The Effects of the Foot-Surface Interface on Agility Performance in Soccer

A Synthesis Project

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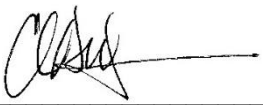

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Acknowledgments

This page is dedicated to anyone who has helped me throughout my academic career at SUNY Brockport and Le Moyne College. First, I would like to thank my mother and father for supporting me all these years, whether on the field, in the classroom, or life. Thank you for everything you have done and provided my brother and me; we are eternally grateful. Drew, thank you for all your support as well. Coming back to Brockport and playing the past two seasons with you is something I will cherish forever, and I am extremely grateful we got to experience it. I know you will go on to do great things in your playing and coaching endeavors. Nani and Chefe, thank you for always supporting me from afar. Lastly, thank you to all my family, friends, coaches, teammates, professors, and employers that I have had throughout my academic journey. I have gained an immense amount of knowledge from you all and thank you for your continued support.

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Abstract

Agility, defined as the ability to change direction quickly and efficiently, is a crucial skill in soccer that impacts a player's ability to outmaneuver opponents, maintain control, and capitalize on scoring opportunities. Agility not only enhances performance by enabling quick and effective responses to dynamic game situations but also serves as an indicator distinguishing higher-level players from lower-level players. Soccer demands agility, and the frequent, rapid changes in direction place significant physical demands on players. Shoe design factors and related accessories, such as high-friction socks and insoles, can influence a soccer player's agility performance. The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer. It was concluded that while stud configuration is the primary design factor of agility performance, supplementary accessories like grip socks or friction-enhanced insoles serve as valuable complements for improving stability and efficiency during rapid directional changes.

Chapter 1 – The Introduction

Rapid changes of direction, or cutting maneuvers, are frequent in team sports. Enhanced capability to change direction quickly enables players to create the space and time needed for a shot, pass, or block that can influence match performance (Apps et al., 2022). As such, agility is considered a crucial factor for success in team sports because players must constantly read and react to various stimuli and move quickly and efficiently in the ever-changing nature of the game environment, particularly in soccer (Matlák et al., 2024).

Whole-body changes in direction, such as cutting and turning, are among the most frequent movements observed in soccer, highlighting the importance of agility in determining the outcome of matches (Apps et al., 2020). Furthermore, the physical demands of soccer require players to perform over 700 cuts and turns within a game (Brinkmann et al., 2020), averaging one about every four to six seconds (Müller et al., 2010). The ability to execute these movements rapidly has been shown to differentiate between higher- and lower-division players (Apps et al., 2022).

In addition to physical skill, agility in soccer is closely linked to neuromuscular control, which enables players to rapidly decelerate and reaccelerate in new directions. This control is essential, as directional changes demand significant braking and propulsive forces, which are transmitted to the ground through the player’s footwear (Brinkmann et al., 2020). The effectiveness of these movements depends heavily on the foot-surface interface.

The foot-surface interface plays a key role in enhancing a player’s ability to maintain grip during quick movements, providing the necessary traction to prevent slipping while allowing for efficient energy transfer (De Clercq et al., 2014). Without an optimal interaction between a player’s footwear and the playing surface, a player's ability to execute agile movements can be

significantly compromised. Therefore, it is imperative for a player's equipment to support them when executing highly demanding movements within a soccer match (Brinkmann et al., 2020). Given this relationship between footwear and agility performance, understanding how footwear design impacts agility is crucial for players.

Soccer footwear has been a focus of research in sports performance for years. Since soccer involves frequent and rapid changes in direction, footwear must compromise between providing stability and allowing freedom of movement (Nunns et al., 2016). The evolution of soccer footwear has led to various boot models, each designed to enhance specific performance characteristics, such as sprint speed, ball control, or agility.

Research has shown that traction, the interaction between the shoe outsole and the playing surface, is a key factor in enhancing agility performance (Sterzing et al., 2014). Higher levels of traction can reduce the risk of slipping during change-of-direction maneuvers, allowing players to change direction more quickly and with greater control (Friedl et al., 2023). Several design factors of footwear, such as the midsole, upper material, insoles, and the configuration of the studs on the outsole influence traction. Studs are the most direct design factor that impacts the shoe-surface interface. These studs must penetrate the playing surface to provide the necessary grip for dynamic movements. Improved traction decreases running times during agility tasks and helps players maintain stability during rapid directional changes.

In addition to footwear design, the foot-surface interface includes high-friction socks which greatly influence agility performance in soccer. Grip socks are specialized athletic high-friction socks designed with added traction elements, such as rubberized grips or textured patterns on the sole. Grip socks are expected to impact agility, particularly during rapid change in direction movements (Apps et al., 2022; Friedl et al., 2023).

Statement of the Problem

Agility, defined by quick directional changes, is a critical factor for success in sports like soccer, where players must constantly react and adapt to the game's fast-paced environment. With players executing more than 700 cuts and turns in a single match, agility is a distinguishing skill between higher- and lower-level athletes. The interaction between the foot and surface is crucial for maintaining a player's grip during quick movements, delivering the traction needed to prevent slipping. Several design factors of footwear, including the midsole, upper material, insoles, and the configuration of the studs on the outsole can influence a player's traction. In addition to footwear design, grip socks have been shown to improve agility by minimizing foot movement inside the shoe, particularly during rapid changes of direction and braking.

Purpose of the Study

The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer.

Operational Definitions

1. Agility: A rapid whole-body movement with a change of velocity or direction in response to a stimulus.
2. Performance: The ability to execute quick directional changes, cutting maneuvers, acceleration/deceleration, and maintain stability during soccer-specific agility tasks.
3. Foot-surface interface: The dynamic interaction between an athlete's footwear and the playing surface, which influences traction, stability, and energy transfer during athletic agility movements.

Research Questions

1. What footwear design factor is the most impactful in affecting agility-related movements?
2. Do high-friction socks significantly improve agility compared to footwear design factors alone?

Delimitations

1. The articles used were peer-reviewed and within the current 2010-2024 date range.
2. The articles all explored how agility was affected by footwear.
3. All participants in the studies participated in a team sport with frequent change of direction movements, particularly soccer.

Chapter 2 – The Methods

The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer. An extensive literature search was completed using Brockport's Drake Memorial Library database. This synthesis benefits from using the most recent and up-to-date materials available from 2010 to the present year. Selection criteria included scholarly, peer-reviewed literature, and full-text references.

Brockport's Drake Memorial Library database was utilized for all of the following searches of articles for this synthesis. For the original search, the terms footwear and agility were used. This yielded 83 results. Keywords were then added to the original search to include footwear and agility performance, decreasing the number of results to 39 articles. From this extensive search of the database, two articles were deemed appropriate and usable for this synthesis. One article evaluated the impact of socks with high frictional properties during soccer-specific change of direction tasks, while the other investigated how soccer shoe ball girth differences affect players' agility running performance.

The next search included the terms footwear and change of direction, which returned 142 results. Keywords were added to include footwear and change of direction performance, which reduced the number of results to 40 articles. From this extensive search of the database, two articles were deemed appropriate and usable for this synthesis. Both articles explored the relationship between different levels of stiffness in soccer boots' effect on agility performance.

The next search used the terms soccer studs and performance, which resulted in 130 results. From this extensive search of the database, three articles were deemed appropriate and usable for this synthesis. Keywords were then changed to soccer boots and performance, resulting in 94 results, and one additional article was deemed appropriate and usable for this synthesis. All four articles shared common information regarding the effects of soccer boot stud configurations on agility and cutting performance.

A general search with the term grip socks was conducted that produced 98 results, with one article deemed appropriate and usable for this synthesis. This article assessed whether grip socks reduce in-shoe foot motion and improve agility performance in team sports players. And a final, general search with the term footwear insoles resulted in 2,890 results. Keywords were then added to the original search to include footwear insoles and performance which reduced the results down to 193 articles. From this extensive search of the database, one article was deemed appropriate and usable for this synthesis. This article assessed whether insoles with higher mechanical friction would enhance agility performance in team sports by reducing in-shoe foot sliding.

The literature review included a selection of articles based on specific inclusion and exclusion criteria. All studies involved participants who were either amateur, recreational, or experienced team sports players, particularly soccer. Studies were excluded if their design,

techniques, or procedures did not directly address the problem statement. For instance, studies involving participants from individual sports, such as tennis, or focusing on other performance aspects like speed, were not considered. Selected articles came from a range of academic journals. These journals include *Journal of Sport Sciences*, *Journal of Applied Biomechanics*, *Footwear Science*, and *Procedia Engineering*.

Each article used a wide range and number of participants. Apps et al. (2022) used 20 recreational team sports players, 10 males and 10 females. Apps et al. (2020) used 17 recreational team sports players, 11 male and six female. Friedl et al. (2023) used 12 recreational male soccer players with a mean age of 20.3 years. Sterzing et al. (2014) used 30 male soccer players. Kersting et al. (2023) used 23 active male soccer players with a mean age of 20.5 ± 1.9 years, mass of 73.5 ± 6.5 kg, and height of 1.78 ± 0.04 m. Müller et al. (2010) used 15 experienced soccer players. De Clercq et al. (2014) used 12 experienced soccer players. Brinkmann et al. (2020) used 18 male soccer players from the German amateur soccer league. Lastly, Luftglass et al. (2023) used 40 participants, 20 males and 20 females. Within all the studies, a total of 187 participants were included.

Chapter 3 – The Literature Review

The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer. After examining the articles cited for inclusion, three main topics emerged that contributed to the overall theme of this synthesis. These topics include footwear traction and grip, footwear fit and comfort, and supplementary footwear elements.

Footwear Traction and Grip

Müller et al. (2010) investigated how different soccer boot stud configurations impact movement patterns, joint loads, and traction during a 135-degree cutting maneuver, using boots

with removed studs, artificial turf, firm ground, and soft ground designs. Fifteen experienced soccer players performed five trials in each of the four different soccer boots, with data collected by using a motion analysis system and two force plates embedded in artificial turf boxes. The boot with removed studs showed a more vertical shank alignment and reduced forces on the ankle and knee but increased foot translation, indicating a higher risk of slipping. The soft ground design had the least foot translation but placed the most strain on the ankle, suggesting increased lower extremity loads. The artificial turf and firm ground designs provided moderate foot translation and joint strain, with no significant differences in approach speed. Movement adaptations due to high traction were evident, particularly at the ankle joint. The study concluded that stud configuration affects both agility performance and injury risk, recommending that soft ground boots be used cautiously on artificial turf due to the higher loads imposed on the ankle.

More recently, Kersting et al. (2023) examined how the design of soccer shoe cleats affects performance and joint loading during midfield tasks, like ball handling, directional cuts, and goal kicks. Twenty-three male soccer players tested three Adidas shoe models (A, B, and C) differing only in stud design. Data was collected using a force plate and a 24-camera infrared system during five soccer-specific tasks: a 90-degree cut, right and left, a 135-degree cut, right and left, and a goal kick into the net. Analysis revealed subtle differences in joint loading and performance across models. Results showed that Model A performed faster in left cuts, while Model B was faster in right cuts, indicating a direction- and task-specific impact of cleat design. Variations in ankle and knee joint strain were also noted, particularly when a ball was involved. Findings suggest that altering stud geometry can significantly impact the rotational behavior of soccer boots, potentially benefiting modern midfield players by addressing specific performance demands.

Additionally, De Clercq et al. (2014) investigated the effects of artificial turf moisture, dry versus wet, and three soccer stud configurations, Turf Field (TF), Artificial Grass (AG), and Firm Ground (FG), on cutting performance, traction, and player perceptions. Twelve experienced soccer players performed shuttle run tests, which involved 180-degree turns on both dry and wet artificial turf while wearing each stud type, with ground reaction forces recorded to measure traction. Results showed no performance difference on dry artificial turf across the three stud designs; however, on wet artificial turf, players performed worse in the TF shoes, with more slips and reduced traction. Player feedback aligned with these findings, indicating poorer grip, stability, and comfort in TF shoes on wet artificial turf. The study concluded that shoes with more aggressive stud designs are unnecessary for dry artificial turf, but AG and FG shoes provide sufficient traction on both wet and dry surfaces.

Similarly, Clarke and Carré (2010) aimed to improve soccer boot performance across artificial turf and natural grass surfaces, focusing on optimizing traction, player comfort, and biomechanical response between various soccer boot designs on different playing surfaces. Using biomechanical analysis and player feedback, the study evaluated various soccer boot configurations tested on both artificial turf and natural grass surfaces during simulated soccer activities like running, cutting, and kicking. Key findings showed that while playing on artificial turf, boots with certain stud configurations and material compositions that enhance grip and stability were recommended. For natural grass, designs that distribute pressure more evenly were favored. The results highlighted that boot design significantly impacts player agility performance and injury risk depending on the surface.

Footwear Fit and Comfort

For an athlete to benefit from boot design, it must be comfortable to use. A study performed by Sterzing et al. (2014) explored the impact of soccer shoe ball girth on players' fit perception, agility running performance, and running speed perception. Thirty male soccer players tested narrow, medium, and wide ball girths, with fit perception, agility running time, and speed perception measured using timing gates and Likert scale ratings. Results showed that players could perceive fit differences, with narrow girths rated as tighter, but no significant impact on agility performance or speed perception was observed. The study concluded that altering soccer shoe ball girth does not significantly impact agility running performance, even though players can perceive differences in fit. The findings suggest that fit properties may be less influential than traction properties in determining running performance.

In addition, Luftglass et al. (2023) investigated the impact of upper panel stiffness on biomechanical performance in athletic footwear, specifically during agility tasks. Involving 40 athletes who regularly engaged in sports with cutting and running movements, the study tested three Adidas FUTURENATURAL shoe conditions with low, medium, and high stiffness levels. Participants completed four agility tasks: lateral skater jumps, counter-movement jumps, triangle drop-step drills, and anterior-posterior drills, while ground reaction forces, contact time, and joint strain were recorded. Results showed that the highest stiffness condition improved lateral quickness by shortening ground contact time in lateral skater jumps tasks. The authors concluded that stiffer uppers could enhance lateral agility in specific tasks but not overall agility performance.

Another study by Brinkmann et al. (2020) explored how different levels of forefoot and midfoot bending stiffness in soccer boots affect agility performance and foot biomechanics. Eighteen male soccer players from the German amateur soccer league performed agility runs and

sidestep cuts in boots with varying levels of forefoot and midfoot stiffness. Results showed that while changes in overall bending stiffness had no significant effect on agility, increasing the forefoot-to-midfoot stiffness ratio by making the forefoot stiffer reduced agility by 1.3% and altered foot biomechanics, particularly increasing the likelihood of the player's foot rotating externally. The study concluded that while increasing the overall bending stiffness of soccer boots did not improve agility performance, it did systematically alter foot biomechanics. More importantly, the ratio between forefoot and midfoot bending stiffness was identified as a critical factor affecting both foot biomechanics and agility performance. The researchers recommend considering this ratio when designing soccer boots to enhance performance in agility-related movements.

Supplementary Footwear Elements

It is possible to add supplementary elements to the boot to improve agility. Apps et al. (2020) aimed to assess whether insoles with higher mechanical friction compared to standard insoles would improve rapid change of direction performance in team sports by enhancing the coefficient of friction (COF) and reducing in-shoe foot sliding. Seventeen recreational athletes completed side-cuts and 180-degree turns wearing shoes with minimal support to isolate insole effects while using both higher mechanical friction and standard insoles. Findings showed that higher mechanical friction insoles significantly increased static and dynamic COF by 35% and 49%, respectively, and reduced foot sliding during braking, particularly in the forefoot and midfoot during 180-degree turns. Performance in change of direction tasks was faster with higher mechanical friction insoles, and participants perceived their movements as quicker compared to standard insoles.

In a more recent study, Apps et al. (2022) examined whether grip socks reduce in-shoe foot movement and improve change of direction performance in team sports. Twenty recreational athletes performed change of direction tasks, including a 45-degree side-cut, 180-degree turn, and a 26-meter slalom course, while wearing grip socks and regular socks. Findings revealed that grip socks significantly reduced in-shoe motion during sharper turns, leading to faster slalom course completion than regular socks. Females reported more notable improvements in speed, grip, and stability compared to males, who displayed more in-shoe displacement due to greater foot spreading from their larger mass. The study concluded that grip socks enhance change of direction performance, particularly in slalom tasks, by reducing in-shoe motion.

Lastly, Friedl et al. (2023) investigated the effects of high-friction socks on in-shoe foot sliding, running performance, and speed perception during soccer-specific change of direction tasks. Twelve male recreational soccer players performed 45-degree side cuts and 180-degree turns wearing high-friction socks and standard compression socks, with traction and foot movement measured via 3D motion capture and ground reaction forces. Results indicated that high-friction socks increased traction during the braking phase of the 45° side cut. While participants felt faster in high-friction socks, actual speed performance did not improve.

Chapter 4 – Results, Discussion, and Recommendations for Future Research

The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer. The purpose of this chapter is to present the results of the review of literature on the effects of the foot-surface interface on agility performance in soccer and how these results align with the research questions, which guided this synthesis project. In addition, recommendations for future research are presented as they relate to the effects of the

foot-surface interface on agility performance in soccer. Several conclusions were taken from the findings of this literature research. First, the fit properties of footwear appear to be less influential in agility-related movements. Whereas, stud configurations are footwear's most impactful design factor in affecting agility-related movements. Second, high-friction socks have positively impacted agility-related movements by reducing in-shoe motion and improving traction, particularly during braking and turning tasks. However, high-friction socks are most effective when paired with the correct footwear designed for specific playing surfaces and movement patterns.

Interpretations

Two research questions were posed as part of this literature review. The first research question investigated what footwear design factor is the most impactful in affecting agility-related movements? The results from the literature review showed that footwear fit properties appear less influential in agility-related movements (Brinkmann et al., 2020; Luftglass et al., 2023; Sterzing et al., 2014). When examining the effect of varying ball girths, players could detect differences in fit, but no significant impact on agility performance was found (Sterzing et al., 2014). Similarly, varying the upper panel stiffness was found to influence lateral quickness in specific tasks; however, these effects were task-specific, and no significant benefits were observed in other agility tasks (Luftglass et al., 2023).

The most impactful footwear design factor affecting agility-related movements is the stud configuration. Traction is heavily dependent on stud geometry, placement, and surface interaction (Clarke & Carré, 2010; De Clercq et al., 2014; Kersting et al., 2023; Müller et al., 2010). For example, shoes with soft ground stud designs provide the least foot sliding but imposed higher loads on the ankle, indicating a trade-off between stability and stress on a

player's legs (Müller et al., 2010). Similarly, stud configurations affect performance directionally, as some configurations work better for left cuts, while others work better during right cuts (Kersting et al., 2023). Also, stud configurations for turf field shoes underperformed in wet artificial turf conditions, increasing the risk of slipping; while artificial grass and firm ground studs provided better traction across both surfaces (De Clercq et al., 2014). Lastly, specific stud configurations and designs were found to be best suited for different surfaces, such as artificial turf or natural grass, to ensure optimal performance (Clarke & Carré, 2010). These findings highlight that stud configuration is the most critical design factor for agility performance, with its ability to enhance traction directly influencing a player's movement.

The second research question was do high-friction socks significantly improve agility compared to footwear design factors alone? Compared to footwear design factors alone, high-friction socks provide a supplementary benefit for improving agility performance by directly addressing in-shoe foot sliding. High-friction socks, such as grip socks, are designed to enhance traction, which reduces in-shoe foot sliding, and is an important factor in agility performance. In fact, grip socks significantly reduce in-shoe motion during sharper turns (Apps et al., 2022). In particular, high-friction socks increase traction during the braking phase of side-cuts (Friedl et al., 2023). The added grip provided by high-friction socks appears to enhance an athlete's ability to execute rapid directional changes, particularly in tasks requiring tight turns (Apps et al., 2022; Friedl et al., 2023).

While grip socks improved agility in tasks involving rapid changes of direction, their effects were less notable in other movements, such as accelerating during straight-line running (Apps et al., 2022; Friedl et al., 2023). As a result, the benefits of high-friction socks appear to be task-specific, and high-friction socks are most effective when paired with the correct footwear

for specific playing surfaces and movement patterns (Apps et al., 2020; Apps et al., 2022; Friedl et al., 2023). In conclusion, high-friction socks have demonstrated a positive impact on agility-related movements by reducing in-shoe motion and improving traction, particularly during braking and turning tasks.

Implications

The literature review performed in this synthesis examined a variety of ways in which footwear and related factors, such as stud configurations, grip socks, and insoles, can enhance agility performance in soccer. It has been estimated that 130 to 300 million soccer players are organized on a club level worldwide, with many more playing in unorganized settings (Kersting et al., 2023). This highlights the substantial audience that could benefit from this knowledge, ranging from elite professionals to casual players. By identifying the design elements that optimize performance and reduce the risk of slipping, this research not only can elevate a player's performance but also address common injuries, such as muscle and ligament strains, often caused by inadequate traction. Understanding these factors can also guide manufacturers in creating better products, ultimately improving performance and ensuring safer play.

Recommendations for Future Research

In reviewing the database on how the foot-surface interface affects agility performance in soccer, several suggestions were made regarding future research. Future research should investigate unanticipated movements during dynamic changes of direction to better replicate game-like conditions and improve our understanding of agility demands (Müller et al., 2010). Future studies should also expand the exploration of upper panel stiffness in footwear by examining its effects on a broader range of athletic movements, such as running, to optimize footwear design and enhance performance (Luftglass et al., 2023). Additionally, future research

should consider the complex relationship between in-shoe traction and performance by accounting for factors such as shoe properties and player skill levels to better understand how traction influences agility (Friedl et al., 2023).

Summary

The purpose of this synthesis is to review the literature on how the foot-surface interface affects agility performance in soccer. Delimiting variables such as “published in the past 14 years”, “peer-reviewed”, “exploring how agility is affected by footwear” and “all participants in the studies participated in a team sport with frequent change of direction movements, particularly soccer” were used to help narrow the literature and shape the overall paper.

The research showed that footwear design, particularly stud configuration, significantly impacts agility-related movements by influencing traction, stability, and joint loading during directional changes. Findings highlighted that stud configuration is critical in enhancing performance by providing optimal grip for specific surfaces, such as artificial turf or natural grass while reducing the risk of injuries. Additionally, the research showed that high-friction socks and insoles enhance change-of-direction performance by minimizing in-shoe foot motion and improving traction. Through the extensive review of the literature, it was concluded that while stud configuration is the primary footwear design factor of agility performance, supplementary accessories like grip socks or friction-enhanced insoles serve as valuable complements for improving agility and stability during rapid directional changes.

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Appendix

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations
Apps et al. (2022)	Grip socks improve slalom course performance and reduce in-shoe foot displacement of the forefoot in male and female sports players .	Brockport's Drake Memorial Library database	This study aimed to assess whether grip socks reduce in-shoe foot motion and improve change of direction performance in team sports players, while also comparing the effects between males and females.	20 recreational team sports players. Participants completed various change of direction tasks, including a 45° side-cut, 180° turn, and a 26-meter slalom course.	Two-way mixed ANOVA tests were conducted to assess sock condition: GS vs RS and sex: male vs female on biomechanical, performance, and subjective perception outcomes.	Grip socks significantly reduced in-shoe foot motion during sharper turns and improved change of direction performance compared to regular socks. Specifically, participants completed the slalom course faster in grip socks.	The study concluded that grip socks enhance change of direction performance, particularly in slalom tasks, by reducing in-shoe motion. It is recommended that product developers enhance sock design by focusing on foot support, particularly in the forefoot region, to further improve agility and performance in team sports.
Apps et al. (2020)	Footwear insoles with higher frictional properties enhance performance by reducing in-shoe sliding	Brockport's Drake Memorial Library database	The study aimed to assess whether insoles with higher mechanical friction compared to standard insoles would enhance performance in	Seventeen recreational team sports players A regular insole and a developed training insole with increased friction were tested. Side-cuts (20º), complete turns (180º), and a slalom	Performance time, subjective perception, and COF between insole conditions were compared.	Insoles with higher friction showed a significant increase in COF compared to standard insoles.	Insoles with higher friction enhance performance during rapid COD, especially in severe directional changes (180° turns) by reducing foot sliding. Future footwear designs should

	during rapid changes of direction		rapid changes of direction in team sports.	course were performed.		Performance in COD tasks was significantly faster in insoles with higher friction. Insoles with higher friction reduced in-shoe foot sliding during braking phases.	consider optimizing insole friction properties, along with upper materials and support structures, to maximize stability and performance during COD movements.
Friedl et al. (2023)	Effects of athletic socks with high frictional properties on in-shoe foot sliding and performance in football-specific movements	Brockport's Drake Memorial Library database	The study aimed to evaluate the impact of socks with high frictional properties on in-shoe foot sliding, running performance, and speed perception during football-specific change of direction tasks.	Twelve recreational male footballers were tested in two sock conditions: a high-friction sock and a standard compression sock. Players performed COD tasks, including 45° side-cuts and 180° turns while wearing each type of sock.	Utilized coefficient of friction (COFu) and ground reaction force angle (GRFa) were analyzed.	The high-friction socks increased utilized traction and reduced GRF angle during the braking phase of the 45° side-cut but not in the propulsion or 180° turn phases. However, participants perceived faster speeds	The high-friction socks improved traction during braking but did not significantly impact propulsion or reduce foot sliding. The relationship between in-shoe traction and performance appears complex and may depend on other factors like shoe properties and athletic skill level. The findings indicate that high-friction socks may improve

						when wearing the high-friction socks.	player perception of performance.
Sterzing et al. (2014)	Effect of soccer shoe ball girth differences on fit perception, agility running and running speed perception	Brockport's Drake Memorial Library database	The study investigates how soccer shoe ball girth differences affect players' fit perception, agility running performance, and running speed perception.	Thirty male soccer players participated in the study, performing agility runs in three experimental shoe conditions: narrow, medium, and wide ball girths.	The main parameters analyzed were: Agility running performance: Measured by time taken to complete the agility course. Fit perception: Rated on a scale from narrow to wide. Running speed perception: Rated using a 9-point Likert scale.	Players perceived fit differences among the shoes. No significant differences were found in agility running performance or speed perception between the three shoe conditions. The use of individual lacing procedures might have compensated for differences in fit.	Altering soccer shoe ball girth does not significantly impact agility running performance. The findings suggest that fit properties may be less influential than traction properties in determining running performance. The authors recommend future research to examine the effect of fit in other parts of the shoe, as well as standardizing lacing procedures to assess whether it affects performance.
Kersting et al. (2023)	Effects of stud design on performance and joint	Brockport's Drake Memorial Library database	The purpose of the study was to compare the performance and joint loading	Twenty-three active male soccer players. Three shoe models (A, B, and C) were provided differing	The data were analyzed for kinematic differences, joint moment	Performance results showed that Model A was faster for left	The findings suggest that altering stud geometry can significantly impact the rotational

	loading during agility tasks including ball handling in soccer		effects of three different soccer shoe models with varying cleat geometries.	only in stud design. Data was collected during five soccer-specific tasks (90-degree cut, right/left, 135-degree cut, right/left, and a goal kick into a net).	curves, and performance outcomes.	cuts, while Model B was faster for right cuts. These results indicated that stud configuration had a task- and direction-dependent impact on performance and joint loading.	behavior of soccer boots, potentially benefiting modern midfield players by addressing specific performance demands. The study recommended further research to explore the direction-specific effects of stud geometry, as well as the impact on the entire kinetic chain.
Müller et al. (2010)	Different stud configurations cause movement adaptations during a soccer turning movement	Brockport's Drake Memorial Library database	The purpose of this study was to investigate the influence of soccer boot stud configurations on lower extremity kinematics and kinetics. The study sought to understand how different sole designs impact movement patterns, joint loads, and traction	Fifteen experienced soccer players performed five trials in each of four different soccer boots Players executed a 135-degree turn after a 6-meter approach.	Data from the trials were collected and analyzed to evaluate lower extremity joint moments, foot translation, and shank alignment at touchdown. The analysis focused on ankle and knee moments, foot translation, and overall movement	The soccer boot with removed studs resulted in the most foot translation, suggesting a higher risk of slipping. The soft ground design showed the least foot translation but increased ankle moments,	The findings suggest that different stud configurations affect movement patterns. The study recommends caution when using soft ground boots on artificial turf due to the higher loads imposed on the ankle. Future research should focus on unanticipated movements during dynamic changes of direction to better

			properties during a soccer-specific cutting movement.		patterns during the turning task.	indicating higher loads acting on the lower extremities.	reflect game-like scenarios.
De Clercq et al. (2014)	Cutting performance wearing different studded soccer shoes on dry and wet artificial turf	Brockport's Drake Memorial Library database	The study aimed to quantify the impact of artificial turf (AT) moisture (dry and wet) and three different soccer shoe stud configurations—Turf Field (TF), Artificial Grass (AG), and Firm Ground (FG)—on cutting performance, traction, and players' perceptions during soccer maneuvers.	Twelve experienced soccer players performed shuttle run tests, which involved 180° turns requiring high traction. The tests were conducted on dry and wet AT surfaces, with players wearing the three different shoe stud types.	Time to complete the shuttle run was recorded. Differences in performance between shoe designs on wet and dry AT were analyzed.	On wet AT, players wearing the TF shoe performed worse compared to those wearing AG and FG shoes. Required traction was significantly lower for the TF shoe on wet AT, correlating with decreased performance. Most slips occurred with the TF shoe in wet conditions.	The TF shoe, with multiple short studs, did not provide sufficient traction on wet AT. This suggests that shoes with more aggressive stud designs are unnecessary for dry AT, but AG and FG shoes provide sufficient traction on both wet and dry surfaces.
Clarke & Carré (2010)	Improving the performance of soccer	Brockport's Drake Memorial	The purpose of the study was to improve the	The study was conducted using different soccer boot	The results from the different surfaces—	The study found notable differences in	The research concluded that boot design should be

	boots on artificial and natural soccer surfaces	Library database	performance of soccer boots on both artificial and natural soccer surfaces.	configurations tested on both artificial turf and natural grass surfaces. Traction, pressure distribution, and player perception were measured during simulated soccer-specific movements, such as running, cutting, and kicking.	natural grass and artificial turf—were also compared to identify any significant differences in performance based on the playing surface.	how certain boot designs performed on artificial versus natural surfaces. Certain designs provided better traction and reduced the risk of slipping on artificial turf.	tailored specifically for the playing surface to optimize performance and minimize injury risk. The study recommended further research into surface-specific boot design to improve the overall safety and performance of soccer players across different playing conditions.
Brinkmann et al. (2020)	Effect of Forefoot and Midfoot Bending Stiffness on Agility Performance and Foot Biomechanics in Soccer	Brockport's Drake Memorial Library database	The study aimed to investigate how different levels of forefoot and midfoot bending stiffness in soccer boots affect agility performance and foot biomechanics.	Eighteen male soccer players from the German amateur soccer league participated. They performed agility and biomechanical tasks in soccer boots that were modified to vary in forefoot and midfoot bending stiffness. Participants performed agility runs around a pylon course and sidestep cutting maneuvers while motion analysis systems	The effects of different bending stiffness conditions on agility performance and foot biomechanics were analyzed.	No significant effects on agility run performance were observed from varying levels of bending stiffness. Stiffer footwear showed greater foot exorotation during change-of-	Increasing overall bending stiffness of soccer boots did not improve agility performance, it did alter foot biomechanics. The ratio between forefoot and midfoot bending stiffness was identified as a critical factor affecting both foot biomechanics and agility performance. Consider this ratio when designing soccer boots to

				captured lower-limb kinematics and kinetics.		direction movements.	enhance performance in agility-related movements.
Luftglass et al. (2023)	The effect of upper panel stiffness on biomechanical performance in athletic footwear	Brockport's Drake Memorial Library database	The purpose of this study was to investigate the effect of upper panel stiffness on biomechanical performance during agility tasks in athletic footwear.	40 participants. All participants were athletes who regularly participated in sports involving running and cutting movements. The participants were provided with three pairs of Adidas FUTURENATURAL shoes, each modified to have different upper panel stiffness levels. Participants performed four agility tasks: lateral skater jumps, counter-movement jumps, triangle drop-step drills, and anterior-posterior drills.	The study examined the differences between the three footwear conditions.	The study found that upper panel stiffness significantly impacted performance in the lateral skater jump task. The highest stiffness condition resulted in the shortest ground contact time, which was associated with faster lateral quickness.	The study concluded that stiffer upper panels in athletic footwear can improve lateral quickness by reducing ground contact time in agility tasks. However, this effect was task-specific, as no significant improvements were observed in other agility tasks. The study also recommended investigating how footwear stiffness affects other athletic movements, to provide a more comprehensive understanding of how to optimize athletic footwear design for different activities.