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Hamstring injuries in sprinting

by Michael Heynen

ABSTRACT

Sprinting and hamstring injuries are synonymous with each other. Despite the high incidence of this injury and countless amounts of research the exact cause of hamstring strains is still debated by sports medicine practitioners. The reason hamstring injuries occur cannot be attributed to any single cause; hamstring injuries are more likely to be caused through a multifactorial group of risk factors. It is the purpose of this article to briefly review one of these risk factors. Biomechanical analyses and electromyographic (EMG) studies of muscle activity while sprinting have revealed characteristic patterns of movement in top sprinters. By examining these it is possible to understand optimal sprinting technique and also consider possible causes of hamstring strains related to sprinting technique.

AUTHOR

Michael Heynen was an Australian National Junior medallist in the pole vault. He has completed Bachelor of Applied Science degrees in Sports Science and Physiotherapy. He also holds a Master's degree in Sports Physiotherapy. Michael has a special interest in track and field injuries. He consults as a Sports Physiotherapist in private practice in Adelaide, South Australia.

Introduction

Hamstring injuries remain a significant cause of injuries in sprinters. The time lost through a hamstring injury can cause major disruption to an elite athlete's training and competition schedule. Despite many different studies the exact aetiology of hamstring strains remains unclear.

Electromyographic (EMG) analysis of muscle activity during running and sprinting has been conducted by several authors and has provided a base line of normal muscular function. Understanding the normal temporal and contractile characteristics of the hamstring muscle group while sprinting may help the sports medicine practitioner, coach and athlete appreciate some of the potential sources of injury. The purpose of this article is to assess the findings of the available EMG studies performed on sprinters and relate these findings to muscle dysfunction and potential sources of hamstring injury while sprinting.

Electromyographic analysis of sprinting

For EMG research to be of value, the normal kinetic and temporal characteristics of a movement must be well documented and understood. Novacheck (1997) performed a kinetic analysis of the muscular sources of power generation while sprinting. Novacheck revealed that as the speed of running increased the contribution of the proximal musculature to the generation of speed also increased. He summarised that hip muscles generated more power (increased speed and force of muscle contraction) as the speed of running increased. He reported the hip

extensors were dominant in the back swing and the first half of the stance phase, while the hip flexors were the dominant power generators in the second half of the stance and early swing phases.

Based on their EMG studies, Mann et al (1986), Reber et al (1993), Montgomery et al (1994), and Weimann and Tidow (1995) also agreed that that the bulk of forward propulsion and power generation while sprinting could be attributed to the proximal musculature of the pelvis.

Mann et al (1986) correlated changes in the magnitude and speed of joint range of motion (ROM) with EMG activity in the lower limb while jogging, running and sprinting. They reported EMG findings consistent with the kinetic model of power development later proposed by Novacheck (1997). Mann et al (1986) observed that as the speed of running increased the magnitude of movement around the hip increased. Mann et al noted that during a 150 msec. contraction while jogging, the iliacus muscle (hip flexor) produced 46% of the total hip flexion range of motion (ROM) while jogging, however it's contraction produced 88% of total hip flexion ROM when sprinting. They believed this result suggested that to increase running speed an athlete must increase speed of hip flexion. Montgomery et al (1994) agreed with this finding.

Weimann and Tidow (1995) offered a different view. They believed that the muscles mainly responsible for forward propulsion in sprinting were the hamstrings, gluteus maximus and the adductor magnus. Their research was complementary to the findings of Ito et al (1993).

Ito et al (1993) analysed data from the Men's 100 metre final at the 3rd World Championships in Tokyo. On that occasion Carl Lewis and Leroy Burrell both broke the world record. Ito et al performed an analysis of the speed of hip extension through the back swing of the gait cycle. By comparing Carl Lewis, Leroy Burrell and slower sprinters, Ito et al (1993) revealed an extremely high correlation between this parameter and sprint velocity. They found that world class sprinters can pull their leg through the back swing at higher angular velocities than other sprinters.

More recently, Mann (1998) indicated he thought the main determinant of achieving maximum sprinting speed was in reducing contact time in the stance phase of the gait cycle. He believed this was related to the finding that elite sprinters have only a very small horizontal distance between the front support foot and their body's centre of gravity during the stance phase. This strategy can reduce the horizontal ground reaction forces that are encountered during the stance phase. Mann's (1998) interpretation was also consistent with Ito et al (1993) and Weimann and Tidow's (1995) assertion that the faster the leg is pulled through the back swing the more efficient the touch down. By placing the leg quickly down under the body, braking forces and contact time can be reduced since there is less need to counteract horizontal and vertical ground reaction forces.

Mann et al (1986), Montgomery et al (1994) and Weimann and Tidow's (1995) EMG studies revealed that the hamstrings were the most active muscles during the sprinting gait cycle. During the forward swing phase the activity of the hamstrings increased as they eccentrically restrained the terminal stages of hip flexion and knee extension. Once the terminal stage of the forward swing phase was complete, muscle activity continued to remain high as the hamstrings concentrically contracted to extend the hip and flex the knee. Mann et al (1986) and Weimann and Tidow (1995) also reported that greater speeds of running were associated with longer periods of hamstring activity during the support phase. They believed this further validated the role of the hamstrings as hip extensors during the stance phase of running and sprinting.

Weimann and Tidow (1995) provided further analysis that investigated the action of the gluteus maximus (GM) and adductor magnus (AM) muscles while sprinting (Figure 2). They believed the gluteus maximus and adductor magnus worked as a synergistic pair to drive the leg through hip extension. These authors suggested an important function of the AM was to provide a neutralising force

(adduction of the thigh and hip) to counteract the tendency of the GM to abduct the hip as it extended it. The correct synergistic actions of the AM and GM have important implications for hamstring strains which will be discussed in the following section.

Clinical implications

Based on the EMG analysis offered by the previous authors it was apparent that the hip flexors/knee extensors (iliacus and psoas) and the hip extensors/knee flexors (gluteus maximus, adductor magnus and hamstrings) play a crucial role in the development of speed and power while sprinting. Through the stretch shortening cycle the hamstrings/adductor magnus work in conjunction with the gluteus maximus to eccentrically decelerate the terminal stages of the forward swing phase and then powerfully contract to extend the hip through the back swing and stance phases. Similarly, the hip flexors decelerate the terminal stages of the backward swing and drive powerfully through the early portion of the forward swing phase to have an effect on sprinting speed. Consideration of these muscle actions while sprinting can help sports medicine professionals and coaches understand potential sources of injury and also help develop rehabilitation and training methods that may reduce the incidence of injury.

Mann (1998) made several recommendations regarding training for sprinting based on the reported EMG and biomechanical findings. These recommendations also have implications for avoiding hamstring injuries or if necessary rehabilitating athletes who have suffered hamstring injuries while sprinting. Mann suggested that sprinting athletes:

1. Practice specific running drills throughout the year that correspond with the recorded EMG muscle activity during sprinting.
2. Correct technical faults in their sprinting action.
3. Focus their sprinting technique on minimising vertical ground reaction force and sweeping through with the back swing to maximise horizontal acceleration.
4. Clearly separate training periods of high volume and lower intensity from low volume, high intensity training.
5. Perform mental rehearsal of the movement to improve their internal representation of the sprinting movement.

Running drills and plyometric training are an effective way to condition and train the stretch shortening cycle of the specific muscle groups involved in sprinting. The emphasis placed on rapid turn around between the eccentric and concentric contractions of the hip flexors, gluteals and hamstrings provides a means of specific conditioning of these muscle groups. Running and plyometric drills also provide the coach with a method of isolating and correcting technical faults in the athletes sprinting action.

A common technical error and potential cause of hamstring injury is over striding. Running drills and plyometric training have the capacity to train the athlete to improve the position they achieve through the stance phase of sprinting. As Mann (1998) indicated, minimal contact time and the placement of the foot under the centre of gravity while running were the key determinants of sprinting speed. Achieving this position appears to be a crucial determinant of performance and may also be related to injury. If an athlete fails to pull their leg down under their centre of gravity during the stance phase while sprinting, they may increase the ground reaction forces they encounter. To compensate for this extra load they may over work or strain their hip extensors and hamstrings by having to "pull" their body over their leg during the stance phase.

The clear separation of slower speed, high volume training from high intensity, low volume sprint training appears to be a logical recommendation. The muscle action used during sprinting requires specific motor pattern and metabolic adaptations (Weimann and Tidow 1995). A clear distinction between the phases of training and maintenance of specific sprinting exercises throughout the training year provides the athlete's musculoskeletal system with an opportunity to adapt to training loads and minimise the risk

of injury due to poor neurological and metabolic adaptation.

Mental rehearsal (MR) of motor activities has been proven to improve the accuracy of motor skills (Taimela et al 1990). If athletes can be educated to understand optimal sprinting technique, then they may be able to utilise MR to improve their internal representation of sprinting. The benefits of this are apparent in coordinating correct motor patterns and reducing the potential for injury.

Muscular length, strength and balance around the pelvis and thigh may also influence hamstring injuries. An international panel of sprint coaches (Bidder et al 1995) considered flexibility and muscle balance between the pelvis and thigh as a crucial determinant in improving sprinting speed and reducing the risk of injury.

Assessment of the length and flexibility an athlete's hip flexors, quadriceps, and iliotibial band is an important consideration. These muscle groups are the antagonists of the hip extensors and the thigh flexors (gluteus maximus, hamstrings and adductor magnus). If the hip flexors and the quadriceps are shorter or tighter than normal, then the hip extensors and the hamstrings effectively have to work relatively harder to perform their function while sprinting. This leads to premature fatigue of the hip extensors and hamstrings and makes them more prone to injury while sprinting.

The strength of an athlete's hip flexors should also be considered a potential contributing factor to hamstring strain and injury. If these muscles are weak, the sprinter may produce less drive through the stance phase. A compensation strategy may involve prolonged or excessive use of the hamstrings and hip extensors to produce adequate drive through the stance phase.

Finally, the correct muscle balance between the GM and AM may play a crucial role in hamstring injuries while sprinting. Weimann and Tidows' (1995) EMG analysis reported that the GM and AM functioned as a synergistic muscle pair to drive the hip and thigh through the back swing. Correct functioning of this pair permits the hamstrings to be the prime mover through hip extension and knee flexion. However, if there is a muscle imbalance between the GM and AM, the hamstrings may have to perform the additional task of stabilising the femur even as they are moving it. Weakness of the adductor magnus and or tightness of the gluteus maximus may require the hamstring muscle group to function as an adductor of the thigh and hip as well as serving its main function as a prime mover of hip and knee. Similarly, if the athlete has weaker gluteals and/or tighter adductors than normal, the hamstrings may be required to produce a stabilising abduction while functioning as the prime mover of hip extension and knee flexion. This extra demand and increased activity in both instances may be enough to place the hamstrings at risk of injury while sprinting.

Clearly there is the need for routine assessment of the sprinting athletes muscle strength, length, relative flexibility and muscle balance around the pelvis and thigh musculature. If these assessments are performed regularly, it is possible to monitor the athlete for any changes that may predispose the hamstrings to adverse strain and load while performing sprinting.

Conclusions

Sprinting is a complicated skill that places supra-maximal loads on the hamstring muscle group and, thus, offers a high potential for injury. Through an understanding of the biomechanics and muscle activity seen in sprinting, sports medicine practitioners and coaches can anticipate and detect potential sources of injury. Appreciation of optimal running technique, training methodology, and accurate assessment of the musculoskeletal system may provide a means of enhancing performance and preventing injuries.

CONTACT

Contact:
Michael Heynen
30A Edward Street, Norwood,
South Australia, 5067
tel.: +61 8 84311457
mobile phone: +61 8 0419 034482
e-mail: michaelheynen@bigpond.com

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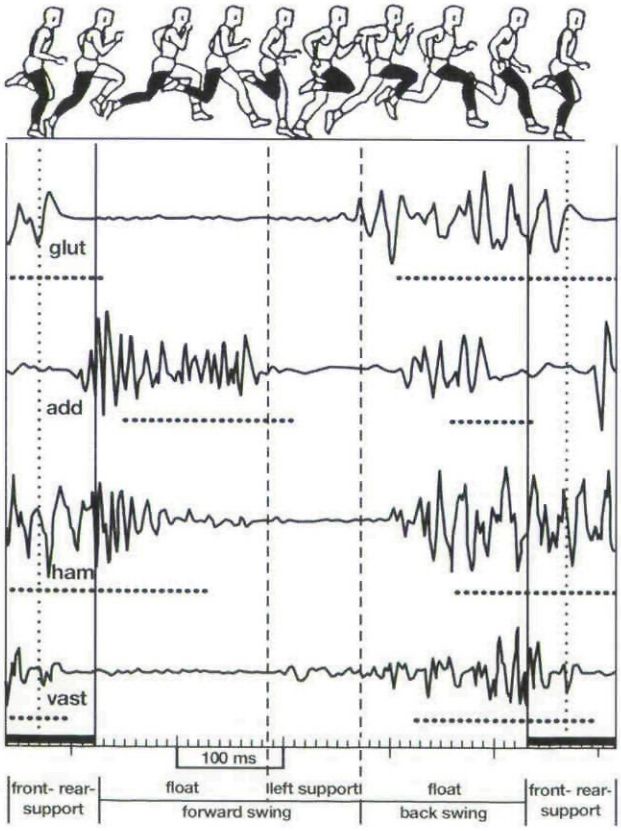
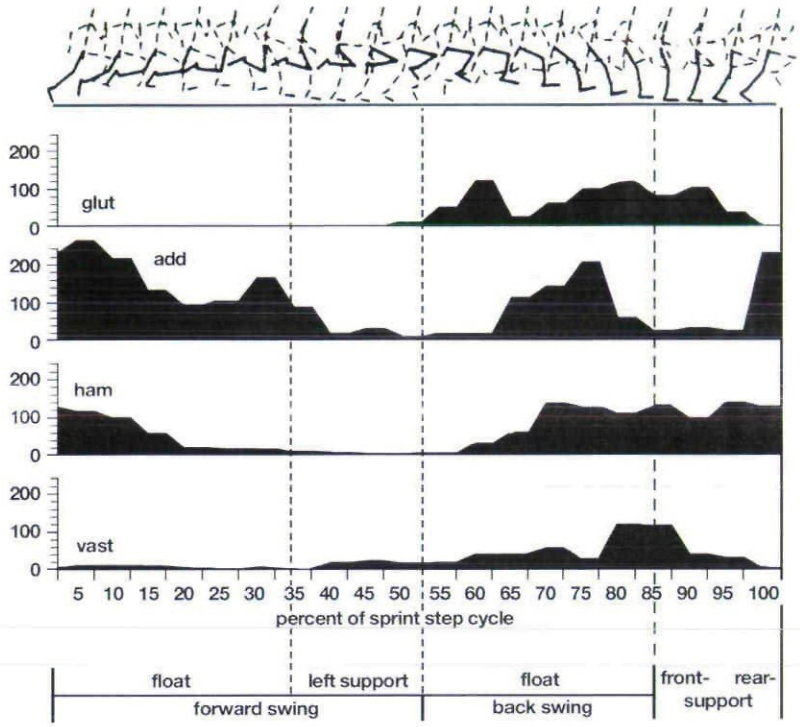
Figure 1. EMG Analysis and the Phases of Sprinting. Adapted from Weimann and Tidow (1995)



Rough EMG of gluteus, adductor, hamstrings and vastus (from top to bottom) of a sprint cycle of the right leg

Black horizontal beams: support phases of the (right) experimental leg. Dotted horizontal beams: hypothetical mechanical effect of electric activity under consideration of an electromagnetic delay of approx. 40ms. Unbroken vertical lines: start and end of the support phase of the right leg. Dotted vertical lines: medial support of the right leg. Broken vertical lines: start and end of the support phase of the left leg.

Figure 2. EMG Analysis of Muscular Contributions during Sprinting. Adapted from Weimann and Tidow (1995)



Standardized EMG of the sprint stride cycle of Figure 1.

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