



Development Of A High-Performance Plan To Prevent Common Lower Body Injuries In Youth Field Hockey Players

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Abstract: This paper presents a comprehensive high-performance plan designed to prevent common lower-body injuries in youth field hockey players. Through an extensive literature review, the study identifies key risk factors and injury mechanisms specific to the sport, such as ankle sprains, knee ligament injuries, and muscle strains. The proposed plan integrates evidence-based strategies, including targeted warm-up routines, strength and conditioning exercises, and technique instruction, tailored to the developmental needs of young athletes. Structured across pre-season, in-season, and off-season phases, the program emphasizes progressive skill development and injury prevention. Key components include fitness testing, core stability exercises, coordination and agility drills, and position-specific strength training, all addressing the unique physical demands of field hockey. Grounded in evidence-based practices, the plan highlights age-appropriate training and position-specific requirements to enhance player safety and performance. By implementing this strategy, coaches and trainers can create a safer playing environment, reduce injury incidence, and support the long-term athletic development of youth field hockey players. This work offers a practical, evidence-informed framework to improve health and performance outcomes in this population.

Index Terms - Youth field hockey, Injury prevention, Lower body injuries, Training program, Strength training, Conditioning, Sports Performance, Athlete safety.

I. INTRODUCTION

Players dash across the pitch with sticks in hand, skillfully manoeuvring the ball in a dynamic display of physical fitness, teamwork, and strategic thinking (Alias et al., 2018; Ucan 2015). Field hockey involves a significant number of young males and females, establishing the groundwork for a long-term interest in sports involvement and nurturing potential future abilities in the sport (Sezen-Balcikanli and Sezen 2019; Elferink-Gemser 2005). The Federation of International Hockey is the international governing body responsible for overseeing field hockey worldwide. It establishes the game's rules, organizes world-class events such as the Hockey World Cup and Champions Trophy, and aims to promote the sport on a global scale (International Hockey Federation, 2024). Field hockey is a dynamic, fast-paced sport played either on grass, synthetic turf, or indoor surfaces (International Hockey Federation, 2024). It involves two teams, each aiming to score goals by hitting a ball into the opponent's goal with a hockey stick. A standard outdoor field hockey game consists of four quarters, with teams made up of eleven players each, including the goalkeeper (Tuca, Franz, and Sepulveda, 2021).

Field hockey involves dribbling, passing, tackling, and shooting during both open play and set pieces such as penalty corners and strokes (Furlong and Rolle, 2018; Mason et al., 2021). The sport demands aerobic endurance for sustained gameplay, as well as anaerobic fitness for high-intensity sprints and recovery (Mason et al., 2021; Eleferink-Gemser, et al. 2005). Additionally, players require muscular strength and power for skills execution and hitting power, agility and flexibility for skilful manoeuvring, along with balance and coordination for maintaining stability and control (Hassan 2018; Granacher et al., 2016; Benobin and Jothilingam, 2024; Granacher and Behm 2023). Players need specific and tailored training that aligns with their position, playing style, and individual requirements to effectively meet these physical demands. Cardiovascular workouts improve stamina, strength exercises enhance muscle function, plyometric training develops explosive power, agility drills focus on quick directional changes, and flexibility routines aim to prevent injuries (Schroeder et al., 2019; Ramasamy et al., 2022; B Barboza et al., 2019; Singh, Appleby and Lavender 2018; Chaudhary et al., 2021; Hanjabam and Kailashiya 2014; Sánchez-Migallón et al., 2020; Sharma and Kailashiya 2017). Participating in a thorough physical training program improves players' performance and reduces the risk of injuries on the field, essential for maintaining peak conditions during a demanding sports season (Elferink-Gemser 2005; Furlong and Rolle 2018; Rees et al., 2021; Cunniffe et al., 2021; Benobin and Jothilingam 2024).

Youth field hockey emphasizes the development of fundamental skills like passing, dribbling, and shooting, while fostering teamwork and strategic awareness (Furlong and Rolle 2018; Mason et al., 2021). It involves faster hits and direct plays toward the goal, as well as elevated aerial passes and robust body contact. Research indicates that female players are more prone to injuries such as concussions and facial injuries, partly due to differences in spatial awareness and playing styles (Barboza, Joseph, and Nauta 2018; Leelavathy and Madhu 2021). Girls are more than three times as likely to experience minor injuries compared to boys (Furlong and Rolle 2018; Leelavathy & Madhu 2021). The most common injuries for girls were contusions from being hit by the ball or stick, while boys tend to have lower limb injuries, possibly due to the physical nature and fast-paced play style of their hockey (Furlong and Rolle 2018; Leelavathy & Madhu 2021). Girls tend to wear protective gear, such as face masks, more often than boys during penalty corners (Furlong and Rolle 2018; Mason et al., 2021).

Lower body injuries are common in youth field hockey due to the high-speed and physically demanding nature of the sport (Furlong and Rolle 2018; Mason et al., 2021; Barboza, Joseph, and Nauta, 2018). Ankle sprains, knee ligament injuries like anterior cruciate ligament tears, and muscle strains in the hamstrings and quadriceps are among the most prevalent (Furlong and Rolle 2018; Mason et al., 2021). Research has shown ankle/foot injuries were about 16%, 27% respectively in women and 13%, 22% respectively in men of field hockey injuries, while and knee injuries were 12%, 7% in women and 28%, 7% in men from all injuries (Theilen et al., 2016; Furlong and Rolle 2018). Implementing targeted warm-up routines, strength and conditioning programs, as well as proper technique instruction can help reduce the risk of these injuries and promote long-term health and performance among players (Granacher and Behm 2022).

The physical demands of field hockey impose a significant strain on the lower body, highlighting the necessity to create a comprehensive high-performance plan aimed at preventing common lower body injuries in youth field hockey players (Barboza, Joseph, and Nauta, 2018). During preparation for high performance in youth field hockey, different positions require specific physical attributes. Forwards prioritize agility and speed to evade defenders, while Midfielders must have endurance to cover the entire pitch, defenders benefit from strength training to fend off opponents, and goalkeepers need specialized drills to enhance their reflexes and positional awareness. (Schwab and Memmert, 2012; Elferink-Gemser 2005; Canepa et al., 2023). To achieve the goal of minimizing injuries among young field hockey players, it is important to identify effective warm-up routines, strength and conditioning programs, as well as proper technique instructions that have been proven to reduce the risk of ankle sprains, knee ligament injuries, and muscle strains in the hamstrings and quadriceps. (Furlong and Rolle 2018; Leelavathy and Madhu 2021; Sánchez-Migallón et al., 2021).

Developing a high-performance plan to prevent common lower body injuries in young field hockey players is crucial for safeguarding their long-term health and performance (Benobin and Jothilingam, 2024; Canepa et al., 2023; Ramasamy, Franklin and Govindharaj 2023; KOCA and Revan, 2023; Granacher and Behm, 2022). This evidence-based plan focuses on the specific physical demands and injury patterns, targeting ankle sprains, knee ligament injuries, and muscle strains, and incorporates customized warm-up routines and strength and conditioning programs while also providing proper technique instruction. (Mason et al., 2021; Sands, Wurth, & Hewit, 2012).

The paper aims to develop a high-performance plan to prevent common lower body injuries in youth field hockey players, enhancing their overall health and performance while decreasing the frequency of injuries.

II. LITERATURE REVIEW

Youth field hockey is a dynamic and fast-paced sport that has gained popularity among young athletes (Mason et al., 2021; Elferink-Gemser 2005; Canepa et al., 2023; Alias et al., 2018). Youth field hockey involves various skill sets, including dribbling, passing, and shooting (Mohan, Murtaza and Katiyar 2021). In field hockey, players must possess a profound comprehension of the sport's dynamic movements, including rapid sprints, abrupt stops, directional changes, and agile manoeuvres. It is crucial to recognize the heightened susceptibility of young players to common lower-body injuries as a result of these demanding actions, potentially leading to sprains, strains, or fractures (Barboza, Joseph and Nauta 2018). To safeguard the well-being of young players, it's crucial to devise customized high-performance plans that address their requirements. This involves incorporating injury prevention strategies like adequate warm-up exercises, conditioning programs, and technique training (Gouttebarga and Zuidema 2018; Furlong and Rolle 2018; Barboza, Joseph, and Nauta, 2018). Addressing these potential risks proactively and understanding the physical demands of youth field hockey can help create a safer environment for young athletes to thrive in this exciting sport.

In youth field hockey, players must possess a thorough grasp of dynamic movements and fundamental skills, such as sprinting, abrupt halts, directional changes, dribbling, passing, and shooting techniques (Gouttebarga and Zuidema, 2018). Players in the sport are expected to execute a variety of movements at varying speeds and intensities, encompassing brief bursts of sprinting, leaping, and changes in direction, alongside extended intervals of lower-intensity actions like jogging or recuperating (Gouttebarga and Zuidema, 2018). Field hockey places significant stress on lower body joints and muscles due to frequent changes in direction, precise ball handling, and continuous running. Understanding the physiological and biomechanical aspects of these movements is crucial for preventing injuries. Studies analyzing the biomechanics of field hockey skills like dribbling and shooting provide insights into potential injury mechanisms (Gouttebarga and Zuidema, 2018; Mason et al. 2021). This is vital for designing targeted interventions to prevent common lower body injuries in youth field hockey players while enhancing their performance.

A significant concern for young field hockey players is lower body injuries. Ankle sprains are the most common, affecting roughly 20.58% of players, followed by knee ligament injuries (often ACL tears) at around 18.75%. Gender differences in injury rates are quite intriguing based on the data. Girls seem to experience a rate of foot and ankle injuries at 27% compared to boys at 22%. Moreover, thigh injuries appear to be more common among girls, at 11% as opposed to boys at 5%. It's critical to comprehend the nature of these ailments. Damage to the ligaments sustaining the ankle joint is the result of an ankle sprain. ACL tears are frequently the outcome of knee ligament injuries, which damage the vital ligaments that stabilize the knee. The hamstrings and groin region are frequently affected by muscular strains, which are defined as overstretching or tearing of a muscle (Furlong and Rolle 2018; Barboza et al., 2019; Das, Singh, & Sinha, 2023). Injury occurrence in adolescent athletes is particularly susceptible to overuse injuries, with the specific types varying based on developmental stage. For example, younger adolescents are more prone to growth plate injuries, while older adolescents may experience a higher incidence of stress fractures and tendinitis. This highlights the need for injury prevention strategies tailored to the specific physiological changes and risks associated with each age group within youth field hockey (Caine, Purcell & Maffulli, 2014).

Table 1 -Common Lower-Limb Injuries in Youth Field Hockey Players

No.	Injury location	Causes	Type of Injury	Reference
1	Knee	Contact with other players, sudden changes of direction, landing from jumps, overuse	ACL tears, patellofemoral pain syndrome, and patellar tendinitis	(Furlong and Rolle 2018; Barboza et al., 2019; Das, Singh, & Sinha, 2023)
2	Ankle	Contact with other players, uneven terrain, landing from jumps, overuse	Sprains, fractures, and Achilles tendinitis	(Furlong and Rolle 2018; Barboza et al., 2019; Das, Singh, & Sinha, 2023)

Table 1 explains Common Lower-Limb Injuries in Youth Field Hockey Players who play field hockey, often experience injuries. Knee injuries can occur from contact with others, movements or overuse of the knee joint. This can result in ACL tears, and tendinitis (Furlong and Rolle 2018; Barboza et al., 2019; Das, Singh, & Sinha, 2023). Ankle injuries are often caused by contact with surfaces or excessive strain, on the ankle joint. These types of injuries can lead to sprains, fractures or Achilles tendinitis (Furlong and Rolle 2018; B Barboza et al., 2019; Das, Singh, & Sinha, 2023). It is crucial to take measures to ensure the safety of these players.

The field hockey game presents biomechanical obstacles for young players because of its demands on quick and complex motions, including unexpected turns, pauses, and accelerations. These motions increase the risk of injuries such as ankle sprains, knee ligament tears, and muscular strains by putting stress on the lower body's muscles, tendons, and ligaments (Cornelissen et al., 2023; Wilmes et al., 2023). These injuries can have a major negative effect on a player's health and performance, frequently necessitating medical care or rehabilitation as well as impeding their capacity to practice and compete.

These movements may increase the risk of knee and ankle injuries, particularly in young players with inadequate eccentric strength in their lower limbs to control rapid decelerations (Ford et al., 2011). Adolescence is a period of rapid growth and development, with bones often growing faster than the supporting muscles. This imbalance can leave young field hockey players more susceptible to injuries, as the muscles may struggle to adequately stabilize joints during the sport's dynamic movements(Toselli et al., 2021).To mitigate this risk, adolescents need to maintain a healthy diet, engage in cross-training to support muscle development and avoid excessive training loads that could outpace their body's ability to adapt(Brenner and Watson, 2024). Suboptimal environmental conditions can increase the risk of lower-body injuries, especially on uneven, slippery, or hard playing surfaces. Extreme weather such as high heat, cold, or humidity can also affect hydration and muscle performance(Levi, Theilen, & Rolle, 2020). Studies show that proper footwear and protective gear are crucial for reducing injury risk in field hockey. Players should prioritize well-fitting shoes with cushioning and traction designed for their playing surface (Feeley et al., 2019). Additionally, protective gear like shin guards, knee pads, and ankle braces can significantly decrease the likelihood of injuries resulting from impact or falls (Jin & Lee, 2022). Understanding these risk factors is crucial for developing interventions to prevent youth field hockey injuries. This can be achieved by addressing biomechanical vulnerabilities through strength and conditioning programs tailored to the athletes' physiological development stage(Cornelissen et al., 2023). Additionally, implementing measures to enhance environmental safety is also important.

High-performance plans and injury prevention programs in youth field hockey aim to reduce the prevalence of lower-body injuries through comprehensive warm-up routines and targeted exercises.(Gouttebarga and Zuidema 2018). Dynamic stretching, agility drills, and targeted activation exercises effectively prepare players for the physical demands of youth field hockey by improving blood flow, muscle elasticity, and neuromuscular function to help reduce the risk of strains and sprains during play(Cornelissen et al., 2023; Mason et al., 2021; Wilmes et al., 2023).To prevent injuries during physical activity, it's important to strengthen the muscles, bones, tendons, and ligaments that support the joints. This can be achieved through strength and conditioning programs that focus on improving joint stability and resistance to stress. These

programs involve exercises targeting multiple muscle groups while enhancing functional movement patterns (Lauersen, Andersen and Andersen 2018). Studies suggest that incorporating core stability exercises into a youth field hockey player's training program may help prevent a range of lower body injuries, including ankle sprains and knee ligament tears (Barboza et al., 2019). These workouts aim to reduce strain on the legs during movements that involve rapid shifts in direction or speed, thus playing a crucial role in injury prevention (Cornelissen et al., 2023). Maintaining proper body mechanics is crucial to reduce the likelihood of injuries, especially during high-risk activities like landing from jumps. Coaches can improve players' landing mechanics, which are linked to lower limb injuries, through plyometric exercises and technique drills that focus on shock absorption and controlled movement (Cornelissen et al., 2023; Al Attar et al., 2022). Adopting a holistic approach to training and development can greatly benefit youth field hockey players. This strategy involves incorporating warm-up routines, strength and conditioning programs, technique instruction, as well as mental and emotional preparation into their high-performance plans. By doing so, they can improve physical fitness, prevent injuries, enhance flexibility, and ready the body for intense activity. Ultimately, this integrated approach forms a robust and effective training plan for youth field hockey players (Cornelissen et al., 2023). Ongoing review is crucial for maintaining the relevance and effectiveness of these interventions in sports science.

Developing an effective plan for youth field hockey to prevent lower-body injuries involves using existing studies to create tailored interventions for young athletes. Several studies have shown that core stability programs based on biomechanical principles contribute to overall stability during dynamic movements and help decrease the risk of lower body injuries (Saki et al., 2023; Wilmes et al., 2023; Jeong, Kim and Park 2023). Additionally, coordination and flexibility play significant roles in lowering the risk of injuries when addressed through targeted drills and exercises (Cornelissen et al., 2023). Understanding the physical demands and injury risks of different field hockey positions is crucial for developing injury prevention strategies for youth players. Forwards need exceptional acceleration and deceleration capabilities to handle rapid sprints and sudden stops. Targeted strength training that focuses on explosive movements and plyometrics can help improve these attributes (Cuadrado-Peñafiel et al., 2023; Brocken et al., 2020). Midfielders cover significant distances, making quick transitions between plays as they serve as the link between offence and defence. Conditioning drills that replicate the intermittent nature of the game can enhance endurance and adaptability (Dewar and Clarke 2021). Defenders face unique challenges with lateral movements and quick changes in direction while defending against opponent attacks. Including agility drills, lateral shuffles, and defensive positioning exercises can develop their lower body capabilities (Cowan et al., 2022). Goalkeepers have a distinct role, requiring specialized training for lower body strength through resistance exercises targeting leg muscles and dynamic stretching routines to boost agility and flexibility. Effectively tailoring injury prevention strategies to each position ensures addressing specific demands placed on different players for holistic development (Emery et al., 2019).

Young field hockey athletes have different needs and abilities based on their age and developmental stage. Coaches and trainers should tailor training programs to align with the physical traits specific to each phase of development to minimize injuries. Younger field hockey athletes may have lower levels of strength, endurance, coordination, and balance compared to older counterparts. This is partly due to differences in growth rates and bone maturity levels. Males typically experience a later growth spurt than females, around ages 13-17, while girls often experience theirs earlier, around ages 10-14. This rapid growth can lead to temporary challenges with coordination in young athletes. Additionally, the growth plates, which are areas of bone development at the ends of long bones, are open in younger athletes, making them more susceptible to injuries like growth plate fractures. As athletes mature, these plates close, creating stronger bones. Prepubescent athletes often have lower bone mineral density compared to pubescent athletes, increasing their risk for certain overuse injuries. Therefore, different age groups of players may have different needs and challenges when it comes to developing their field hockey skills and performance. Training programs should be tailored to consider these growth and maturity variations to optimize player development and minimize injury risk. (Manna et al., 2010; Mandorino et al., 2023). For example, younger players who are still learning the basics of the game may require more attention to their movement abilities and coordination, which are essential for mastering the technical and tactical aspects of field hockey. On the other hand, older players who are going through rapid physical changes may face some difficulties and risks related to their growth and maturation (Elferink-Gemser 2005; Magee et al., 2021; Cuadrado-Peñafiel et al.,

2023). Tailoring training programs for young field hockey athletes can help prevent injuries and support their overall health, promoting long-term athletic progress. It is crucial to successfully implement essential youth field hockey programs for effective high-performance strategies. When implementing training interventions, it's crucial to consider the available resources, coaching expertise, and adaptability of young field hockey players (Cornelissen et al., 2023). It's important to showcase effective instances and emphasize the significance of collaboration in improving interventions tailored to the specific circumstances of youth field hockey. Encouraging ongoing feedback to enhance the practicality and effectiveness of the plan will be beneficial for its success (Cornelissen et al., 2023).

Physical fitness parameters that are significant for the development of a high-performance plan for youth field hockey players include body composition, core muscle strength, upper muscle strength, and aerobic performance. These parameters have been identified through various studies on field hockey players (Alias et al., 2018). Research has indicated that optimal performance is contingent upon body composition, core muscle strength, and agility (Sharma and Kailashiya 2017; Ramasamy et al., 2022; Barboza et al., 2019). The 3RM test is a reliable method for assessing muscular strength, but further research is needed to explore its specific relevance to lower body performance in youth field hockey players (McCurdy et al., 2004; Bishop et al., 2014). Aerobic performance is a critical factor in determining physical fitness for youth field hockey players. While research on collegiate athletes provides a foundation, it's essential to consider the age-specific needs of younger players. The Yo-Yo Intermittent Recovery Test (Yo-Yo IRT), which differs from the 20-meter shuttle run, is a tool used to estimate maximal oxygen consumption (VO₂ max), an important indicator of overall athletic ability. Further research focusing specifically on youth field hockey is needed to determine the most effective fitness testing methods and optimal aerobic performance levels for this age group (Magee et al., 2021). By considering age-appropriate physical fitness assessments, a high-performance plan can be developed to enhance the performance of youth field hockey players. These assessments need to be tailored to the developmental stage of the athlete, considering both physical and cognitive capabilities (Silva et al., 2012).

The Q-angle, indicative of patellar alignment, influences knee mechanics in youth field hockey. A larger Q-angle correlates with an increased risk of Patellofemoral Pain Syndrome (PFPS), due to heightened stress on the kneecap cartilage during field hockey movements (Franca et al., 2016). Addressing Q-angle-related factors is vital in injury prevention strategies for young field hockey players. Muscle imbalances, notably quadriceps dominance, significantly affect young field hockey players, increasing injury risks and performance limitations. Joint stress and altered mechanics, impacting agility and coordination, highlight the importance of balanced muscle development (Farley et al., 2020). These imbalances hinder power, endurance, and skill development, essential for the sport (Farley et al., 2020). Balanced muscle development is crucial for supporting explosive movements, agility, and injury prevention. Incorporating exercises targeting both agonist and antagonist muscles is vital for optimizing performance and minimizing injury risks (Farley et al., 2020).

In summary, to reduce the risk of lower body injuries in youth field hockey, Customizing training programs for the specific physical demands of different positions in the sport is crucial. The goal is to analyze the factors that affect athlete performance, including physical attributes like speed, strength, and endurance, as well as injury statistics. Understanding how these factors intersect and impact one another can lead to better-designed, personalized programs aimed at improving athletes' health, fitness, and skills (Sánchez-Migallón et al., 2021). Youth field hockey programs focused on high performance must consider various factors that impact players' physical development. Core stability is important for preventing injuries and improving performance. Strength training enhances speed, agility, and endurance by increasing muscle mass and power. Coordination is essential for developing skills and tactics as it involves executing complex movements with precision and timing. Flexibility helps prevent stiffness and improves mobility. Injury prevention is a critical area of research that requires ongoing investigation. Many unanswered questions and challenges in this field necessitate thorough and methodical inquiry. Quality research improves comprehension of the causes, mechanisms, and outcomes of injuries, as well as effective methods for prevention and treatment. Physical fitness parameters such as body composition, core muscle strength, upper muscle strength, and aerobic performance are significant for developing a high-performance plan for youth field hockey players. These parameters have been identified through various studies on field hockey players and play a crucial role in enhancing their performance (Bandyopadhyay, Datta and Dey 2019; Sharma and Kailashiya 2017; Ramasamy et al., 2022; Barboza et al., 2019). Coaches play a crucial role in helping young field hockey players reach their full potential and derive enjoyment from the sport. They

must be able to adapt to their athletes' evolving needs and goals, as well as the challenges on the field. Creating a positive and supportive environment using evidence-based high-performance methods can enhance the development and well-being of these athletes. To improve youth field hockey performance, it's crucial to stay updated on the latest discoveries and incorporate new methods. Sports professionals should maintain an open-minded approach and be eager to learn from emerging evidence and practices that can enhance their athletes' performance.

III. HIGH-PERFORMANCE PLAN FOR INJURY PREVENTION

A comprehensive high-performance plan for young field hockey players addresses both injury prevention strategies for common lower-body injuries (ankle sprains, ACL tears, and overuse injuries) and age-appropriate training to maximize strength, agility, and on-field endurance. Strategic planning emphasizes player development and reducing injury risks through targeted interventions (Barboza, Joseph, and Nauta, 2018). Implementing a high-performance plan improves athlete well-being and performance outcomes by emphasizing a comprehensive approach. A comprehensive injury prevention plan recommends incorporating specific strength and flexibility exercises to reduce the incidence of common lower body injuries such as hamstring strains and ankle sprains, potentially lowering the risk of injuries (Brunner, Friesenbichler and Casartelli 2019). Enhancing the health and performance of young field hockey players involves taking a holistic approach that integrates nutritional guidance, sufficient rest, and mental resilience training. Tailoring the plan to position-specific demands is important. Forwards can benefit from speed and agility drills, midfielders may focus on endurance conditioning, defenders should prioritize strength training, and goalkeepers need specialized agility and reaction time exercises (Dewar and Clarke 2021). Implementing these strategies aligns with practices that enhance injury prevention and improve performance outcomes in youth field hockey.

Table 2- PRE-Season -8 Weeks Training Program

Week	Activities	Reference
1-2	Fitness Testing-Retesting (Regular fitness testing is an essential component of a high-performance plan for youth field hockey players. By re-assessing fitness levels every 8-12 weeks (or an age-appropriate interval), to track progress, identify areas for improvement, and make informed adjustments to training programs for optimal development)	(Liao et al., 2021; Magee et al., 2021; Faigenbaum et al., 2012; Chaudhary et al., 2021)
3-5	Core Stability Exercises	(Jeong, Kim and Park 2023)
	Coordination & agility drills	(Sánchez-Migallón et al., 2021)
	Strength & ground conditioning	(Cuadrado-Peñafiel et al., 2023)
6-8	Advanced Training (Core Stability Exercises)	(Saki et al., 2023)
	Advanced Coordination & agility drills	(Sánchez-Migallón et al., 2021)
	Advanced Strength & ground conditioning	(Koca and Revan 2023)

Table 2 outlines the fitness tests to assess strength, agility, and endurance during the first two weeks. Regular fitness testing is an essential component of a high-performance plan for youth field hockey players. By re-assessing fitness levels every 8-12 weeks (or an age-appropriate interval), to track progress, identify areas for improvement, and make informed adjustments to training programs for optimal development. The study used common methods to measure strength, including the one-repetition maximum (3RM), for exercises like squats and bench presses (McCurdy et al., 2004; Bishop et al., 2014). Assess

agility using the Illinois Agility Run Test(Chaudhary et al., 2021; Barboza et al., 2019). Endurance tests, the Yo-Yo Intermittent Recovery Test, are used to measure the aerobic capacity and vo2max of young athletes(Magee, K, M. et al., 2021; Silva et al., 2012).

Table 3 Core and Coordination Activities

Exercise	Set Reps	x	Intensity/rest between sets	Notes
Planks	3x30s		Moderate	Focus on maintaining a neutral spine.
Russian Twist	3x20		Light	Use a medicine ball for added resistance
Leg Raises	3x15		Moderate	Control the movement to engage the core.
Ladder drills(In & outs, lateral shuffles, Cariocas (crossovers,)Drills that involve direction changes after certain ladder patterns, mirroring the unpredictable nature, dribbling through the ladder, stick taps between rungs, or passes to a partner)	2x5		1 min	Emphasise precise footwork and quick movements
Cone drills(Weave Drills ,Slalom Drills ,calls out colors or numbers corresponding to cone)	2x8		1min	Focus on directional changes and acceleration.
Reactive agility(Pro-Agility Test 5-10-5)	2x10		1min	Use visual or auditory cues for rapid response.

During weeks 3-5 in Table 3, the baseline Training will begin with a comprehensive program of core stability exercises. These exercises aim to improve trunk strength and stability while addressing needs such as rotational power for strong hits, injury prevention of the lower back and hips, and dynamic balance for agility on the field. Including exercises that target the main muscle groups used in hockey moves, such as planks (including side planks and anti-rotational variations) for core stability, Russian twists with medicine balls for rotational power, bird dogs for core stability and coordination, squats (with jump squat or single-leg squat variations) for lower body strength and power, lunges for leg strength and balance, deadlifts for posterior chain power, push-ups for upper body pushing strength, rows for pulling strength and core stability, overhead presses for shoulder and throwing power, and plyometric exercises like box jumps and depth jumps (for advanced athletes) can significantly improve overall performance. Introducing coordination and agility activities will improve players' ability to change direction quickly while maintaining balance. In Week 3, the core stability exercises, coordination, and agility drills from weeks 2-4. In Week 4, a gradual increase in the intensity or duration of core stability exercises by 10-20% may be

appropriate, based on individual progress and readiness. This aligns with the principle of progressive overload, which is essential for continued improvement (Granacher and Behm 2023). It's important to closely monitor athletes for signs of fatigue or improper form to ensure safe and effective progression (Granacher and Behm 2023). Week 5 will either build on the progress made in Week 4 or maintain the current intensity based on individual requirements. It is important to monitor player feedback and make any necessary adjustments to the program to optimize personal or team development during the pre-season.

Table 4 Strength Training Program for In-Season and Competition Season Workouts (Weeks 9-44)

Exercise	setxrepxloadxrest	Reference	Components Addressed
Workout-1			
Hang Clean	3x8x60-80%x90-120 sec	(Faigenbaum et al., 2012;Sharma and Kailashiya 2018;Bishop et al 2015;Granacher et al., 2016;Granacher and Behm 2023).	Q-Angle reduction, Balanced muscles, Knee stability, Balanced muscles ,Plyometric training, Core stability
Goblet Squat	3x8x60-80%x90-120 sec		
Romanian Deadlift	3x8x60-80%x90-120 sec		
Plyometric Box Jumps	3x12x50-70%x60-90 sec		
Lateral Bounds	3x12x50-70%x60-90 sec		
Standing Calf Raises	3x12x50-70%x60-90 sec		
Stability Ball Plank	3x30sx40-60%x60-90 sec		
Side Plank Leg Raise	3x30sx40-60%x60-90 sec		
Workout-2			
Medicine Ball Slams	3x12x50-70%x60-90 sec	(Singh, Appleby and Lavender 2018; Schroeder et al., 2019; Sharma and Kailashiya 2018;Bishop et al 2015; Granacher et al., 2016;Granacher and Behm 2023).)	Core stability, Upper body strength, Power,Core stability, Hip stability, Lower body strength
Split Squat Jumps	3x12x50-70%x60-90 sec		
TRX Wood Chops	3x12x50-70%x60-90 sec		
Leg Press	3x8x60-80%x90-120 sec		
Plank with Leg Lift	3x12x50-70%x60-90 sec		
Single Leg Glute Bridge	3x12x50-70%x60-90 sec		
workout-3			
Kettlebell Swings	3x12x50-70%x60-90 sec	(Singh, Appleby and Lavender 2018; Schroeder et al., 2019; Sharma and Kailashiya 2018;Bishop et al 2015; Granacher, U	Lower limb strength, Balanced muscular growth, ACL injury risk reduction
Step Ups	3x12x50-70%x60-90 sec		
Bulgarian Split Squats	3x12x50-70%x60-90 sec		

Stability Ball Hamstring Curl	3x12x50-70%x60-90 sec	et al., 2016)	
Standing Calf Raises	3x12x50-70%x60-90 sec		
Russian Twists	3x12x50-70%x60-90 sec		
Tapering week workout -1			
Clean and jerk	2x12x50%x60-90 sec	Hermassi et al., 2019.	Lower body strength, Knee stability
snaches	2x12x50%x60-90 sec		
Half squat	2x12x50%x60-90 sec		
Tapering week workout -2			
Clean and jerk	2x12x50%x60-90 sec	Hermassi et al., 2019.	Full body strength, Knee stability
snaches	2x12x50%x60-90 sec		
Half squat	2x12x50%x60-90 sec		

Table 4 demonstrates how this strength training program incorporates proven exercises to target specific components. These include reducing the Q-angle, promoting balanced muscle growth, improving knee stability, and increasing lower limb strength stability. This program emphasizes core and hip stability as crucial factors in reducing common lower limb injuries in youth field hockey players. Strong core muscles support the spine and pelvis, promoting proper alignment during the sport's dynamic movements, which can decrease the stress on knees and ankles (Ramasamy et al., 2022). Stable hips are vital for controlling changes of direction and absorbing impact forces, helping to protect against ligament injuries like ACL tears (Saki, Shafiee and Tahayori 2023). The program incorporates exercises like planks, side bridges, hip thrusts, and single-leg balance drills to develop these preventative strength and stability areas. Each session consists of three regular workouts and one tapering week, which include compound movements such as hang cleans, medicine ball slams, and kettlebell swings. Functional workouts like plyometric box jumps and TRX wood chops help improve neuromuscular coordination and provide dynamic stability, which contributes to injury prevention in youth field hockey players (Al Attar et al., 2022). In the tapering weeks, exercises such as Clean and jerk, Bench press, snaches and Half squats can promote muscle development and stability (Hermassi et al., 2019).

Table 5 Conditioning Program for In-Season and Competition Season Workouts (Weeks 9-44)

Exercise	Reference	Component Addressed
Interval Sprints(40-meter sprints with 30-second rest)	(Bandyopadhyay et al., 2019; Cuadrado-Peñafiel et al., 2023). (Benobin & Jothilingam 2024; Schroeder et al., 2019)(Elferink-Gems	Cardiovascular Endurance, Speed and Agility
Shuttle Runs(5-10-5 Pro-Agility run)		Speed and Agility, Muscular Strength and Endurance
Cone Drills(Illinois Agility drill)		Agility, Flexibility, Balance, and Coordination

High-Intensity Running(Repeated sprints with work/rest ratio based on fitness level)	er et al., 2006; Magee et al., 2021)	Cardiovascular Endurance, Speed and Agility
Ladder Drills (forward/lateral patterns, progressing to reactive variations)		Agility, Flexibility, Balance, and Coordination
Shuttle Sprints(Short sprints (10-20m) with sudden changes of direction based on partner cues)		Speed and Agility, Muscular Strength and Endurance
Medicine Ball Throws(Rotational chest pass)		Power, Muscular Strength and Endurance
Agility Drills(Lateral shuffles with cone touches)		Agility, Flexibility, Balance, and Coordination
Plyometric Exercises(Box jumps (start with low height, progress as tolerated)).		Power, Muscular Strength and Endurance
Tapered Running(Gradual decrease in pace and distance leading into competition)		Cardiovascular Endurance, Speed and Agility

In the table-5, conditioning programs aim to improve various fitness components crucial for hockey, including cardiovascular endurance, agility, speed, and sport-specific abilities. The combination of drills and workouts is designed to develop a versatile athlete ready for the dynamic requirements of youth field hockey.

Strength Training Program Significance

The Hang Clean enhances power, explosiveness, and full-body coordination.

- Goblet Squats develop lower body strength by targeting the quads, hamstrings, and glutes.
- Romanian Deadlifts strengthen the hamstrings and lower back for hip hinge movements.
- Plyometric Box Jumps boost lower body power and reactive strength.
- Lateral Bounds enhance lateral stability and agility.
- Standing Calf Raises target calf muscles for explosive movements.
- oblique and hip abductors, enhancing lateral stability and strengthening lateral core muscles and hip abductors.
- Leg Press: Targets lower body strength.
- Plank with Leg Lift: Engages core muscles for stability and balance.
- Single-Leg Glute Bridge: Strengthens the glutes and hamstrings.
- Kettlebell Swing: Targets posterior chain muscles, and improves hip movement.
- Step Up: Works on unilateral leg strength and stability.
- Bulgarian Split Squat: Develops single-leg strength and stability.
- Stability Ball Hamstring Curl – Targets hamstrings to improve overall stability.
- Russian Twist – Engages obliques to enhance rotational core strength.

Strong core muscles support the spine and pelvis, promoting proper alignment and reducing the risk of lower back injuries. Strong legs and core are crucial for absorbing impact forces and maintaining proper form during movements, reducing stress on joints like knees and ankles. Exercises like the Hang Clean enhance power, explosiveness, and full-body coordination, which are all crucial for dynamic field hockey

movements (Hermassi et al., 2019). Goblet Squats develop lower-body strength, particularly in the quads, hamstrings, and glutes, providing athletes with a strong base for sprints, jumps, and tackles (Granacher and Behm 2023; Koca and Revan 2023; Bright, Handford and Mundy 2023).

Conditioning Program Significance

Interval sprints and shuttle runs provide an effective way to simultaneously improve cardiovascular endurance, speed, agility, muscular strength, and endurance in youth field hockey players. These training methods enhance anaerobic capacity and the ability to perform repeated high-intensity sprints with short recovery periods, as often required in field hockey (Bandyopadhyay et al., 2019; Cuadrado-Peñafiel et al., 2023). Cone drills are designed to enhance agility, flexibility, balance, and coordination, all vital for executing quick changes of direction and maintaining stability during tackles (Chaudhary et al., 2021). For a focus on endurance, speed, and agility, endurance running can be a valuable addition to a training program (Hanjabam & Kailashiya, 2014). Ladder drills improve agility, flexibility, balance, and coordination by promoting quick footwork and dynamic movements (Schroeder et al., 2019). Shuttle sprints, requiring rapid acceleration and deceleration, are excellent for developing speed, agility, muscular strength, and endurance, crucial for explosive movements in field hockey (Benobin & Jothilingam 2024; Schroeder et al., 2019). Medicine ball throws can improve power, strength, and endurance throughout the upper body and core, contributing to forceful shots and tackles in field hockey (Hassan, 2018). Agility drills directly target the ability to move quickly and efficiently, while also emphasizing flexibility, balance, and coordination, supporting players' ability to navigate the field with control (Singh et al., 2018). Plyometric exercises enhance power, strength, and endurance, improving athletes' ability to jump, change direction explosively, and maintain stamina throughout matches (Elferink-Gemser et al., 2006; Magee et al., 2021). Dynamic stretching can improve flexibility, balance, and coordination, helping athletes move through a wider range of motion and potentially reducing muscle tightness that could contribute to injury (Sharma & Kailashiya, 2017). Finally, tapered running can optimize cardiovascular endurance, speed, and agility in the lead-up to the competition, ensuring athletes are at peak performance when it matters most (Cuadrado-Peñafiel et al., 2023)."

Youth hockey players should always start with a 15-20 minute warm-up before engaging in skill or strategy training. It's crucial to properly warm up and cool down. Use a foam roller or myofascial release ball for 3 minutes on each target area, aiming for 5-8 strokes per area. This helps release muscle tension, address trigger points, and improve blood flow. This can enhance flexibility, reduce pain, and support faster muscle recovery. Next, ease into it by jogging slowly or spending six minutes on a treadmill, bike, or rowing machine. Then move on to stretches targeting various muscle groups including triceps extension, neck flexion and extension, side forearm stretches, spinal twist, and lower back stretches along with hip flexor and adductor stretching exercises. Additional warm-up drills incorporate side shuffles, butt kicks, high knees as well as ladder drills. In the gym setting go through barbell warm-ups that include squats, good mornings, shoulder presses, and Romanian deadlifts done for three to five repetitions. Dynamic motions such as loop/Thera tube movements, Pogo Jumps, and leg swings can last anywhere from two to three minutes. After every session utilize static or PNF stretches during the cool-down period (Barboza et al., 2019; Ramasamy, Franklin and Govindharaj 2023; Manna et al., 2010; Cornelissen et al., 2023). This routine aims to reduce the risk of ACL injury in field hockey players by strengthening muscles, improving stability, and enhancing alignment. Tapering periods are essential for athletes' recovery allowing them time to adjust themselves while maximizing their abilities. During the 8-week off-season, athletes focus on recovery and preparation. This involves a continuous 4-week block followed by a 1-week intermittent phase. Weeks 1-4 complete rest, Weeks 5-8 Slowly increase activity level, starting with bodyweight strength work and basic conditioning. Skill Maintenance (Optional): Light, fun drills without full-intensity competition. Prepare for the Next Phase: Towards the end, introduce elements that align with your upcoming training phase's focus (Funch et al., 2017).

The youth field hockey training program utilizes a unique periodization model tailored to the developmental needs of young athletes, with a focus on progressive skill development and injury prevention. Regular fitness assessments and skill evaluations ensure the program's effectiveness and ongoing adaptations (Molmen, ofsteng & Ronnestad, 2019). The training program aims to enhance the performance and minimize injury risks for young hockey players by focusing on specialized fitness

components. These components are designed to achieve increased agility, strength, and cardiovascular endurance (Benobin & Jothilingam 2024). This set it apart from traditional training programs due to its use of plyometric exercises specifically designed for youth athletes, as supported by recent research (Wilmes et al., 2023). It is vital to assess facility, equipment, and technology requirements for technical feasibility. Additionally, ensuring program integrity requires consideration of the availability and accessibility of fitness testing resources (Bishop et al., 2015; Brocken et al., 2020). Pre-season: May-June, In-season/Competition Season: July to March, Off-season: 4 weeks of April and 1 week 4 times during in between July to March when it requires or after any major tournament. Manage pre-season training, in-season skill development and competition support, and off-season recovery strategies, with a timeline aligned to the typical youth field hockey calendar. Operational feasibility assesses the program's suitability for implementation, with trained coaches and support staff prepared to effectively manage the various stages according to a clear timeline that takes into account the seasonal nature of hockey (Elferink-Gemser 2005; Rees et al., 2021; Schwab & Memmert, 2012). Risk assessment involves identifying issues and proposing solutions to mitigate them. Evaluation criteria for measuring program success include tangible results, participant feedback, and performance indicators (Schwab & Memmert, 2012; Mason et al., 2021). Legal and ethical considerations ensure compliance with laws and standards. A certified strength and conditioning coach provided access to well-equipped training, sports medicine, and physiotherapy facilities for prompt assistance with injury prevention and management. They dedicate time to intense training while limiting disruption to routine practice, promoting both technical and operational feasibility. Proper equipment ensured technical feasibility for strength training for supporting effective workouts. Position-specific coaches tailor training based on each player's position demands, thereby enhancing overall performance. This feasibility study presents a comprehensive youth hockey development strategy, including considerations for video analysis technology, coach development programs, and ethical guidelines focused on athlete well-being. Recommendations include specific injury prevention protocols, scheduling strategies aimed at reducing burnout, and policies to promote a safe and inclusive training environment. These measures are designed to ensure the program's success and longevity.

IV. JUSTIFICATION

The proposed youth field hockey training and conditioning program aligns strategically with the objectives of the youth hockey development plan. This program emphasizes specialized fitness components like agility, strength, and cardiovascular endurance, which research suggests are crucial for young athletes in this sport (Ramasamy et al., 2022). This targeted approach ensures the training directly supports the development plan's goals for player growth. Enhancing performance and minimizing injury risks are the key goals. This involves incorporating targeted exercises aimed at different muscle groups and aspects of physical fitness, such as balance, stability, and power. These elements are essential for achieving the desired outcomes of the study (Benobin and Jothilingam 2024). In addition, prioritizing warm-up, cool-down, and injury prevention is in line with the overall goal of ensuring the long-term fitness and well-being of young field hockey athletes (Barboza et al., 2019).

The training program for youth field hockey players is designed with evidence-based practices, incorporating specific warm-up and cool-down exercises such as dynamic stretches and foam rolling. These exercises can aid in reducing the risk of ACL injuries in field hockey players (Barboza, Joseph, and Nauta, 2018). In addition, evidence supports the use of tapering periods for athletes' recovery, emphasizing the importance of rest, injury rehabilitation, and mental rejuvenation in optimizing performance (Ramasamy Franklin and Govindharaj 2023; Wang et al., 2023). It highlighted the significance of specialized fitness components like agility, strength, and cardiovascular endurance for young hockey players (Manna et al., 2010). These factors not only improve performance but also decrease the risk of injury, perfectly aligning with the goals of the youth hockey development project. An alternative approach could have been to concentrate only on traditional strength and conditioning exercises without incorporating specialized fitness components such as agility and cardiovascular endurance. However, this approach may contribute to overall strength but lacks the specific training needed for field hockey players who depend on agility and cardiovascular endurance for the dynamic nature of the sport (Tuca et al., 2021). Such an approach may also neglect the importance of addressing injury prevention and long-term well-being, which are crucial for youth field hockey athletes. An alternative strategy could have been to implement a purely technical training program without a comprehensive strength and conditioning component (Benobin and Jothilingam 2024). This approach could, however, overlook the physical development necessary for young athletes to perform

at their best and reduce the risk of injury. This preferred strategy integrates specialized fitness components, fosters collaboration between sports science and coaches, and leverages knowledge of position demands to provide tailored training plans that consider individual strengths and weaknesses. This collaborative and data-driven approach ensures a more holistic program that better prepares athletes for the specific demands of their positions (Canepa et al.2023). It effectively caters to the specific needs of field hockey players, enhances overall performance, and reduces the risk of injury.(Granacher and Behm 2022). Ensuring the operational feasibility of the program involves allocating necessary resources like qualified coaches, sports medicine facilities, physiotherapy support, and well-equipped training facilities(Brunner, Friesenbichler and Casartelli 2019). Creating a comprehensive training plan that integrates specialized fitness components, including agility, strength, and cardiovascular endurance based on assessment findings is essential for improving the overall performance of the players while reducing the risk of injuries(Manna et al., 2010; Bright et al., 2023). Developing a strategy that focuses on specialized fitness components like agility, strength, and cardiovascular endurance is expected to greatly enhance the overall performance of young field hockey players(Gouttebarga and Zuidema 2018). This will improve their physical capabilities and skills, leading to enhanced on-field performance(Chaudhary et al., 2021). The holistic approach aims to minimize the risk of injuries and ensure the long-term health and well-being of the players(Schroeder et al., 2019). Based on the needs identified in the program's Needs Assessment, concrete outcomes will be monitored. This includes physical improvements measured through standardized fitness tests (3rm, yo-yo test, agility test) and performance metrics like goals scored, defensive saves, and game-win rate (Benobin and Jothilingam 2024). This data will be used to assess the program's effectiveness in achieving its goals and support necessary adjustments.

V. SUMMARY

A comprehensive high-performance plan for youth field hockey incorporates strength training, flexibility exercises, and skill-specific drills to address the multi-faceted demands of the sport and minimize injury risk. The high-performance plan includes assessing current fitness levels, allocating resources, creating a training schedule, establishing a timeline, and monitoring outcomes. The strategic plan prioritizes injury prevention, and the implementation of a comprehensive full-season program to support player development, reduce injury risks, and ensure the well-being of young hockey players. Training and conditioning are essential for developing young field hockey players. It is crucial to assess current fitness levels to tailor the training program to individual needs. The presence of skilled coaches, sports medicine facilities, physiotherapy support, and well-equipped training facilities has also contributed significantly to its feasibility. A plan that integrates specific fitness components based on assessment findings is essential for success. The pre-season begins with an eight-week program focusing on fitness testing, biomechanical analysis, and core stability exercises. The initial weeks include strength, agility, and aerobic capacity assessments, followed by a regimen of strength training, conditioning, and injury prevention exercises with a scheduled tapering week after every 4 weeks of training. The conditioning program gradually intensifies training intensity and complexity for individual development. During the off-season, players prioritize active relaxation, injury recovery, and mental renewal to enhance performance. The strategic plan aims to promote long-term health and player development.

VI. LIMITATION

The study focused on developing an effective training plan for young field hockey players, with a focus on improving agility, strength, and cardiovascular endurance. The study does have some limitations though, such as practical constraints like financial investments, availability of modern training facilities, and commitment from athletes, coaches, and support staff. These limitations could affect the full implementation and success of the suggested strategy; especially in smaller sports programs or those with limited financial resources. Acknowledging these limitations demonstrates a comprehensive understanding of the challenges involved in implementing this high-performance plan. The study's limitations can significantly affect the high-performance training and conditioning program's overall effectiveness and implementation. Moreover, challenges in working with specialized coaches and sports scientists, as well as difficulties in accessing modern biomechanical analysis technologies for tracking performance, present methodological limitations. This study focuses on youth field hockey and provides a specialized high-performance injury prevention plan that addresses the sport's particular demands as well as the specific needs of young athletes. While the

program itself may not be directly applicable to other situations, the principles of evidence-based training, emphasis on age-appropriate development, and integration of performance and injury prevention measures are valuable beyond field hockey. This work provides a strategy for creating precise, sport-specific programs to improve young athletes' long-term performance success. To tackle these obstacles, collecting perspectives from diverse sources and seeking innovative solutions is paramount. The study acknowledges practical limitations and obstacles that could impact the implementation of the high-performance development strategy for young field hockey players. Financial investments, modern training facilities, and the commitment of athletes, coaches, and support staff pose significant challenges. These constraints may impede the execution and effectiveness of the proposed strategy, particularly for smaller sports programs or those with limited financial resources. Collaboration issues with specialized coaches and sports scientists as well as difficulties in accessing modern technologies also influence the study's methodology. The emphasis on young field hockey players restricts its findings' applicability to other sports or age groups. The study did not investigate the impact of cultural and environmental factors on the implementation of high-performance programs. Further research is necessary to explore these influences, create strategies to mitigate their effects and evaluate the long-term effectiveness of the program in terms of career longevity and injury prevention. Subsequent studies could concentrate on improving the understanding of high-performance training in field hockey as well as other sports.

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