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Compression Sportswear for Spinters

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Abstract:- Compression garments are specialized pieces of clothing designed to exert controlled pressure on specific parts of the body, promoting better circulation and providing support to muscles and soft tissues. These garments have a broad range of applications, including in sports, medical rehabilitation, and post-surgical recovery. In athletic environments, compression garments are often used to enhance performance, reduce fatigue, and facilitate faster recovery.

Although numerous studies suggest that compression garments can improve athletic performance and speed up post-exercise recovery, the exact mechanisms that make them effective are still not completely understood. The specific benefits may be influenced by the level of compression applied, which can vary based on individual requirements and the nature of the condition being addressed. The optimal degree of pressure to achieve the desired outcomes is an area of ongoing research, as over-compression can sometimes lead to discomfort or even cause negative effects, such as restricting blood flow.

I. INTRODUCTION

Compression garments have increasingly become a popular choice among sprinters aiming to improve performance, prevent injuries, and enhance recovery. These garments, which apply controlled pressure to specific muscle groups, are widely used across various sports but have found particular relevance in track and field, where explosive power and speed are critical. Sprinting is a high-impact, high-speed activity that demands rapid acceleration, maximum power output, and precise coordination. During a sprint, muscles undergo rapid contractions and decelerations, leading to significant strain. This strain increases the likelihood of muscle fatigue, injury, and delayed recovery, making it essential for sprinters to find effective strategies to enhance muscle function and reduce recovery time. Compression garments are designed to help mitigate these challenges by providing targeted pressure to the muscles and tissues, which is thought to facilitate better blood circulation, minimize muscle vibration, and enhance overall support [3]. Many athletes report feeling more confident and secure when using compression wear, possibly because of the added support and the feeling that their muscles are being protected. This sense of security can contribute to a positive mental state, which is crucial for achieving peak performance [1].

II. COMPRESSION CLOTHING

A. Compression Clothing

Compression clothing has become increasingly popular among athletes due to its potential benefits for enhancing performance, supporting recovery, and reducing the risk of injuries. These garments are designed to fit snugly against the body, applying consistent pressure to the skin. Typically made from stretchy materials, compression clothing provides targeted pressure to different parts of the body, which can aid in a variety of ways. There are two primary types of compression garments: **compartmental compression** and **graduated compression** [1].

Compartmental compression focuses on applying pressure to specific areas of the body, usually for therapeutic reasons. This type of compression is often used to support particular muscles or joints, helping to alleviate discomfort and promote healing. On the other hand, graduated compression involves varying levels of pressure, with the most intense compression at the extremities (such as the legs or arms) and gradually reducing pressure as it moves towards the torso [1]. This type of compression is mainly used to improve blood circulation and assist in venous return, which helps blood flow back to the heart more efficiently.

Compression garments are available in both ready-made and custom-fit options, giving users the flexibility to choose based on their individual needs. These garments come in a variety of sizes, styles, and compression levels, making them adaptable for different areas of the body, including the legs, arms, and torso. Depending on the intended use, the level of compression can be adjusted to provide the most effective pressure [32].

Compression clothing has a wide range of applications across multiple fields. In healthcare, compression garments are commonly used for **post-surgical recovery**, managing **chronic venous** [31] **conditions**, **scar healing**, and conditions like **lymphedema** and **swelling in amputated limbs** [2]. They are also utilized in **arthritis management** and to reduce swelling in the **head and neck**. In sports, athletes use compression garments to enhance **performance**, speed up **muscle recovery**, and help **prevent injuries**. Compression wear has also found use in **body shaping**, providing support and helping to shape the body.

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B. Types of Compression Garment;

- *Compression Sleeves:*

Typically worn on the arms or legs, these garments apply focused pressure to particular muscle groups, helping improve circulation and reduce fatigue.

- *Compression Shorts:*

These garments cover the thighs and hips, offering support to the large muscle groups in the lower body, which is particularly beneficial during physical activity.

- *Compression Tops:*

Commonly worn by runners and other athletes, compression tops provide support to the upper body, aiding in muscle stabilization and potentially improving posture during movement.

- *Full-Body Compression Suits:*

These suits are designed to provide comprehensive support and coverage, offering compression across the entire body, which can enhance overall performance and recovery for athletes [3].

III. GARMENT DESIGN IN COMPRESSION GARMENT

Compression garments are typically made using a standard cut-and-sew method. In this process, flat knitted elastic fabrics are first knitted to the required size and shape, a technique called "fully fashioned knitting." Once the pieces are ready, they are sewn together to form the finished garment. This approach is commonly used for sportswear that provides low levels of compression, offering advantages such as reduced production costs and greater flexibility. However, the cut-and-sew method has significant drawbacks, primarily the discomfort caused by seams, which can irritate the skin. Additionally, these seams can weaken the fabric, leading to the garment breaking down more easily over time.

A more advanced method used in compression garment production is the one-piece construction technique, also known as the "whole garment" method. This technique eliminates the need for seams by knitting the entire garment in one piece. Machines like double needle bar warp machines, flat knit machines, and circular knit machines are employed in this process to create seamless compression garments. This seamless approach is especially beneficial for high-compression products such as medical stockings, swimwear, and support garments. Without seams, these garments offer a more comfortable fit and are less likely to cause skin irritation or wear out prematurely [30].

Compression garments can be designed with different knitting techniques, such as single jersey, mesh, or rib, to achieve specific fabric properties and the desired level of compression. For example, the seamless knitting pattern can be strategically designed to apply targeted pressure to particular muscle groups. In compression sportswear, mesh structures are often incorporated into areas like the underarms, chest, and back. This enhances the fit of the garment and allows for better air circulation, making it more comfortable for the wearer, especially during physical activity [32].

The effectiveness of a compression garment depends largely on its fit and compression level. A poorly fitted garment may not provide the intended benefits, and in some cases, excessive compression can lead to discomfort, restricted blood flow, and other health issues. Therefore, the need for customized compression garments has grown. These garments are tailored to meet the specific needs of individual wearers, ensuring that the garment offers the right amount of compression and support. Customization is particularly useful in sports context, where the garment's performance must be optimized for the wearer’s unique needs [4, 30].

IV. ENHANCED COMPRESSIONS:

A. Lycra Elastomeric Pannels:

Extra compression in compression garments is often achieved through the use of Lycra elastomeric panels. These specialized panels are designed to offer several important functions, contributing to both the performance and comfort of the wearer. The primary function of Lycra elastomeric panels is to deliver **targeted compression**, which helps provide muscle support and reduce fatigue during intense physical activity. By applying focused pressure to specific muscle groups, the panels enhance the overall effectiveness of compression garments, allowing athletes or active individuals to engage in activities with more stability and less strain [34].

One of the advantages of Lycra is its **elastic properties**, which not only allow for controlled compression but also enable a **full range of motion**. This flexibility ensures that the garment remains comfortable during various activities, whether the wearer is involved in sports, exercise, or even day-to-day tasks. The ability of Lycra to stretch and move with the body is crucial for maintaining comfort and performance, particularly for athletes who require freedom of movement for optimal performance [33].

Many Lycra blends are equipped with **moisture-wicking** capabilities, which assist in keeping the skin dry. These fabrics draw sweat away from the body and help regulate body temperature during physical exertion. This feature is especially valuable in sports and activities that induce heavy sweating, as it helps prevent discomfort and chafing caused by moisture buildup. As a result, Lycra compression garments can maintain comfort and performance throughout extended periods of physical activity [35].

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Fig 1 – Lycra Elastomeric Panels [5]

Lycra is also highly **durable**, maintaining its shape and function over time. This durability is crucial because compression garments need to retain their effectiveness through repeated use and washing. Lycra's ability to **retain its shape** ensures that the garment continues to provide the necessary compression, even after frequent wear, making it an ideal choice for garments used in demanding athletic or therapeutic applications. Whether worn during intense training sessions or for recovery, Lycra maintains the structure needed to offer consistent support [33].

The **graduated compression** provided by Lycra elastomeric panels is another key feature. This type of compression is designed to gradually decrease from the lower extremities upwards, which enhances blood circulation by encouraging venous return. Improved circulation can significantly benefit athletes by promoting quicker recovery, reducing swelling, and helping to flush out metabolic waste products like lactic acid from the muscles. Additionally, enhanced blood flow can reduce the risk of injuries by improving muscle oxygenation and keeping muscles properly nourished during physical exertion [34].

Lycra elastomeric panels are typically composed of blends such as 80% nylon and 20% Lycra or 92% polyester and 8% elastane. These panels are strategically placed in high-impact areas of the body, where the most compression and support are needed, such as the thighs, calves, or upper body. These targeted panels enhance the garment's overall effectiveness by providing maximum support where it's most required [5].

B. Thermoplastic Polyurethane:

Thermoplastic polyurethane (TPU) is a specialized type of plastic formed through a polyaddition process, where a diisocyanate reacts with one or more diols. This results in a versatile material with a wide range of properties suitable for diverse applications [29].

TPUs can be divided into three main chemical classes: polyester, polyether, and polycaprolactone, each offering distinct advantages.

Polyester-based TPUs are well-regarded for their compatibility with PVC and other polar plastics, making them a popular choice for blending with other materials. These TPUs are resistant to oils, chemicals, and harsh environments, which contributes to their durability and longevity. They also exhibit exceptional abrasion resistance, making them suitable for applications where wear and tear are a concern. Additionally, polyester TPUs provide a well-rounded balance of mechanical properties, including strength, flexibility, and toughness. This versatility allows them to be used in a variety of products, such as automotive parts, footwear, and industrial applications [6, 36].

Polyether-based TPUs, on the other hand, have a slightly lower density compared to polyester and polycaprolactone TPUs. These materials are highly flexible at low temperatures, which makes them ideal for use in colder environments or in applications that require high elasticity. Polyether TPUs are also highly resistant to abrasion and tearing, offering long-lasting performance even under challenging conditions. Another key benefit is their resistance to microbial growth, which is essential for certain medical and food-related applications. These TPUs also demonstrate excellent hydrolysis resistance, meaning they perform well in environments exposed to water or moisture, such as in marine, outdoor, or plumbing applications [37].

Polycaprolactone-based TPUs combine the toughness and chemical resistance of polyester TPUs with enhanced performance at low temperatures. They also exhibit a relatively high resistance to hydrolysis, making them a strong choice for applications where exposure to moisture or harsh chemicals is a concern. Polycaprolactone TPUs are particularly well-suited for use in hydraulic and pneumatic seals, where durability and reliable performance are essential. The combination of high resistance to wear and tear, along with low-temperature flexibility, makes them ideal for sealing applications in industrial machinery and automotive components [6].

V. THE IMPORTANT MUSCLES FOR SPRINTERS

The important muscles used by sprinters while sprinting include:

A. Hip Flexors and Extensors
B. Quadriceps and Calves
C. Abdominal and Obliques
D. Back and Shoulders [7]

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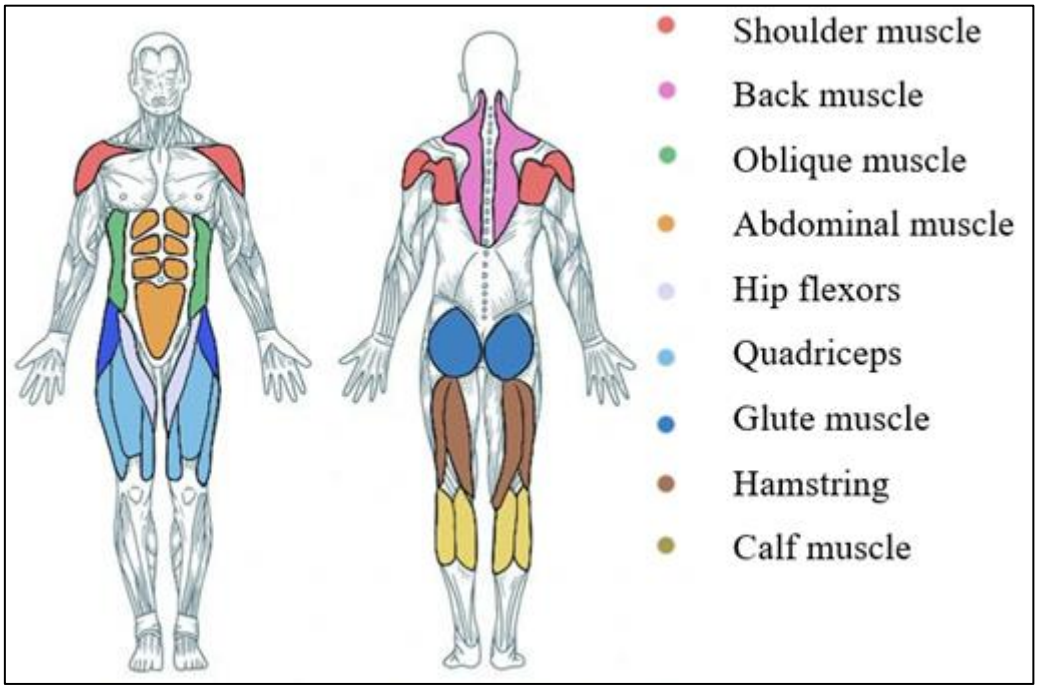

Fig 2 – Muscle under Activation in Human Body during Sprinting [39]

A. Hip Flexors and Extensors:

The hip flexors and extensors play a crucial role in sprinting performance. The **hip flexors**, including the iliopsoas, are responsible for lifting the thigh and driving the leg forward during the sprint's stride cycle. Efficient hip flexion enables sprinters to achieve faster stride frequency. The **hip extensors**, particularly the gluteus maximus and hamstrings, are essential for powerful push-off during acceleration and maintaining speed. These muscles generate force to extend the hip and propel the body forward. Proper strength, flexibility, and coordination of both muscle groups are critical for maximizing sprinting efficiency, speed, and reducing the risk of injury. The traits and strength of the hip flexor muscles significantly influence the actions in this backward position. They affect the distance the leg moves back, the elevation of the foot from the ground, the swing path of the leg returning to the front, the duration it takes for the leg to return, and ultimately, how high the knee lifts before descending again [8,9].

B. Quadracips and Calves:

The quadriceps and calves are essential muscle groups for sprinters, contributing to both speed and power. The quadriceps, located at the front of the thigh, are responsible for extending the knee and driving the leg forward during the sprint. Strong quads enable efficient knee extension, helping sprinters maintain stride length and speed. It helps in production of force, changing the direction, jumping and landing [10]. The calves, particularly the gastrocnemius and soleus muscles, play a critical role in propelling the body forward with each step. They generate force for push-off and help with ankle stability during running. Proper strength and coordination of both muscle groups are vital for explosive acceleration, maintaining speed, and preventing injuries [11, 12].

C. Abdominal and Obliques:

The abdominals and obliques are crucial for sprinters as they provide core stability, power, and control. The abdominal muscles, including the rectus abdominis, help stabilize the torso and maintain proper posture during sprints, preventing energy loss and improving stride efficiency. The obliques, which are located on the sides of the torso, play a key role in rotational movements and maintaining balance while sprinting. They assist in controlling the body's movements, enhancing coordination between the upper and lower body. A strong core, including the abdominals and obliques, is vital for explosive acceleration, efficient sprinting mechanics, and injury prevention. [7, 13]

D. Back and Shoulders:

The back and shoulder muscles are vital for sprinters, contributing to overall speed and running efficiency. The back muscles, including the latissimus dorsi and trapezius, help maintain posture and provide stability, allowing sprinters to maintain an upright position and efficient stride mechanics. These muscles also assist in arm drive, which is crucial for generating speed. The shoulder muscles, particularly the deltoids and rotator cuff, play a key role in arm movement, helping to propel the arms forward and backward in sync with the legs. Strong back and shoulder muscles enhance overall coordination, balance, and power, contributing to faster sprinting performance [14,15].

VI. SPRINTERS POSTURE

Proper posture is essential for sprinters to maximize their performance and generate significant force with each stride. One key aspect of sprinting posture is lifting the front thigh so that it is approximately parallel to the ground. This position allows for efficient power generation through the

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glutes, quadriceps, and hamstrings, which work together to drive the sprinter forward. To produce the necessary force for fast acceleration, sprinters need to apply a considerable amount of force to the ground—typically around five times their body weight. This requires the muscles of the lower body to generate large concentric forces to propel the sprinter forward quickly.

In addition to the lower body, all the muscles in the body should be engaged to some degree to maintain proper alignment and form. The core muscles play a crucial role in stabilizing the body and maintaining posture, while the arms assist in driving the legs and enhancing overall balance. The entire body must work together, with the right posture enabling the sprinter to transfer energy effectively from their muscles to the ground. By focusing on correct positioning and muscle engagement, sprinters can improve their stride length, stride frequency, and overall speed while minimizing the risk of injury [16, 20].

A. Sprinters Posture

- *Head Position:*

The head must remain upright and aligned with the body. It should be kept relaxed, free from tension, while the eyes focus directly ahead on the path. Ensuring the head is properly positioned and facing forward helps to lengthen the spine, promoting balance and reducing the risk of injuries caused by uneven stress on one side of the body. A forward-facing head also supports better concentration, minimizing distractions and allowing for improved focus. Additionally, maintaining this alignment contributes to faster movement and efficiency, as the body can move more naturally and effectively. This correct posture encourages proper biomechanics, enhancing overall performance [17].

- *Shoulder Position:*

The torso should remain straight, aligned with the direction of motion. To avoid losing speed during a sprint, eliminate unnecessary side-to-side movement of the upper body and focus on driving the arms. When the shoulders are out of proper alignment, the body expends extra energy to correct the form, leading to faster fatigue. Maintaining good posture is crucial for overall health and long-term performance. The habits formed off the track play a significant role in how the body performs while running. The shoulders should stay stable and close to the body, ensuring efficiency and reducing unnecessary strain [17].

- *Hip Position:*

The hips must stay aligned with the head and shoulders, pointing forward. Proper hip height is achieved by keeping the head and shoulders straight. Over-rotating the shoulders can cause the body's momentum to move off course, rather than driving it forward. The primary objective of hip positioning is to minimize joint stress and channel all momentum in a forward direction. At top speed, the torso should be almost upright, at a roughly 50-degree angle [17, 18].

- *Knee Position:*

Knee position is crucial for generating power while sprinting. To maximize force, drive your knees forward and lift them high, which also helps in extending the stride length. Shorter steps limit the potential of your stride, while high knees enable your legs to cover more distance. Consider the powerful stride of a cheetah; as it sprints, its body flattens, but the extension of its legs is what creates explosive speed. Although our bodies don't flatten in the same way, the concept of leg reach and power in knee placement is similar. A high knee position allows the body to store energy for maximum explosive force when the foot strikes the ground [17].

- *Feet Position:*

To achieve maximum speed in sprinting, a high force output that maximizes flight time and minimizes ground contact time is essential. During each stride, the foot should land on the midsection. As the knee drives the foot upwards and it moves downward towards the ground, the toes should be lifted towards the shin, ensuring the foot lands on the ball and middle part, rather than the heel. The foot should be aligned directly beneath the body, not ahead of it. The heel should lift off the ground and follow a smooth arc toward the glutes, without touching them [17].

- *Arm Position:*

During the starting phase, the arms should swing in opposition to the legs, with the elbows bent at about 90 degrees and the fists moving towards the forehead. As the arms swing forward, the hands should reach up to shoulder level. When moving backward, the hands should pass beyond the hips. Just like with body positioning, proper arm movement is crucial for driving momentum and power in a forward direction [17, 19].

B. Gaining Speed Posture:

In sprinting, it is crucial for the entire body to lean forward to optimize the time the foot remains in contact with the ground. This forward lean helps sprinters generate more force and increase speed during the acceleration phase.

Sprinters aim to move horizontally, maximizing their forward lean to achieve a quick and powerful stride. To maintain efficient sprinting posture, the torso and shin should be aligned, forming an angle of about 45 degrees with the ground. This positioning helps optimize the transfer of energy through the body, allowing for maximum propulsion with each stride.

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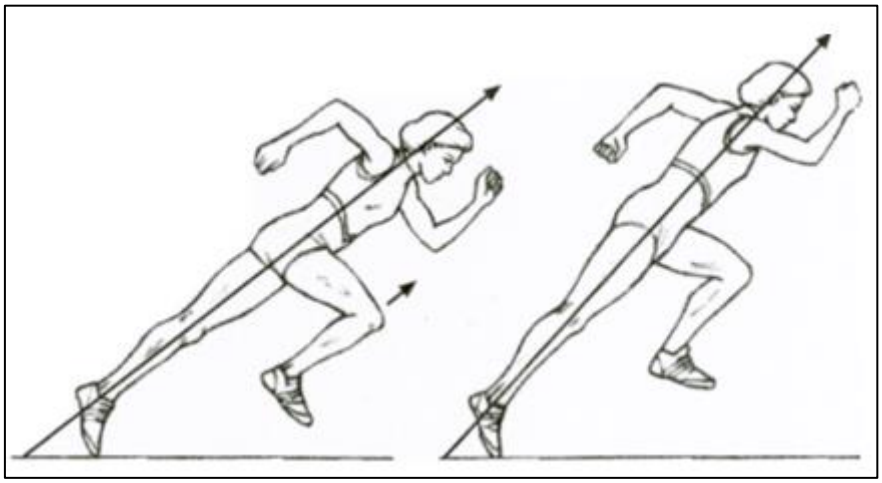

Fig 3 – Gaining Speed Posture [23]

However, it is important not to lean too far forward, as an excessive horizontal position could reduce the effectiveness of vertical force. This misalignment could lead to instability, causing the sprinter to lose balance and potentially stumble. The key is to maintain a controlled lean that allows the body to drive forward efficiently without compromising stability. By balancing the forward lean with the appropriate vertical force, sprinters can enhance their speed, minimize energy loss, and maintain optimal running form throughout their race [21, 22].

C. Maintanance Phase:

In the maintenance phase of sprinting, the body's lean angle relative to the ground should be minimal, typically between 5 to 10 degrees. This slight forward lean ensures proper posture and efficient force application while avoiding excessive strain on the muscles.

During this phase, sprinters should focus on maintaining an upright posture, allowing the body to stay aligned for optimal movement efficiency. The torso should remain tall and stable, which helps in sustaining balance and promoting fluid, fast strides.

As the sprint progresses, the foot contact with the ground becomes more frequent. This increased ground contact time is important for generating sustained power and momentum, allowing the sprinter to maintain their speed. Proper technique ensures that the foot lands efficiently with each stride, allowing for quicker recovery and preparation for the next powerful push-off. A controlled balance between posture, lean, and foot contact helps sprinters retain their momentum and avoid loss of speed or technique, ensuring they can maintain high performance throughout the race [23].

D. Drive Phase:

The drive phase occurs when the foot makes contact with the ground during sprinting. At the beginning of this phase, the foot strikes the ground either directly under or just ahead of the body's centre of mass. During the middle part of the phase, the ankle undergoes plantarflexion, where the calf muscles engage to point the foot downward. Simultaneously, the hip extends, with the glutes and hamstrings contributing to this downward movement, helping propel the body forward.

Towards the end of the drive phase, the knee flexes, and the foot moves into dorsiflexion, which involves the foot bending upward, away from the ground. Dorsiflexion is the opposite of plantarflexion, where the foot moves downward. This change in foot position prepares the leg for the next stride.

The proper coordination of plantarflexion and dorsiflexion, along with the extension of the hip and flexion of the knee, is critical for generating the maximum force needed during the drive phase. This combination of movements propels the body forward efficiently, contributing to faster acceleration and speed. Mastering the drive phase helps sprinters maintain momentum and ensures an effective push-off from the ground, enhancing overall performance [24, 25].

VII. COMMON MUSCLE INJURY IN SPRINTERS

Hamstring injuries are one of the most common and problematic issues faced by sprinters due to the high-intensity, explosive nature of their sport. The hamstrings, located at the back of the thigh, are responsible for actions such as knee flexion and hip extension, both of which are critical during sprinting. These muscles are under considerable strain as sprinters accelerate, decelerate, and perform the high-speed running required in their events. However, the fast-twitch muscle fibres that are vital for sprinting are also more susceptible to injury, especially when not properly conditioned or overexerted [28].

A. Causes of Hamstring Injury:

A. Muscle Overload:

The most common cause of hamstring injuries in sprinters is overloading, where the muscle is stretched beyond its capacity or subjected to excessive force, especially during the sprint's acceleration or deceleration phases. When a sprinter reaches top speed, the hamstrings

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work hard to decelerate the leg while maintaining control, which places the muscles under high strain [38].

B. Imbalance Between Muscle Groups:

Sprinters often experience hamstring injuries when there is an imbalance between the quadriceps (front thigh muscles) and hamstrings. A stronger quadriceps muscle group compared to the hamstrings can lead to disproportionate stress on the hamstrings, making them more prone to injury.

C. Insufficient Warm-Up:

Sprinting without a proper warm-up increases the risk of hamstring strain. Cold muscles are less elastic and more vulnerable to tearing, particularly during high-speed activities that require a lot of power and force.

D. Fatigue:

As a sprinter's muscles become fatigued, their ability to absorb impact and maintain control diminishes, leading to an increased risk of injury. This is particularly true when a sprinter pushes their body beyond its physical limits during intense training or competition.

E. Poor Running Technique:

Inadequate sprinting form or inefficient biomechanics can contribute to hamstring injuries. For instance, overstriding or incorrect posture can place undue stress on the hamstrings, especially during the push-off phase of the sprint [26, 27].

VIII. CONCLUSION

Compression garments have attracted considerable interest in sprinting for their potential to improve performance and assist with recovery. Research indicates that these garments may enhance muscle stabilization, reduce muscle vibration, and improve circulation, which can lead to less fatigue and faster recovery. However, the evidence regarding their direct effect on sprinting performance remains inconclusive. Despite this, many sprinters report benefits such as increased comfort and reduced muscle soreness both during and after intense exercise or competition. Compression garments may also help prevent injuries by promoting proper muscle alignment and minimizing the risk of strains. Still, additional high-quality research is necessary to fully determine their role in optimizing sprinting performance and recovery.

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