FALLON WIEDEMEIJER N11275901
ID STUDIO 7 DNB311
CRITICAL REPORT A1

WORD COUNT: 4313

RAYZR PERFORMANCE

ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION IN FEMALE SPRINT ATHLETES FOR LONG TERM PERFORMANCE AND WELLBEING

AUTHENTICITY STATEMENT

Authenticity Statement
This is to certify that to the best of my knowledge, the content of this report is my own work. This report has not been submitted for any subject or for other purposes. I certify that the intellectual content of this report is the product of my own work and that all the assistance received in preparing this report and sources have been acknowledged.

Your name: Fallon Wiedemeijer
Student number: n11275901
Date: 01/09/2025

AI Use Statement
I have utilised Generative AI in this report, including ChatGPT, Grammarly and Otter AI, to assist in various ways. The use of Artificial Intelligence throughout this report includes Otter AI for transcribing interview audio recording, ChatGPT for reduction of word count to stay within word limit, and Grammarly AI to ensure grammatical accuracy.

Your name: Fallon Wiedemeijer
Student number: n11275901
Date: 01/09/2025

EXECUTIVE SUMMARY

"What are the key factors that contribute to the heightened frequency and severity of Anterior Cruciate Ligament injuries among female sprint athletes, and how can these issues be addressed to enhance long term athletic performance and wellbeing?"

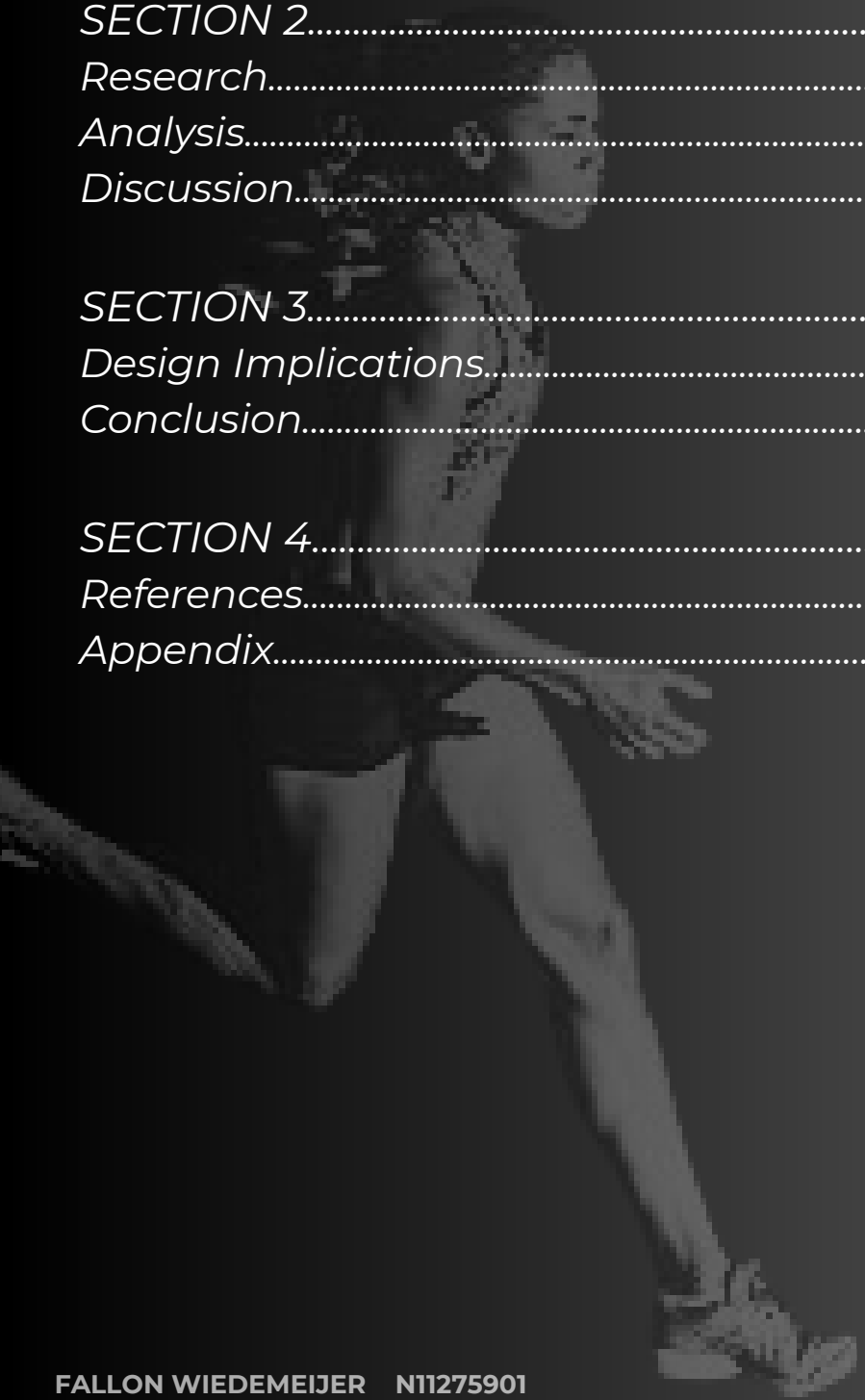
Female sprint athletes experience a higher rate of non-contact knee ligament injuries, most commonly to the anterior cruciate ligament (ACL) and medial collateral ligament (MCL), when compared to their male counterparts (Renstrom et al., 2008). This is the result of a combination of anatomical, physiological, and hormonal differences (Papoutsidakis, A., 2011). These specific differences include greater ligament laxity, wider Q-angles between the hips and knees, reduced leg stiffness, and hormonally influenced neuromuscular control (Mancino et al., 2024). Knee ligament injuries cause a significant decline in athletic performance and progression, and also compromise long-term ligament health and physical ability (CDC, 2024). This highlights the importance of preventative strategies that address these biomechanical, physiological, and hormonal fluctuations. Acknowledging this could mean a reduction in injury severity and frequency, therefore promoting sustained performance, longevity, and long term well being.

This report critically examines the biomechanical and physiological risk factors contributing to ligament injuries in female sprinters, with a particular focus on the role of footwear. By evaluating current evidence and identifying design limitations in sprint spikes, the report highlights opportunities for preventative strategies. The findings support the development of evidence-based solutions to reduce injury severity and frequency, thereby promoting sustained performance, longevity, and athletic well being.

ABBREVIATION KEY:
ACL: Anterior Cruciate Ligament
ACLR: Anterior Cruciate Ligament Reconstruction Surgery
EMS: Electro Muscular Stimulation

FALLON WIEDEMEIJER N11275901
ID STUDIO 7 DNB311

CONTENTS



FALLON WIEDEMEIJER N11275901
ID STUDIO 7 DNB311

1 SECTION

INTRODUCTION
BACKGROUND
BENCHMARKING

FALLON WIEDEMEIJER N11275901
ID STUDIO 7 DNB311

INTRODUCTION

PROJECT OVERVIEW

Female sprint athletes are at increased risk of Anterior Cruciate Ligament (ACL) injuries due to anatomical, physiological, and biomechanical differences when compared to male athletes (Mancino et al., 2024). ACL injuries require surgery for full rehabilitation (Papaleontiou et al., 2024), prolonging time away from sport. The experience of an ACL injury directly affects athletic progression, performance and long-term wellbeing.

Despite the prevalence of knee injuries in female sprinters, currently available devices and equipment are designed based on male metrics and sprint biomechanics, with minimal consideration for ACL injury prevention. This highlights the need for accessible, effective and female-specific preventative technologies for sub-elite athletes.

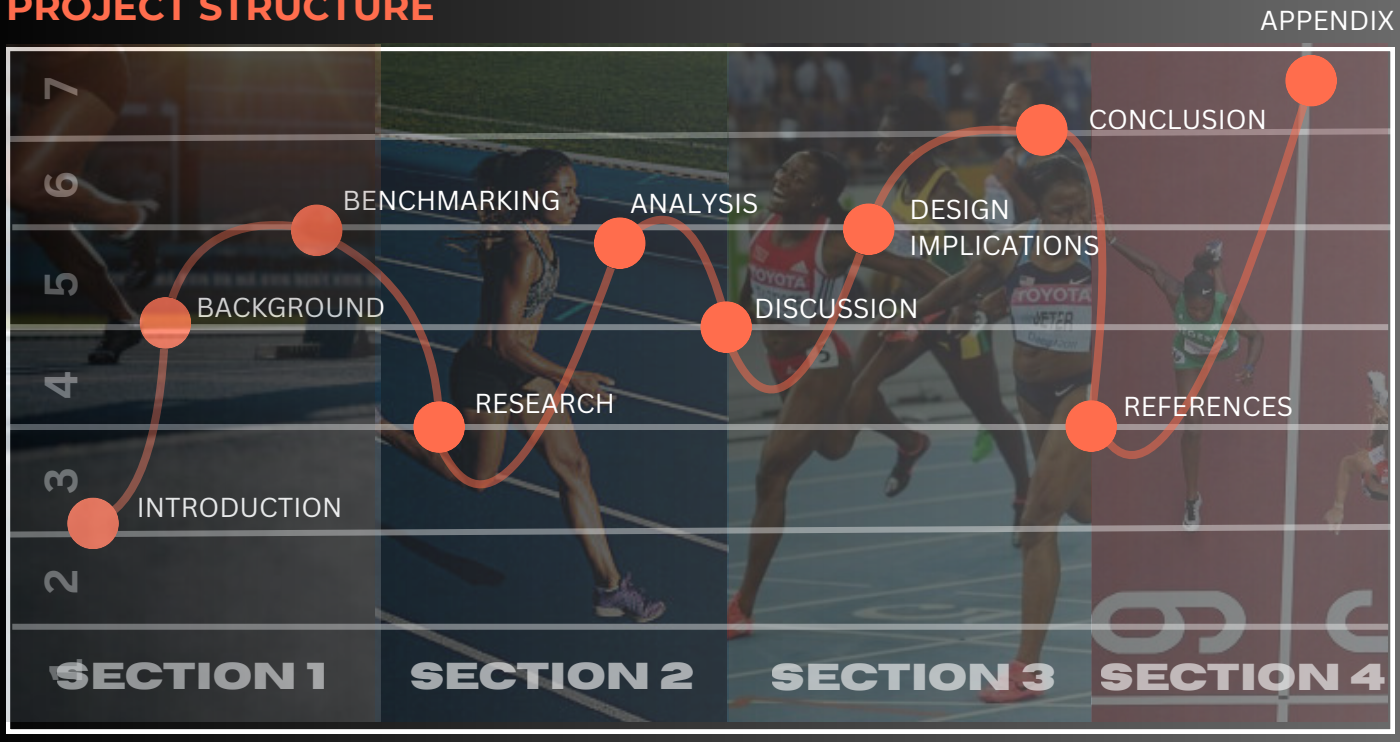
PROJECT SIGNIFICANCE

Preventing ACL injuries in female sprinters is critical not only for athlete safety but also for maintaining progression, performance, and long-term joint health. By exploring the contributing factors and identifying opportunities for innovation, this project aims to address the gap in female-specific athletic equipment for injury prevention and athletic performance.

PROJECT AIM

This project aims to reduce the severity and frequency of non-contact overuse knee ligament injuries in female sprint athletes by identifying key contributing factors and exploring opportunities for innovation.

PROJECT STRUCTURE



BACKGROUND

OVERVIEW

The purpose of this section is to explore existing research regarding the problem surrounding ACL injuries in female sprint athletes, the key contributors to this, and the future implications. The aim is to develop a better understanding of the issue present.

PROBLEM

Anterior cuciate ligament injuries have proven to be a highly prevalent problem among female athletes, preventing them from reaching their **full athletic potential** (Mancino et al., 2024). ACL injuries are presented as the **highest non-contact injury risk for female athletes** (Renstrom et al., 2008) due to a range of anatomical, neuro-muscular, hormonal and ligament laxity factors (Mancino et al., 2024). It was found that female athletes are 2-8 times more likely to acquire an ACL injury when compared to their male counterparts (PMC, 2016). ACL injuries present more of a risk than other knee ligament injuries, as they generally require **surgical intervention** to heal effectively (Papaleontiou et al., 2024). Since the ACL resides within the synovial cavity of the knee, it lacks direct blood supply from surrounding bone or soft tissue , which decreases the ability for the body to recover without surgery (Kiapour & Murray, 2014).

Figure 1: Statistic Infographic

Figure 2: Statistic Infographic

According to a recent systematic review, it was found that only "Fifty-five percent return to competitive sport following anterior cruciate ligament reconstruction surgery" (Ardern, 2014), which further increases the significance of the issue. Additionally, it is important to consider the **mental**, **emotional** and **physical** limitations and setbacks an injury can have on an athlete. Not to mention **future implications**, as it was found that "people who have injured their ACL are more likely to get osteoarthritis in that knee later in life." (CDC, 2024).

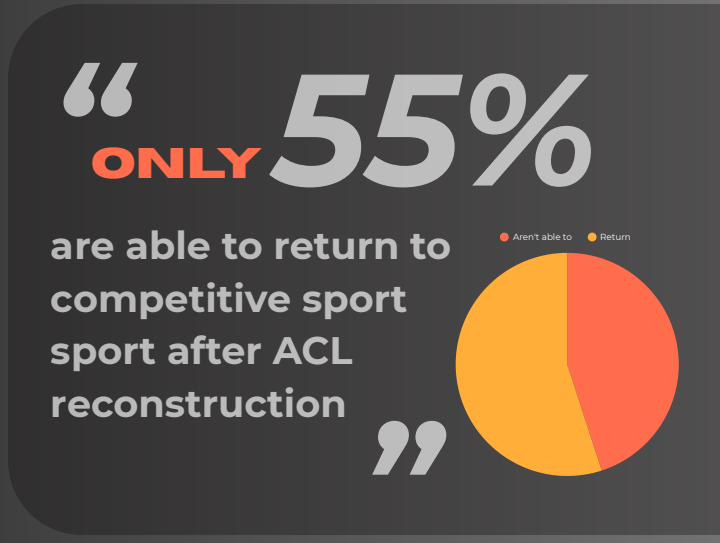


Figure 3: Statistic Infographic

BACKGROUND

CONTRIBUTORS TO INJURY RISK

Female athletes face a range of physiological and biomechanical factors that increase their risk of ACL injury. One major contributor is **muscular imbalance** and **neuromuscular activation** (Myer et al., 2004). Women often show lower levels of **hamstring activation** due to dominance of the quadriceps and hip flexors (Myer et al., 2009) . As hamstring recruitment is essential for efficient sprint mechanics (VALD, 2025), this imbalance encourages compensatory movement through the hips and adductors, which further promotes **knee valgus** (O'Sullivan et al., 2022). The combination of adductor tightness and poor activation patterns lead to increased susceptibility to ACL injury.

Females generally have **thinner** and **laxer ligaments** (PMC, 2016) with the ACL being 20 to 30 percent smaller than in males, which reduces the ligaments' capacity to absorb force (Lipps et al., 2011). With wider hips, a greater **Q-angle** and higher arches, lower limb alignment is negatively affected, promoting **pronation** and **knee valgus** under high impact (Sharma et al., 2023). It was discovered that *"the female athlete must exert a larger amount of force in order to obtain the same amount of extensor force as their male counterparts"* (Gant et al., 2024), therefore, in combination with biomechanical misalignments, it places increased strain on the ACL.

Hormonal fluctuations have a significant influence as well, increasing susceptibility to ACL injury. Changes in **oestrogen levels affect ligament stiffness, neuromuscular control and fatigue** (Shultz, Schmitz, Nguyen, & Schulte, 2012)**.** During the pre-ovulatory and ovulatory phases, increased oestrogen increases **knee laxity** and reduces **leg stiffness** (Hewett, Myer, Ford, Paterno, & Quatman, 2016).

Low oestrogen and progesterone levels during menstruation impair proprioception and slow neural responses (Roditi et al., 2024) , which elevates injury risk.

Fatigue directly interacts with these factors and amplifies risk. High training demands reduce **muscular activation, strength** and impair **technique**, making athletes more susceptible to **misalignment,** promoting poor landing and sprinting **mechanics**. **Fatigue** has been directly linked to ACL injury as it diminishes the body's ability to **compensate** for anatomical differences (Bourne et al., 2019).

Figure 4:AI Generated Infographic

SUMMARY

In summary, it was found that **muscular imbalance, anatomical structure, hormonal fluctuations** and **fatigue** put female athletes at **higher injury risk**, explaining the **higher prevalence of ACL injuries in female athletes.**

BENCHMARKING

OVERVIEW

The purpose of this section is to analyse the effectiveness of current tools and technology that could potentially be utilised in the prevention of ACL injury in female sprint athletes. The products were split among four categories to better understand the efficiency of the range of applications available. Each product theme was analysed based on accessibility, cost, female specific consideration and ACL injury prevention effectiveness.

PRODUCT TABLE MATRIX

THEME	PRODUCT	ACCESSIBILITY	COST	INJURY PREVENTION	FEMALE SPECIFIC	GAP
Wearable Technology	Compex SP 8.0	3	2	3	2	These products are accessible and portable, very popular among athletes due to low cost, but focus mainly on recovery rather than active ACL injury prevention. They do not consider female specific metrics in their design.
	Therabody PowerDot	4	3	3	2	
	RunScribe Plus Pods	4	3	2	2	
Biomechanical Analysis	Vicon Motion Capture	1	1	5	2	These tools are highly accurate and target sprint mechanics, however are lab based, costly and largely inaccessible. They do not provide integrated solutions for correcting high risk movements and do not directly target female specific metrics.
	Qualisys + Force Plates	1	1	5	2	
	VALD HumanTrak	2	2	4	2	
Footwear / Orthotics	Nike Superfly Elite 2	4	3	2	1	Sprint spikes are designed for performance, therefore lacking support needed for training sessions. Arch support offer added support, but promote strength deficits and can actually worsen the issue, causing the individual to rely on them to have the correct foot position. Both of these products provide limited evidence specifically for ACL injury prevention. They do not address knee valgus or sprint specific mechanics and do not consider female anatomical differences.
	adidas Adizero Prime SP 2	4	3	2	1	
	Currex RunPro Insoles	5	2	2	2	
Strength / Asymmetry Analysis	VALD ForceDecks	2	2	4	2	These tools identify asymmetries and strength deficits which help to identify contributors to injury and therefore prevent them. They are facility based and their programs are generic rather than tailored to female sprint athletes.
	VALD NordBord	2	2	4	2	
	VALD ForceFrame	2	2	4	2	

Figure 5: Product Table Matrix

BENCHMARKING

MARKET GAPS

After combining the benchmarking data into a product table matrix as shown in *Figure 5*, the specific strengths and weaknesses could be determined across each sector. The most effective solution found for ACL injury prevention was **Strength and Asymmetry Analysis**. This technology, as shown in *Figure 6*, although highly effective in identifying **imbalances** that contribute to knee ligament injuries, is highly **inaccessible** to sub-elite athletes. Similarly, with the second most effective category in ACL injury prevention, biomechanical analysis technology, displayed in *Figure 9*, provides detailed insights into **joint angles**, force outputs, and **high-risk movements** that could contribute to injury, these two categories were clearly displayed as most effective for injury prevention in *Figure 10*. However, as indicated in *Figure 4*, these are inaccessible due to high cost and a lab-based environment.

In contrast, less effective injury prevention methods are more **accessible.** As indicated in Figure 7**, neuromuscular stimulation** devices are effective for enhancing **muscular activation** patterns. However, these products are not specifically targeted towards **knee ligament stability.** In contrast, wearable gait analysis tools such as the *RunScribe Plus Pods (RunScribe Plus - GAIT Analysis, n.d.)*, are effective in analysing metrics such as pronation, impact forces, stride length, and asymmetry, which are relevant to identifying ACL risk factors, however still lack the consideration of **female specific** anatomical and biomechanical differences.

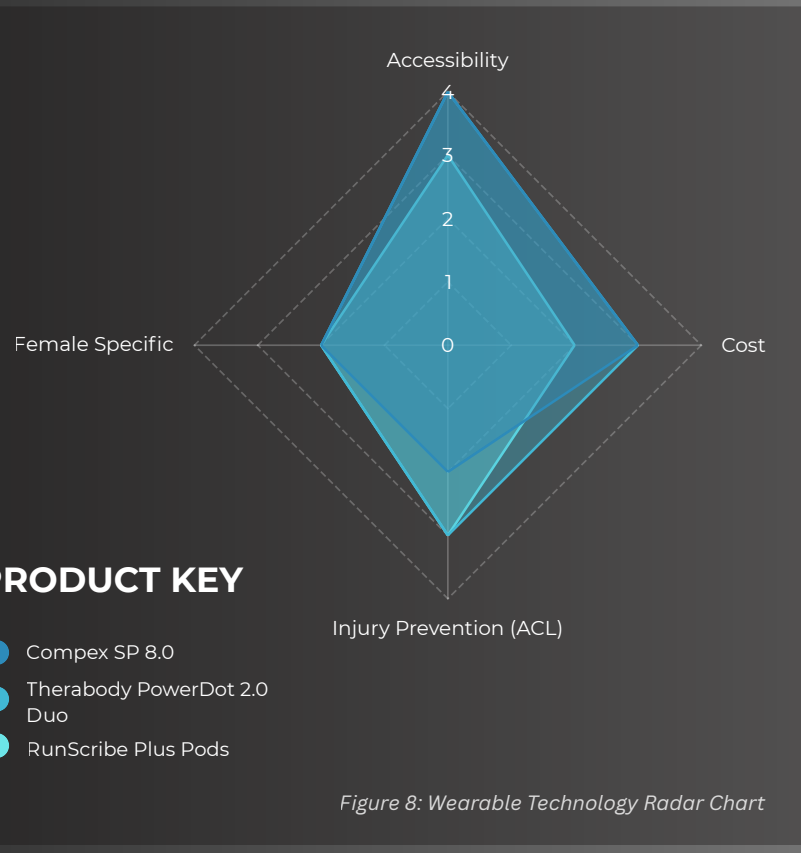


Figure 8: Wearable Technology Radar Chart

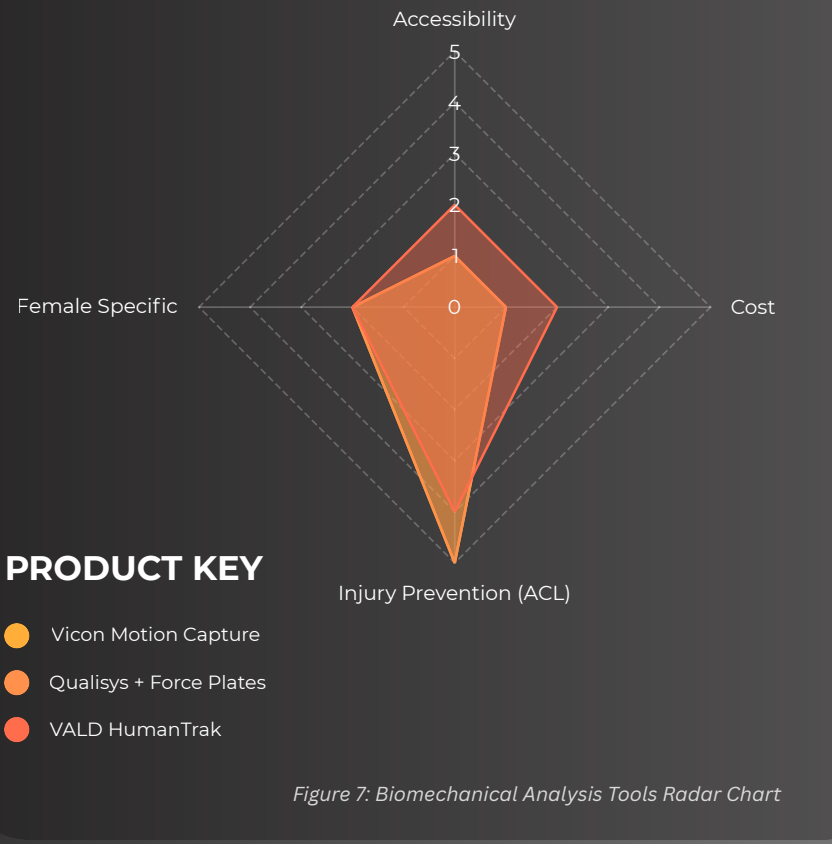


Figure 7: Biomechanical Analysis Tools Radar Chart

BENCHMARKING

Current sprint footwear presents another major market gap, as sprint spikes potentially **contribute to ACL injury risk** in female athletes (Akhundov et al., 2022). Factors such as a negative heel position, and overall lack of support increase stress on the forefoot. This promotes a **pronated** foot position, further exacerbating high-risk **knee valgus** position in females (PMC, 2008).

Sprint spikes are currently designed based on **male metrics**, *Figure* 8 displays the neglect of **female-specific** needs across all footwear products. Orthotics are a popular method to help with arch support, however **develop dependence** on the product and worsening of foot strength, further **promoting injury risk** (Robert, 2025).

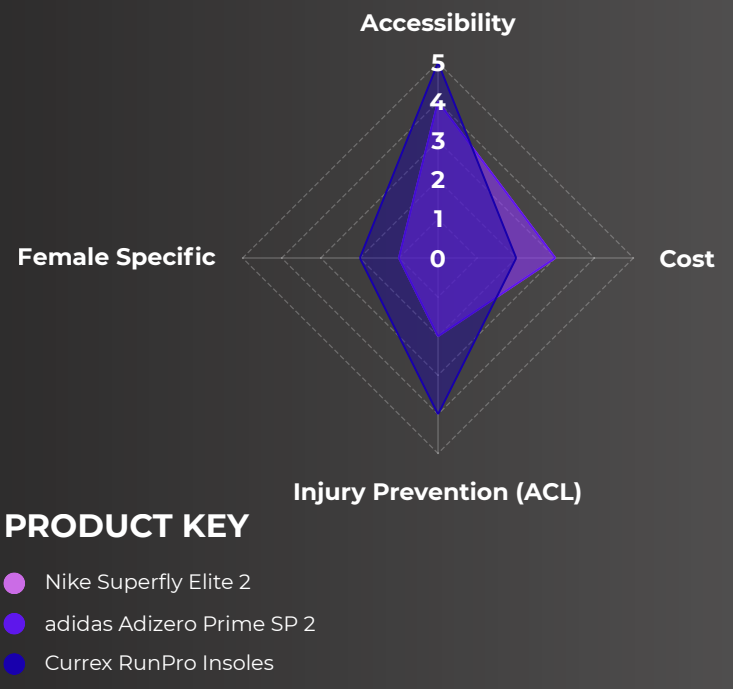


Figure 8: Footwear and Orthotic Product Radar Chart

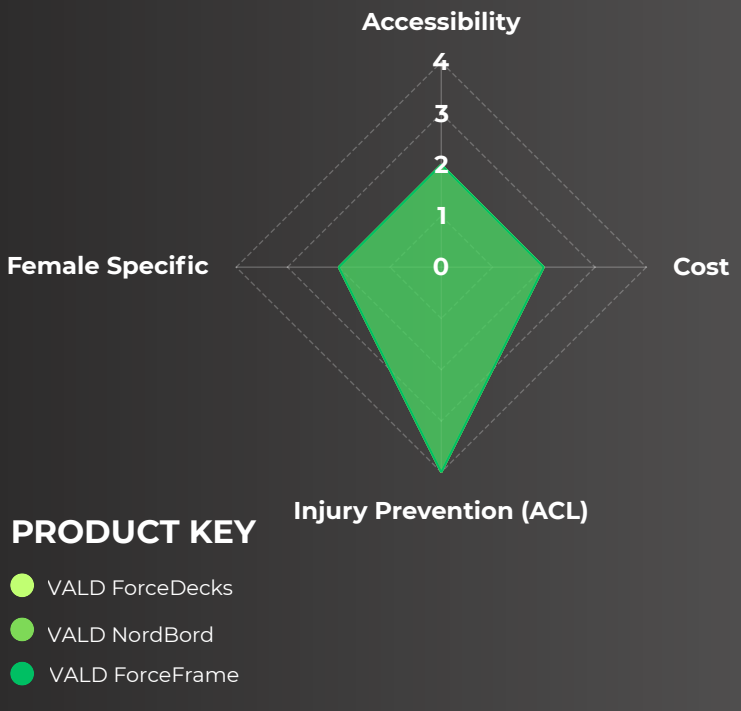


Figure 9: Strength and Asymmetry Analysis Tool Radar Chart

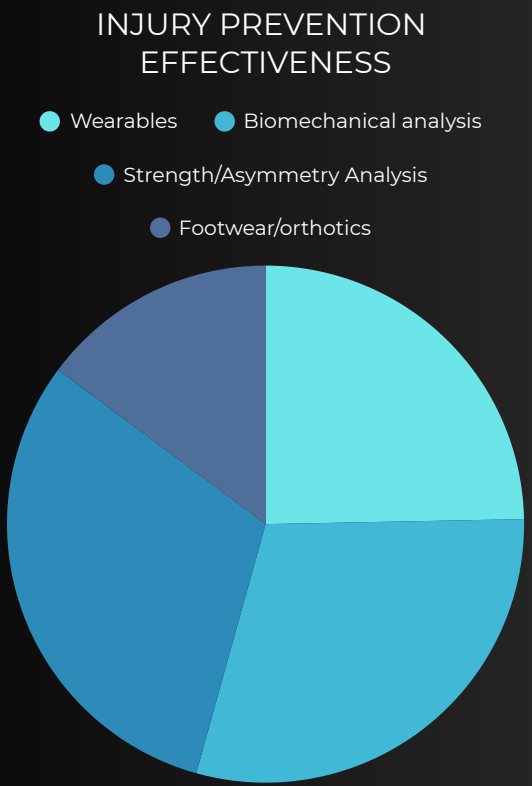


Figure 10: ACL Injury prevention effectiveness

BENCHMARKING

After analysing each category, the data was then visualised into a shaded line graph in order to analyse existing trends across all benchmarking data. Referring to *Figure 11*, the existing trends found that there is a significant gap across all product categories surrounding the consideration of **female-specific data** in the design of sprint analysis and wearable injury prevention tools. There was a **clear gap** between the **accessibility** of these products and their **effectiveness in injury prevention**, which was due to high costs, lab-based tools, and the need for expert interpretation, making them largely **unavailable** to sub-elite and female athletes.

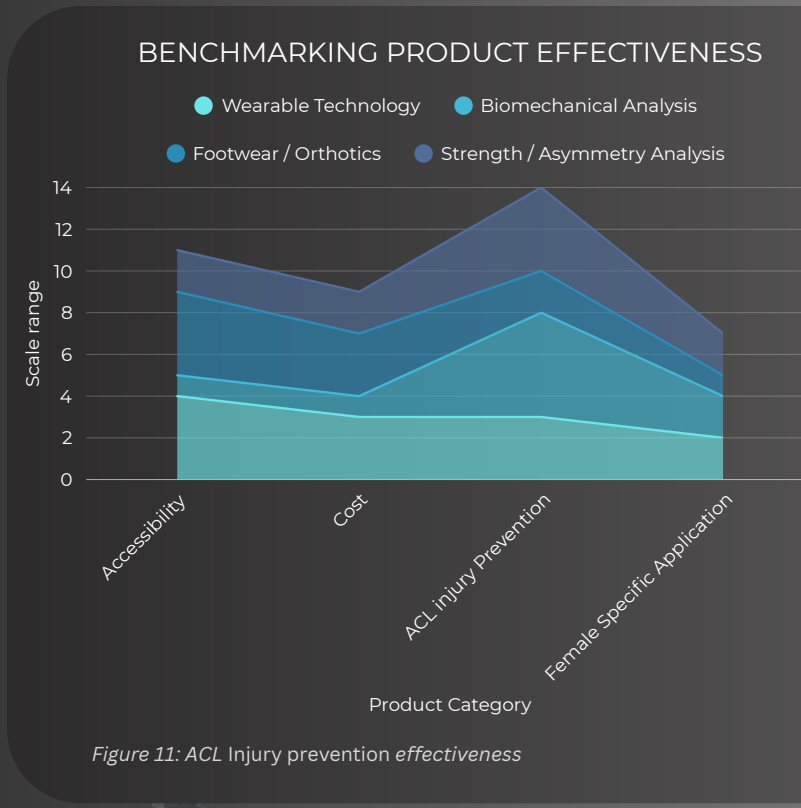


Figure 11: ACL Injury prevention *effectiveness*

SUMMARY

This section effectively revealed the key gaps among existing tools and technologies that could potentially be utilised for ACL injury prevention in female sprint athletes. Strength and asymmetry analysis tools were proven the most effective, yet highly inaccessible to sub elite athletes. Similarly, biomechanical analysis tools identified high risk movements but were also largely inaccessible. More accessible options, such as electro-muscular stimulation and wearable gait analysis tools, were found to be less effective in the prevention of injury. Current sprint footwear provided minimal support and contributed to injury risk. With minimal female-specific metric consideration across all product ranges, this gap increases female athletes' susceptibility to ACL injuries.

2 SECTION

RESEARCH
ANALYSIS
DISCUSSION

RESEARCH

OVERVIEW

The focus of this research was to examine the risk of anterior cruciate ligament (ACL) injury in female athletes, with particular attention to anatomical, physiological, and hormonal contributors. Primary research was undertaken to validate common risk factors identified in secondary research and to explore the effectiveness of current prevention strategies. This study also seeks to understand the long-term impacts of ACL injuries on athletes' performance and wellbeing, providing deeper insights into the implications of injury prevention and management in female athletics.

METHODOLOGY

As for the methodology, qualitative data collection was utilised with the purpose of obtaining deeper insight into the factors contributing to ACL injuries in female athletes. This approach enabled the attainment of research objectives, through gathering knowledge and comprehensive perspectives among injured athletes, athletic coaches, and physiotherapists who experience this problem first-hand. This methodology allowed for a deeper insight into the challenges, contributors, and broader contexts surrounding ACL injury prevention, developing data that could not be obtained through secondary or quantitative methods. This method is essential for discovering evidence-based and female-specific design opportunities for injury prevention.

Throughout this study, two research methods were implemented. The first method was semi-structured interviews, which allowed structured questions to be asked while also providing space for discussion to explore topics that may not have been initially considered. The utilisation of this method enabled an in-depth review of personal perspectives, past experiences, and the broader implications of ACL ligament injuries. The second method was observation, which involved attending a track session with a female athlete who had recently experienced a knee ligament injury. The observation provided valuable insight into recurring issues and behaviours, while also confirming themes identified throughout the interviews.

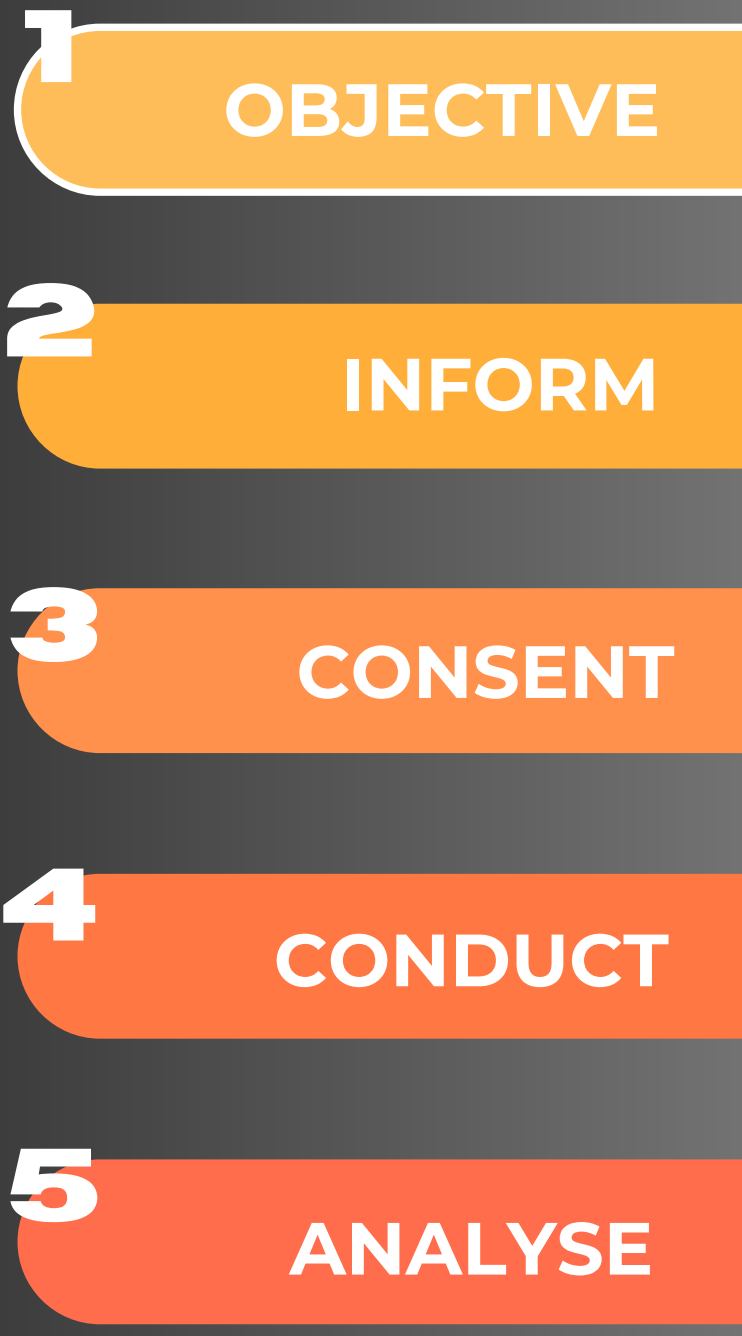


Figure 12: Data Collection Design

RESEARCH

INTERVIEW DESIGN

Semi-structured interviews were the first utilised method for data collection. This method was chosen for this study as it provides detailed insight into personal experiences and opinions, and seemed most effective in the pursuit of the project objectives. The utilisation of this method was highly effective for gathering expert perspectives from coaches, physiotherapists, and athletes with first-hand experience dealing with overuse ACL injuries in female athletes. The interview structure utilised a total of 6-7 open-ended questions to encourage discussion, with additional add-on questions to gain further insight on their personal experiences and knowledge. With incentives such as coffee, and previously handed out design briefs in order to inform the participant of the project background and aims, they were relaxed and more comfortable talking about and sharing their personal experiences.

OBSERVATION DESIGN

The observation was chosen as a data collection method because it allowed insight into exactly what the athlete does throughout a training session, helping to identify subtle factors that might lead to injury, which included decision making, behavioural aspects and fatigue management. This method was useful to gain further insight into how equipment is actually utilised rather than relying solely on reported experiences. With the collaboration of two female athletes and an athletics coach, a tripod was utilised to video capture the entire training session. From warm-up, to cool down, field notes were taken based on the athletes' actions, comments and decision making throughout the session. Field notes were also taken based on the coach's observations and comments about the athlete's technical form and their advice based on technique.

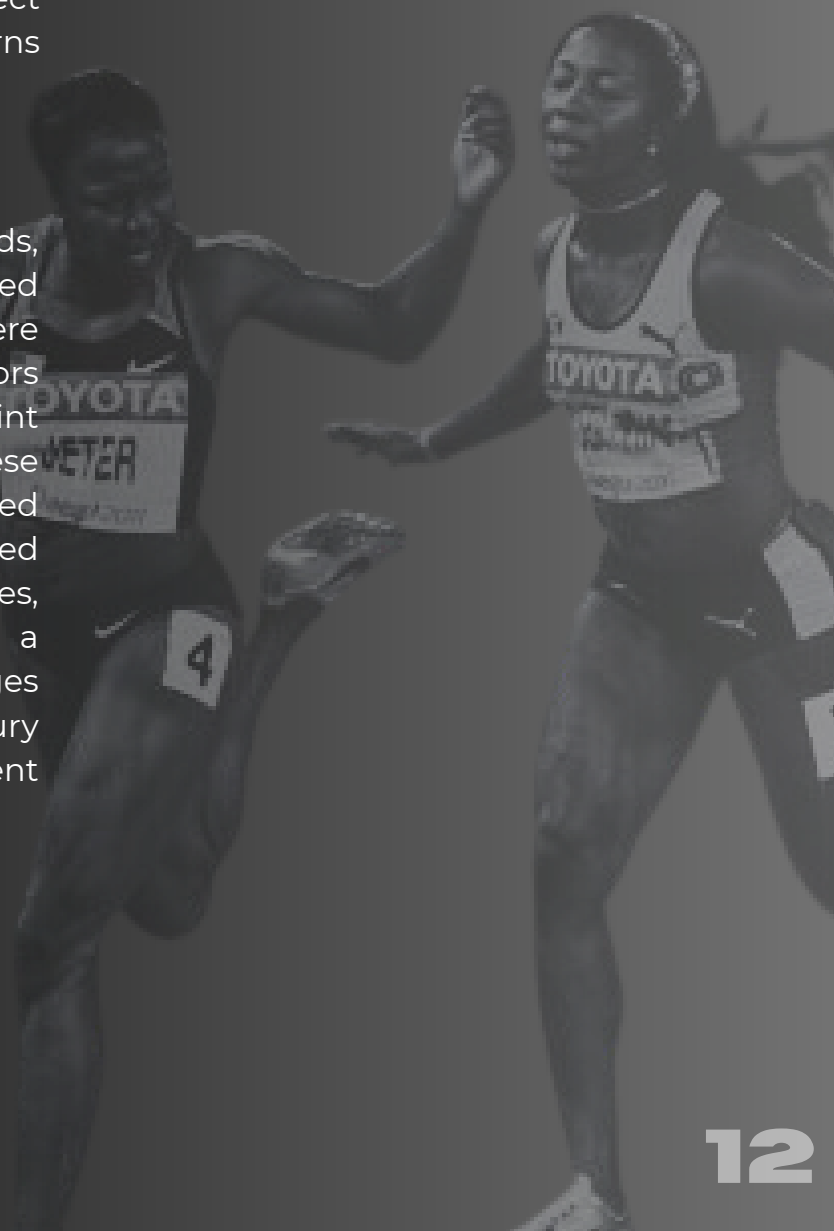
RESEARCH

LIMITATIONS

The main limitation of these primary data collection methods was the small sample size, with only a limited number of participants interviewed and observed, which restricted the breadth of insights of the findings. Another limitation was potential selection bias, as many participants were drawn from existing connections, which may have influenced their responses. With personal background in athletics, this may have shaped the way that the data was interpreted. Finally, contextual factors were relevant, as the observation was conducted in rainy conditions, which may not accurately reflect typical athletic behaviour or running patterns of the athlete.

SUMMARY

The selected primary research methods, including a focus group, semi-structured interviews, and an observation, were implemented to explore the factors contributing to ACL injuries in female sprint athletes, as well as the implications of these injuries. These qualitative methods enabled the collection of insightful and detailed perspectives from physiotherapists, coaches, and athletes. This approach provided a thorough understanding of the challenges and contexts surrounding ACL injury prevention and supported the development of practical insights into the issue.



ANALYSIS

ANALYSIS METHOD

After the interviews and audio recordings, which were transcribed using Otter AI. The transcripts were manually annotated and analysed to extract data aligned with the research objectives. Affinity mapping was utilised to categorise the data into codes and overarching themes. The data was then organised in Excel and visualised using Flourish Studio to enhance understanding and interpretation.

INTERVIEW 1

The first interview was with Level 5 athletics coach Annette Rice, who shared insights into injury patterns from her experience. She explained, “My first point of focus is their **body awareness** and how they are using their body in their running...” Without this awareness, athletes may not **recognise warning signs**, preventing effective injury management. This was reflected in the data, where **body awareness, overuse** and **muscle imbalance**, and **gradual progression** emerged as the most common themes as seen in *Figure 15*. Annette also highlighted **biomechanical issues** such as **knee valgus** and **foot pronation**, noting that athletes often act only once injury occurs. Another concern was **training load** and **progression**: “You've got to start very gently and have very nice increments, very slow development...” (0:12). Without this, athletes may struggle to adapt to sprinting forces on synthetic tracks, increasing injury risk.

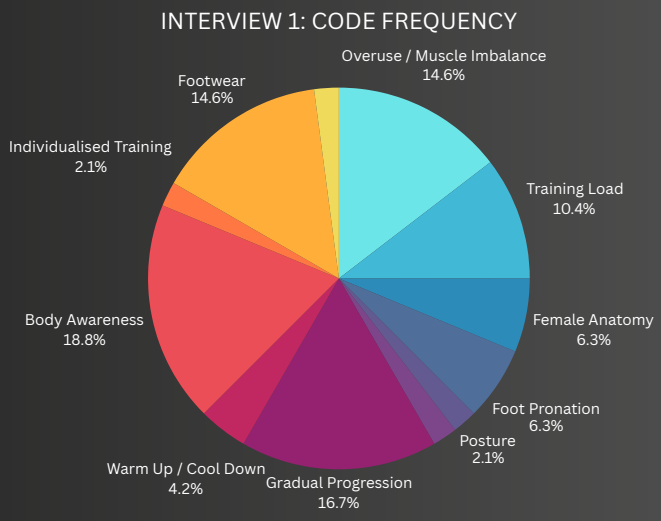


Figure 15: Interview 1 Code Frequency

INTERVIEW 2

The female athlete interviewed highlighted that **self-awareness** of pain and **body signals** is critical in preventing injury. A previously injured female sprinter shared her experience with an overuse knee ligament injury and its impact on her long-term progression. **Returning to training too early worsened her symptoms** and ultimately required her to have **surgery.** She stated that sprinting contributed to the severity due to the **high-impact** forces and the track surface. Reflecting on what she would have done differently, she said, “The surgeons told me to give it a rest for six months to let it heal by itself... I would have taken a break.”

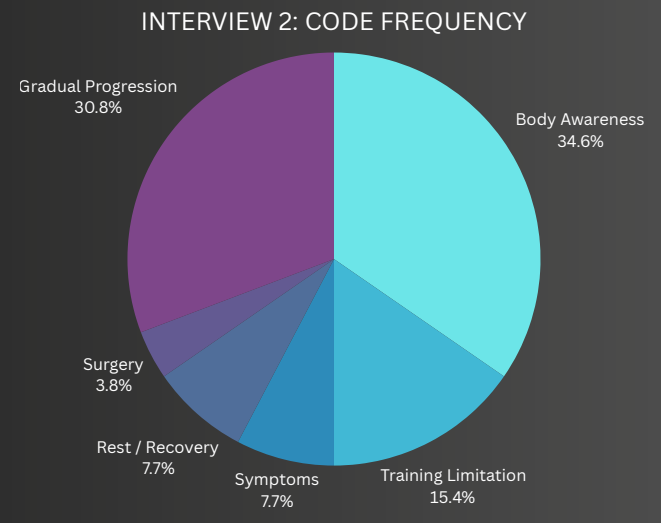


Figure 16: Interview 2 Code Frequency

ANALYSIS

I would have stopped for a couple of months." (4:16–4:51). As displayed in *Figure 16*, The most prevalent themes were **body awareness, gradual progression** and **training load**, which further increases the importance of athletes **listening to their bodies, gradually increasing** intensity, and following structured training to reduce the risk of long-term setbacks.

INTERVIEW 3

In interview three, physiotherapists discussed injury patterns and prevention for female knee ligaments. They agreed athletes often **push through pain** due to the "no pain, no gain" mentality, increasing **fatigue** and injury risk. "That's also what athletes as a mental approach, have a no pain, no gain viewpoint, when that's really not the right way to approach it.. If you have **pain, it's your body's way of indicating something"** (17:35). They also emphasised monitoring technique and strength, stating, "You need to know whether or not they're using the muscles the right way. If there is any **imbalance in the muscle** that could lead to injuries" (5:53), as *Figure 17* highlights, **body awareness, muscle balance** and **neuromuscular connection are critical for prevention**.

OBSERVATION

The observation validated key themes from the interviews, with **body awareness and training load** emerging as the most prominent factors displayed in *Figure 18*. Athletes demonstrated awareness by modifying footwear or pausing mid-session in response to knee pain, showing how **early recognition can reduce injury severity.** The observation also confirmed the **influence of track surface, sprint intensity, and footwear on knee load**, supporting the need for **gradual progression,** close monitoring, and supportive equipment.

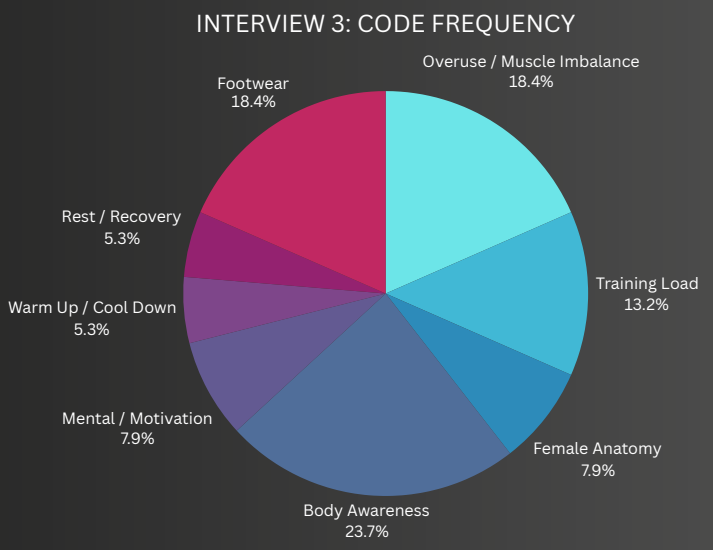


Figure 17: Interview 3 Code Frequency

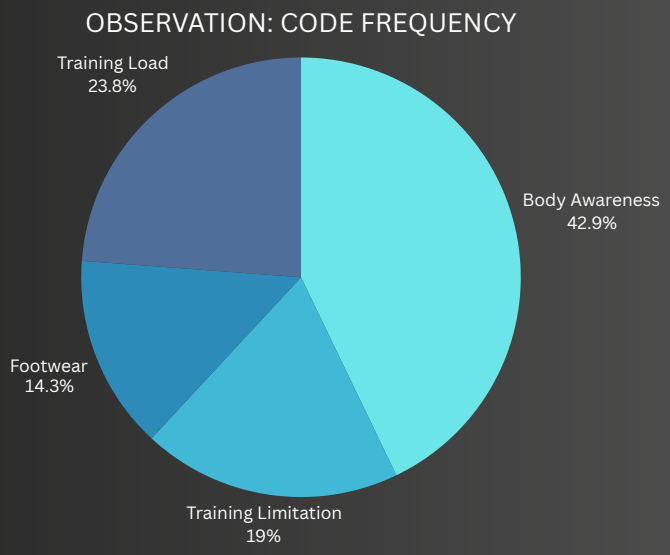


Figure 18: Observation Code Frequency

ANALYSIS

COMBINED DATA

After analysing the individual interviews and observation, the findings were coded and categorised into six overarching themes. *Figure 19* displays a sunburst chart showing the weight of each theme and frequency of each subcode. **Body awareness, gradual progression and overuse emerged as the most significant issues,** appearing consistently across all data collection methods. Subcodes such as recognition of **fatigue, pain signals and training intensity** were particularly prevalent, highlighting the areas most relevant to injury risk. The chart visually emphasises these patterns and provides a clear overview of which factors dominated the primary data. Based on the overarching themes present, additional themes and subcodes were developed to analyse the data further.

COMBINED THEME AND CODE FREQUENCY

Figure 19: Sunburst chart representation of theme weight and code frequency

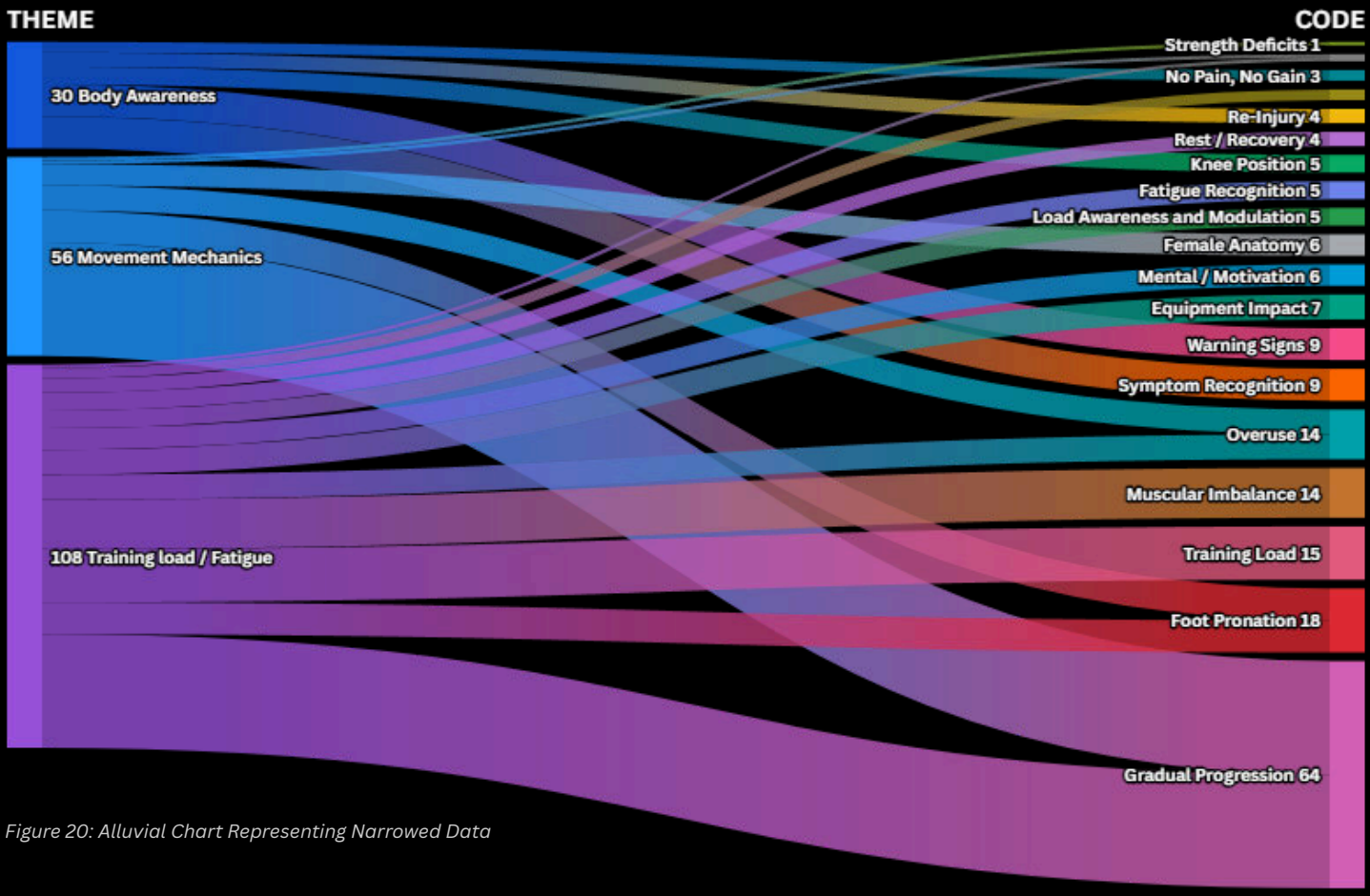


Figure 20: Alluvial Chart Representing Narrowed Data

ANALYSIS

THEME 1 BODY AWARENESS

Body awareness emerged as a key theme across all interviews and the observation. Athletes' ability to **recognise fatigue, discomfort**, and **early warning signs** was crucial in managing training and reducing injury risk. The injured sprinter emphasised how returning to training too early worsened her condition, while the coach highlighted that athletes often only take action after an injury occurs. Observation confirmed that athletes adjusted footwear or paused sessions in response to knee pain, demonstrating how **self-awareness informs preventative decision-making.** These findings reinforce the importance of **recognising warning signs** and **maintaining body awareness** to prevent overuse and ligament injuries.

THEME 2 MOVEMENT MECHANICS

Movement mechanics was a strong and recurring theme across all interviews and the observation. Physiotherapist participants expressed that **muscular imbalances** and **knee stability** were common issues they have observed that reduce stability and increase the vulnerability for ligament injuries. The participants also expressed that athletes often pushed through pain, which increases fatigue and therefore lowers **neuromuscular connection,** promoting **inefficient sprint mechanics.** The athletics coach interview further confirmed this insight, with the first aspect she observes as a warning sign involving foot pronation and knee valgus positions, indicating weaknesses that directly impact knee ligament impact. These findings emphasise the critical role of proper **movement mechanics** in maintaining **stability** in order to reduce the risk of ligament injury in female sprint athletes.

THEME 3 TRAINING LOAD + FATIGUE

Training load and fatigue emerged as the most significant theme across all data, as visibly present in the alluvial diagram displayed in *Figure 20*, showing the greatest contribution to ACL injury risk and the highest number of sub-code connections. Participants consistently highlighted that **high intensity sessions, excessive volume, and insufficient recovery** increase **fatigue**, which in turn **impairs neuromuscular connection** patterns, as well as **knee** and **foot positioning**. This theme is closely linked with **body awareness**, as athletes are not always perceptive of their **fatigue** and often **push through pain**. Overuse injuries were frequently associated with a lack of **gradual progression** and monitoring of **training loads**. Inefficient load management stresses **joints** and **muscles** beyond their capacity, increasing injury risk.

ANALYSIS

SUMMARY

This data was collected to gain insight from individuals with first-hand experience of ACL injuries, with the aim of identifying the most critical factors and implications for female sprint athletes. The process involved transcribing the raw data and coding it to organise recurring patterns, connections, and the relative weight of key issues. Through this process, themes were collated and refined, allowing for the scope to be narrowed to three dominant contributors: with **training load and fatigue** being most prominent, as well as **movement mechanics,** and **body awareness** being extremely prevalent. These themes provide a structured understanding of the most crucial underlying causes of ACL injuries.

DISCUSSION

INTRODUCTION

The purpose of this section is to compare the primary research collected through observations and interviews with the secondary data presented in the background and benchmarking sections. This project aimed to explore the key factors contributing to ACL injuries in female sprint athletes and to identify opportunities for prevention. Across both primary and secondary research, three major contributors emerged: a **lack of body awareness, inefficient movement mechanics**, and inadequate management of **training load and fatigue**.

1 BODY AWARENESS

Across all primary data collection, participants reported that athletes often fail to **recognise warning signs** and symptoms linked to injury. The injured athlete revealed that a **lack of awareness** contributed to the severity of her injury and suggested that earlier **recognition** might have prevented the need for surgical intervention. The coach and physio participants noted that athletes often push through pain or **fail to notice warning signs,** delaying validation until the injury becomes serious. Secondary research supports these findings, showing that **low neuromuscular activation** reduces an athlete's ability to **detect fatigue** and **compensate** for female **anatomical structural differences** during sprinting, therefore **increasing ACL injury risk.**

2 MOVEMENT MECHANICS

Inefficient movement mechanics were consistently identified as a **significant contributor to ACL injury in female athletes,** including the biomechanical factors that influence movement patterns, such as **knee alignment** and **muscular coordination**. This finding was validated through secondary research, where it was discovered that **low hamstring activation encourages compensatory movement** through the **hips** and **adductors**, which further promotes **knee valgus** (O'Sullivan et al., 2022).. Primary data confirmed this finding. In interview one, Annette explained that **knee valgus** and **foot pronation** are the first factors she observes among her athletes. She noted a clear **correlation** between these **observed inefficiencies** and athletes later **sustaining injuries,** highlighting the significance of **insufficient mechanics** and injury risk.

DISCUSSION

3 TRAINING LOAD + FATIGUE

Primary data identified overuse injuries as strongly linked to poor **training load** management, lack of **gradual progression**, and **fatigue**. This theme was the most prominent across the entire research phase. All interview participants emphasised that athletes often continue training **despite pain**, which places excessive **stress on joints** and **muscles** beyond their physical capacity. **Fatigue** not only **increases the likelihood of injury** but also reduces sprint mechanic efficiency, as the body is unable to adapt or **compensate** for the **female anatomical structure** during sprinting. The finding was confirmed through secondary research methods, where it was discovered that **fatigue has been directly linked to ACL injury** as it diminishes the body's ability to **compensate for anatomical differences** (Bourne et al., 2019).

RESEARCH GAPS

The most significant gap identified was the lack of female specific design considerations that address **body awareness** and **recognition** of **fatigue warning signs**. Another significant gap lies in the **inaccessibility** of effective technologies such as strength and asymmetry analysis or biomechanical testing, which are limited to elite and world class athletes, and only conducted within lab-based environments. Sprint footwear represents an additional gap, as spikes are designed with the consideration of **only male metrics**, while also providing **minimal support,** further **promoting pronation** and **knee valgus** in female athletes. Female athletes are significantly more prone to ACL injuries than their male counterparts (PMC, 2016), yet **current prevention tools and technologies fail to support their needs**, with added limited accessibility to these technologies, there is a clear opportunity for intervention.

3 SECTION

DESIGN
IMPLICATIONS
CONCLUSION

DESIGN IMPLICATIONS

The insights gained from this research provide clear direction for the design process and highlight opportunities for innovation in female-specific ACL injury prevention. Building on the key themes identified in the discussion, including **inefficient movement mechanics, limited body awareness, and the impact of training load and fatigue**, there is a clear need for products that support the **early recognition of injury warning signs**. Design solutions should address **movement mechanics** by monitoring **knee alignment, foot pronation**, and **muscular coordination**, promoting **body awareness** through feedback on **movement patterns** and **compensatory** actions. The design should also **support training load management** by helping athletes **recognise fatigue** and **adjust intensity** based on **body awareness** insights. **Wearable technologies** offer practical opportunities to deliver accessible solutions and could be developed further to **integrate biomechanical analysis** and **neuromuscular stimulation tools** specifically suited to female anatomical differences and **sprint mechanics**. By addressing the gaps highlighted in this study surrounding **limited accessibility** to **female-specific** tools for injury prevention, innovative solutions have the potential to reduce ACL injury risk, improving athletic progression, as well as promoting long-term well-being for female sprinters.

MUST

- Address female-specific risk factors such as biomechanics, fatigue, and anatomical differences.
- Be practical and safe for sprint training environments.
- Provide real-time, preventative insights and indications of warning signs
- Be durable, accessible, and effective in ACL injury prevention

COULD

- Incorporate wearable or smart textile technologies to monitor biomechanics and neuromuscular signals.
- Offer predictive feedback to reduce injury risk.
- Explore corrective or supportive product features such as orthotic or footwear adaptations.
- Use sustainable or eco-friendly materials.

SHOULD

- Be affordable and accessible for both elite and sub-elite athletes.
- Encourage early recognition of fatigue and injury warning signs.
- Integrate with existing training products and technologies.
- Support progressive load management and adaptation.

SHOULD NOT

- Replace professional medical advice or physiotherapy, or provide a diagnosis
- Rely solely on generic or male-based biomechanical data.
- Overcomplicate use with excessive features
- Create financial or technological barriers that exclude sub-elite athletes
- Neglect female specific-data

CONCLUSION

The aim of this project was to explore the key factors contributing to the heightened frequency and severity of anterior cruciate ligament injuries among female sprint athletes, and to consider how these issues could be addressed to support long term athletic performance and wellbeing. The findings of this project highlighted that while **biomechanical, physiological,** and **environmental** factors all contribute to injury risk, the **absence of accessible female-specific injury prevention tools** remains a critical gap. Addressing this gap through tailored solutions that help to **identify injury warning signs, promote body awareness,** and **recognise fatigue signals** could play a vital role in r**educing both the frequency and severity of injuries in female sprint athletes**. The reduction in severity and frequency of ACL injury could also contribute to the prioritisation of the athletes wellbeing, which is essential for ensuring sustainable performance and supporting the long term success of female sprinters.

4 SECTION
REFERENCES

REFERENCES

ACL Injuries—The Gender Bias. (2008, October 1). https://pmc.ncbi.nlm.nih.gov/articles/PMC2547879/

ACL injury in female athletes – HPSNZ. (n.d.). https://hpsnz.org.nz/wellbeing-and-engagement/healthy-women-in-performance-sport/acl-injury-in-female-athletes/?

Akhundov, R., Bryant, A. L., Sayer, T., Paterson, K., Saxby, D. J., & Nasseri, A. (2022). Effects of Footwear on Anterior Cruciate Ligament Forces during Landing in Young Adult Females. Life, 12(8), 1119. https://doi.org/10.3390/life12081119

Ardern, C.L., Taylor, N.F., Feller, J. and Webster, K.E. (2014) Fifty-Five Percent Return to Competitive Sport Following Anterior Cruciate Ligament Reconstruction Surgery An Updated Systematic Review and Meta-Analysis Including Aspects of Physical Functioning and Contextual Factors. British Journal of Sports Medicine, 48, 1543-1552. - References - Scientific Research Publishing. (n.d.). https://www.scirp.org/reference/referencespapers?referenceid=3395165#:~:text=and%20Webster%2C%20K.E.%20(2014)%20Fifty%2DFive%20Percent%20Return,Cruciate%20Ligament%20Reconstruction%20Surgery%20An%20Updated%20Systematic

Afp, F. S. W. N. Y. P. A. (2021, August 3). New women's GOAT repeats Bolt feat, 17yo freak blows minds with 'jog' as champ stuffs up finish. Fox Sports. https://www.foxsports.com.au/tokyo-olympics-2021/tokyo-olympics-day-11-live-updates-news-running-athletics-events-testosterone-christine-mboma-cycling-finals/news-story/7aafc82e0c5dc77f58b2a4227edd51e6

Bourne, M. N., Webster, K. E., & Hewett, T. E. (2019). Is fatigue a risk factor for anterior cruciate ligament rupture? Sports Medicine, 49(11), 1629–1635. https://doi.org/10.1007/s40279-019-01134-5

Compex SP 8.0. (n.d.). https://www.compex.com/au/compex-sp-8-0

Female athletes running in competition on blue track. (n.d.). SciencePhotoLibrary. https://www.sciencephoto.com/media/1208341/view/female-athletes-running-in-competition-on-blue-track

Female Sprinter Images – Browse 27,632 stock photos, vectors, and video. (n.d.). Adobe Stock. https://stock.adobe.com/au/search?k=female+sprinter

ForceDecks | Portable, powerful and easy-to-use force plates. (n.d.). https://valdperformance.com/products/forcedecks

ForceFrame | Fast and adaptable strength training and testing. (n.d.). https://valdperformance.com/products/forceframe

HumanTrak | Movement analysis system. (n.d.). https://valdperformance.com/products/humantrak

Kiapour, A. M., & Murray, M. M. (2014). Basic science of anterior cruciate ligament injury and repair. Bone and Joint Research, 3(2), 20–31. https://doi.org/10.1302/2046-3758.32.2000241

Limited, A. (n.d.). Sprinters starts out of the blocks on athletics racetrack with bright sunlight. Low section shot of female athletes starting a r. Alamy Images. https://www.alamy.com/stock-photo-sprinters-starts-out-of-the-blocks-on-athletics-racetrack-with-bright-87681057.html

REFERENCES

Lipps, D. B., Oh, Y. K., Ashton-Miller, J. A., & Wojtys, E. M. (2011). Morphologic characteristics help explain the gender difference in peak anterior cruciate ligament strain during a simulated pivot landing. The American Journal of Sports Medicine, 40(1), 32–40. https://doi.org/10.1177/0363546511422325

Mancino, F., Kayani, B., Gabr, A., Fontalis, A., Plastow, R., & Haddad, F. S. (2024). Anterior cruciate ligament injuries in female athletes: risk factors and strategies for prevention. Bone & Joint Open, 5(2), 94–100. https://doi.org/10.1302/2633-1462.52.bjo-2023-0166

Mihailomilovanovic. (n.d.). mihailomilovanovic. https://www.istockphoto.com/search/2/image-film?phrase=female+sprinter

Myer, G. D., Ford, K. R., & Hewett, T. E. (2004, December 1). Rationale and clinical techniques for anterior cruciate ligament injury prevention among female athletes. https://pmc.ncbi.nlm.nih.gov/articles/PMC535528/

Myer, G. D., Ford, K. R., Foss, K. D. B., Liu, C., Nick, T. G., & Hewett, T. E. (2009). The relationship of hamstrings and quadriceps strength to anterior cruciate ligament injury in female athletes. Clinical Journal of Sport Medicine, 19(1), 3–8. https://doi.org/10.1097/jsm.0b013e318190bddb

Nike Zoom Superfly Elite 2 Athletics Sprinting Spikes. (n.d.). Nike.com. https://www.nike.com/au/t/nike-zoom-superfly-elite-2-athletics-sprinting-spikes-HpaV6Osh

NordBord | The gold standard in hamstring testing. (n.d.). https://valdperformance.com/products/nordbord

O'Sullivan, L., Preszler, J., & Tanaka, M. (2022). Hamstring injury rehabilitation and prevention in the female athlete. International Journal of Sports Physical Therapy, 17(6). https://doi.org/10.26603/001c.38254

Papaleontiou, A., Poupard, A. M., Mahajan, U. D., & Tsantanis, P. (2024). Conservative vs Surgical Treatment of Anterior Cruciate Ligament Rupture: A Systematic Review. Cureus. https://doi.org/10.7759/cureus.56532

Pickering, C. (2016, April 20). Tapering for Speed-Power Events: A look at the science - Freelap USA. Freelap USA. https://www.freelapusa.com/tapering-for-speed-power-events-a-look-at-the-science/

Qualysis. (n.d.). Force Plates. https://www.qualisys.com/software/integrations/force-plates/?gad_source=1&gad_campaignid=14612541971&gbraid=0AAAADbwGw1_qzejJGX2xnO-99okTnPB5&gclid=CjwKCAjwlOrFBhBaEiwAw4bYDT0qKHPoozTrgHfNcgYUfVek08BmyLu1WGxcLbkZraZqHb70yvd1hBoCnHAQAvD_BwE

Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., Georgoulis, T., Hewett, T. E., Johnson, R., Krosshaug, T., Mandelbaum, B., Micheli, L., Myklebust, G., Roos, E., Roos, H., Schamasch, P., Shultz, S., Werner, S., Wojtys, E., & Engebretsen, L. (2008). Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. British Journal of Sports Medicine, 42(6), 394–412. https://doi.org/10.1136/bjsm.2008.048934

Research Gate. (2024). How The Male and Female Average Q Angles 14 and 17 respectively influence the Tbl. https://www.researchgate.net/figure/How-the-male-and-female-average-Q-angles-14-and-17-respectively-influence-the_tbl1_386067887

REFERENCES

Robert. (2025, January 21). Orthotics making foot pain worse? Reasons and solutions. Adelaide Foot and Ankle. https://adelaidefootandankle.com.au/orthotics-making-foot-pain-worse-reasons-and-solutions/#:~:text=A%20properly%20prescribed%20orthotic%20from,this%20can%20cause%20muscle%20soreness.

Roditi, E., Tsatalas, T., Sakkas, G. K., Koutedakis, Y., Giakas, G., & Karatzaferi, C. (2024). Effects of muscular fatigue on position sense in two phases of the menstrual cycle. Journal of Functional Morphology and Kinesiology, 9(3), 115. https://doi.org/10.3390/jfmk9030115

RunDNA. (n.d.). adidas Adizero Prime SP 4 - Unisex Track Sprint Spikes - Cloud White/Cloud Black/Lucid Red. https://www.rundna.com.au/p/adidas-adizero-prime-sp-4-unisex-track-sprint-spikes-cloud-white-cloud-black-lucid-red?gad_source=1&gad_campaignid=21745416205&gbraid=0AAAAA-KK-UuTkV3SVjbtOS74tpVaULLVw&gclid=CjwKCAjwlOrFBhBaEiwAw4bYDaz5T7sHFg9FEzOMiUcRSgcau6ZV_BKBtWo9C8OwS6eZfXANpdUKohoCN-8QAvD_BwE

RunPRO - CurrexSole. (n.d.). CurrexSole. https://currexsole.com.au/our-insoles/runpro/

RunScribe Plus - GAIT Analysis (FooT). (n.d.). RunScribe. https://shop.runscribe.com/products/runscribe-plus-1?variant=15164766519342

RunScribe Plus - GAIT Analysis (FooT). (n.d.-b). RunScribe. https://shop.runscribe.com/products/runscribe-plus-1

Scholtz, M. (n.d.). Female sprinter in track starting blocks. Jacob Lund Photography Store. https://jacoblund.com/products/female-sprinter-in-track-starting-blocks?variant=39818041229381

Sharma, R., Vaibhav, V., Meshram, R., Singh, B., & Khorwal, G. (2023). A Systematic Review on quadriceps angle in relation to knee Abnormalities. Cureus. https://doi.org/10.7759/cureus.34355

The female ACL: Why is it more prone to injury? (2016). Journal of Orthopaedics, 13(2), A1–A4. https://doi.org/10.1016/s0972-978x(16)00023-4

The female ACL: Why is it more prone to injury? (2016b). Journal of Orthopaedics, 13(2), A1–A4. https://doi.org/10.1016/s0972-978x(16)00023-4

The Quadrant of Boom: Sprint speed and hamstring strength | VALD Performance. (2025, April 16). https://valdperformance.com/news/the-quadrant-of-boom-sprint-speed-and-hamstring-strength

Therabody US. (n.d.). PowerDot 2.0 Duo (Blue) | TENS and NMES targeted muscle stimulation. https://www.therabody.com/products/powerdot-duo-blue?srsltid=AfmBOoq-BieDlyajcalbNpO-CrOLVELvPZvDCb8kN-Pbqz1Xb5gifAVf

Vicon. (2025). Vicon Markerless Motion Capture: Available Now. Retrieved September 6, 2025, from https://www.vicon.com/

Women's 100m – Preview. (2025). World Athletics.
Akhundov, R., Bryant, A. L., Sayer, T., Paterson, K., Saxby, D. J., & Nasseri, A. (2022). Effects of Footwear on Anterior Cruciate Ligament Forces during Landing in Young Adult Females. Life, 12(8), 1119. https://doi.org/10.3390/life12081119

REFERENCES

ACL Injuries—The Gender Bias. (2008, October 1). https://pmc.ncbi.nlm.nih.gov/articles/PMC2547879/

Robert. (2025, January 21). Orthotics making foot pain worse? Reasons and solutions. Adelaide Foot and Ankle. https://adelaidefootandankle.com.au/orthotics-making-foot-pain-worse-reasons-and-solutions/#:~:text=A%20properly%20prescribed%20orthotic%20from,this%20can%20cause%20muscle%20soreness.

Mancino, F., Kayani, B., Gabr, A., Fontalis, A., Plastow, R., & Haddad, F. S. (2024). Anterior cruciate ligament injuries in female athletes: risk factors and strategies for prevention. Bone & Joint Open, 5(2), 94–100. https://doi.org/10.1302/2633-1462.52.bjo-2023-0166
Renstrom, P., Ljungqvist, A., Arendt, E., Beynnon, B., Fukubayashi, T., Garrett, W., Georgoulis, T., Hewett, T. E., Johnson, R., Krosshaug, T., Mandelbaum, B., Micheli, L., Myklebust, G., Roos, E., Roos, H., Schamasch, P., Shultz, S., Werner, S., Wojtys, E., & Engebretsen, L. (2008). Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. British Journal of Sports Medicine, 42(6), 394–412. https://doi.org/10.1136/bjsm.2008.048934

The female ACL: Why is it more prone to injury? (2016). Journal of Orthopaedics, 13(2), A1–A4. https://doi.org/10.1016/s0972-978x(16)00023-4

Papaleontiou, A., Poupard, A. M., Mahajan, U. D., & Tsantanis, P. (2024). Conservative vs Surgical Treatment of Anterior Cruciate Ligament Rupture: A Systematic Review. Cureus. https://doi.org/10.7759/cureus.56532

Kiapour, A. M., & Murray, M. M. (2014). Basic science of anterior cruciate ligament injury and repair. Bone and Joint Research, 3(2), 20–31. https://doi.org/10.1302/2046-3758.32.2000241

Ardern, C.L., Taylor, N.F., Feller, J. and Webster, K.E. (2014) Fifty-Five Percent Return to Competitive Sport Following Anterior Cruciate Ligament Reconstruction Surgery An Updated Systematic Review and Meta-Analysis Including Aspects of Physical Functioning and Contextual Factors. British Journal of Sports Medicine, 48, 1543-1552. - References - Scientific Research Publishing. (n.d.). https://www.scirp.org/reference/referencespapers?referenceid=3395165#:~:text=and%20Webster%2C%20K.E.%20(2014)%20Fifty%2DFive%20Percent%20Return,Cruciate%20Ligament%20Reconstruction%20Surgery%20An%20Updated%20Systematic

Myer, G. D., Ford, K. R., & Hewett, T. E. (2004, December 1). Rationale and clinical techniques for anterior cruciate ligament injury prevention among female athletes. https://pmc.ncbi.nlm.nih.gov/articles/PMC535528/
Myer, G. D., Ford, K. R., Foss, K. D. B., Liu, C., Nick, T. G., & Hewett, T. E. (2009). The relationship of hamstrings and quadriceps strength to anterior cruciate ligament injury in female athletes. Clinical Journal of Sport Medicine, 19(1), 3–8. https://doi.org/10.1097/jsm.0b013e318190bddb

RAYZR PERFORMANCE

ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION IN FEMALE SPRINT ATHLETES FOR LONG TERM PERFORMANCE AND WELLBEING

FALLON WIEDEMEIJER N11275901

ID STUDIO 7 DNB311

CRITICAL REPORT A1