on athlete performance intensity in the USA rather than on more subtle aspects of childhood and adolescent sport development. Additionally, late adolescence-to-young adulthood age subjects are more

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likely to experience higher intensity sports competitions and practices with collisions or contact episodes. Other factors to consider in future studies is the influence of the culture of sports commercialization for different sports in different countries, and environmental climate change influences. Lastly, it also might be that the athletic organization and school revenue generating potential of early to late adolescence sports activities may equate to greater AT playing field surface access.

This study has several important limitations, and these results should be interpreted from the perspective of diverse contributing study designs, with some studies being statistically powered by large subject numbers obtained from injury surveillance databases and other studies representing small cohorts of <100 participants. These results were not weight-based on total study participant volume. The musculoskeletal and concussion injury incidence in every study was not normalized to athletic exposure, training hours, games played, etc. However, although studies with large participant numbers from injury surveillance databases are more likely to possess high statistical power, they may also lack the attention to individual research subject oversight details that smaller cohort studies often provide. Because of unique playing surface characteristics such as different generations of AT, several contributing studies suggested that broad generalization of their study findings was not recommended. However, with the inclusion of participants ranging in age from late childhood-to-young adulthood, differing study designs, and differing countries of origin, the current scoping review controlled bias, thereby improving study result generalizability. Also, a detailed integration of biomechanical theory and specific injury mechanisms was considered beyond the objectives of this review. A final limitation was that studies involving USA National Football League (NFL), Major League Baseball (MLB), and Major League Soccer (MLS) athletes were not included as the average age of these professional leagues was > 25 years[67,68]. Despite these study limitations, results suggest that NG may be the better playing surface for younger, developing athletes, and the study methods used may increase the generalizability of these findings.

CONCLUSION

Athletes who practice and compete on NG surfaces from late childhood-to-late adolescence may experience better musculoskeletal and concussion injury prevention.

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