LITERATURE REVIEW

Triathlon injuries: A review of the literature and discussion of potential injury mechanisms

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Summary

Background: Triathlon is a unique, rapidly growing sport that encompasses three disciplines: swimming, cycling and running. Triathlon distances can vary greatly and injuries occur as a result of an individual leg of the event, or as a result of a combination of the three. The likelihood of overuse-related injuries is vast.

Methods: The current scientific literature was investigated using online web databases: Medline, Cinahl and Mantis. Triathlon, Triathletes and Injuries were the terms used for this search. Additionally the reference lists of selected papers (not found in the original search) were examined for relevance to the topic.

Results: A review of past epidemiological triathlon studies is presented. The incidence of injury varied between 37% and 91%. Each discipline of triathlon has characteristic areas of the body that are susceptible to injury, mostly of an overuse, mechanical nature. The lower limb, particularly from the running component, produced most injuries. Most studies identified triathletes seeking some form of medical care.

Discussion: Methodological analysis and limitations of past epidemiological triathlon studies are discussed. In addition, the basic mechanics of the swim, cycle and run phases are discussed to illustrate the contribution of these factors on common overuse musculoskeletal injuries, including exhaustion-related conditions. Each of the three disciplines has unique, sport-specific injuries.

Conclusion: Triathlon is a growing sport with wide participation. This review alerts the practitioner to the potential causes of injury and encourages the practitioner to liaise with relevant coaches to seek a greater knowledge and understanding of triathlon injuries.

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1 A.H. and H.P. conceived of the study, participated in its design and helped to draft and edit the manuscript.

2 M.F. participated in its design and helped to draft and edit the manuscript.

3 All authors read and approved the manuscript.

Background

Triathlon is a sport that comprises three consecutive disciplines—swimming, cycling and running. Part of its popularity is due to the diversity of events in
which one can compete. There are varying distances over which triathlon events are held; these include the sprint event, Olympic distance, long distance and ultra distance or 'Ironman' (see Table 1). As such, a race may last a total of approximately 1 h for a sprint event, and up to 10 or more hours for the Ironman endurance event. As a result of this variability, the examining practitioner can expect great variation in the typical presentation of the injured triathlete, and a proper history of the type of triathlon and training patterns used is important in establishing a diagnosis. The purpose of this paper is to critically review the epidemiology of triathlon injuries and examine some of the more common injury mechanisms in the different legs of a triathlon.

Methods

A search of the literature was conducted in the following databases: Medline, Cinahl and Mantis (1966 to present, 1982 to present and 1980 to present, respectively). A search of the terms Triathlon, Triathletes and Injuries revealed 32 papers. After setting criteria that required blinded peer-reviewed studies in English language journals, 12 papers were eventually selected. The literature was collated and sorted according to injury site and relevance. The reference lists of selected papers were examined to determine if any reference papers not found in the original search were relevant. The authors conducted an assessment of methodology and shortcomings of studies, with the findings presented in the discussion section.

Results

Epidemiological studies of triathlon injuries

Research has been conducted on the incidence of injury in the sport of triathlon, with the results allowing the treating practitioner to familiarise themselves with this patient population. A summary of all epidemiology studies reviewed can be seen in Tables 2 and 3.

Table 1  Triathlon event distances

<table>
<thead>
<tr>
<th></th>
<th>Swim (m)</th>
<th>Cycle (km)</th>
<th>Run (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint</td>
<td>750</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Olympic</td>
<td>1500</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Long</td>
<td>2000</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Ironman/Ultra</td>
<td>3800</td>
<td>180</td>
<td>42</td>
</tr>
</tbody>
</table>

The incidence of injury in triathletes reported in the literature varies between 37% and 91%.1–8 O’Toole et al. gathered data from participants of the 1986 Hawaii Ironman triathlon and identified 91% sustaining at least one injury, whilst Korkia et al. reported 37% of 155 British triathletes suffering at least one injury.1 The large difference in injury incidence may be due to the different 'definitions' of injury quoted in the studies examined, along with the triathletes’ interpretation of that definition.

The majority of triathlon injuries reported were related to running (58–72%).1,4–6,9–11 Epidemiological investigations revealed the incidence of running injuries in triathletes is similar to that of non-triathlon runners.9 Running is thought to be the most stressful of all exercises, thus the high report of injury.11 Vleck and Garbutt analysed the injury characteristics of three different levels of male triathletes (Elite, Developmental and Club levels). They found the more elite the athlete, the more likely the injury.4 Running injuries accounted for more of the total number of injuries than cycling in all three groups.4 In contrast, Egermann et al. reported injuries were most often due to cycling (54.8%) and believed this was associated with the number of weekly hours spent training in this discipline.7

The most affected anatomical site of injury was the lower extremities.1,4–12 Most studies identified the ankle, foot, thigh, knee and lower leg (Achilles, tendon) as the most vulnerable. The large contribution of both cycling and running (particularly in training) contribute to this high incidence, although running was deemed responsible for the greater number of injuries.1,3,10 A number of studies also reported the low back as an injury site.3,10,12 O’Toole et al. discovered 72% reported low back pain or sciatica,3 while Manninen and Kallinen, who studied the occurrence of low back injury in Japanese triathletes, identified cycling to be a major risk factor for low back pain in 74% of all triathletes.12 Swimming accounted for the majority of upper extremity injuries. All injuries of the upper extremity exclusively related to the shoulder.1,7,11,12 however, Egermann et al. noted fractures of the clavicle were related to cycling and training sessions.7

Several studies1–5,7,11,12 confirmed triathlete injuries are mostly non-traumatic in nature and occur due to overuse activity. Korkia et al. found overuse only accounted for 41% of injuries,1 while Wilk et al.2 discovered overuse injuries dominated (78.9%) when compared to injuries related to trauma (33.3%). Vleck and Garbutt found the more elite the athlete, the more likely the injury was
<table>
<thead>
<tr>
<th>Author</th>
<th>Injury definition</th>
<th>Injury mechanism (%)</th>
<th>Discipline injury sustained (%)</th>
<th>Combined legs (%)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clements et al.</td>
<td>Decrease or cease training for at least 2 days</td>
<td></td>
<td>22 72 6</td>
<td></td>
<td>The lateral knee was the most commonly affected area</td>
</tr>
<tr>
<td>Massimino et al.</td>
<td>No injury definition described</td>
<td>85 15 5</td>
<td>20 58</td>
<td></td>
<td>Those who cycled faster and pushed higher gear had more injuries</td>
</tr>
<tr>
<td>Collins et al.</td>
<td>Decrease or cease training for &gt; 1 day or seek medical care.</td>
<td></td>
<td>49 11 13 62</td>
<td>8</td>
<td>50% were injured in the past year</td>
</tr>
<tr>
<td>O’Toole et al.</td>
<td>Not defined. Left up to the athletes judgement</td>
<td>91</td>
<td></td>
<td></td>
<td>91% sustained an overuse injury in 1 year prior</td>
</tr>
<tr>
<td>Korkia et al.</td>
<td>Injury stopped current training session</td>
<td></td>
<td>41 10</td>
<td>65</td>
<td>Prospective investigation 8 week training diary</td>
</tr>
<tr>
<td>Manninen and Kallinen</td>
<td>Off training &gt; than 1 day</td>
<td></td>
<td>74 43</td>
<td></td>
<td>Study on back pain</td>
</tr>
<tr>
<td>Vleck and Garbutt</td>
<td>Off training &gt; than 1 day</td>
<td></td>
<td></td>
<td></td>
<td>Running injuries correlate with the number of running sessions done</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Club</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wilk et al.</td>
<td>Any injury that occurred whilst training or racing in triathlon or single event</td>
<td>75 41</td>
<td>34.50 62.10</td>
<td></td>
<td>Overuse related injuries interfering with daily function</td>
</tr>
<tr>
<td>Cipriani et al.</td>
<td>Injury which occurred over the last 10 years</td>
<td>Analysis not complete</td>
<td></td>
<td></td>
<td>Surveyed injury incidence and compared with other studies</td>
</tr>
<tr>
<td>Egermann et al.</td>
<td>Injury during training or competition causing the triathlete to stop</td>
<td>74.80 33.30</td>
<td>5.80 54.80 33.70</td>
<td></td>
<td>Injuries most often due to cycling</td>
</tr>
<tr>
<td>Burns et al.</td>
<td>Any bone or soft tissue problem causing rest for at least 1 day, taking medicine, seeking medical aid and not from acute trauma</td>
<td></td>
<td></td>
<td></td>
<td>Increased years of triathlon experience was the most significant predictor of pre-season injury</td>
</tr>
</tbody>
</table>
Overuse injuries are likely to occur owing to the high number of training hours, along with other features such as extrinsic (those that are independent of the athlete) and intrinsic factors (those that are inherent to the athlete) and the number of years of triathlon experience.\textsuperscript{1,4,11} Egermann et al. report conflicting evidence, finding a positive and negative correlation, when referring to injury and weekly training hours.\textsuperscript{7} However, they did find most injuries (81.3\%) occur during triathlon training hours compared with the 18.7\% during competition. When considering the hours spent training in relation to competition, there was a six-fold higher incidence for injury during competition, which implies that triathletes tend to push their limits during competition (i.e. higher speeds and exhaustion during competition).

There was information regarding medical care sought by triathletes. Egermann et al. state 55.1\% sought medical advice more than once per year.\textsuperscript{7} Clements et al. found 78\% and Cipriani et al. found 42\% of triathletes sought treatment from healthcare professionals.\textsuperscript{6,9} Wilk et al. found 65.3\% of responding participants sought medical help, with medical physicians and physical therapists most likely to be seen.\textsuperscript{2} There is a great need for further analysis with respect to the prevention of triathlon injuries.\textsuperscript{7}

### Discussion

#### Methodological analysis of triathlon injuries

When in reviewing the data produced by these studies, a number of methodological issues need to be considered. The response rate of surveys should be reported or otherwise evaluated, as the response rate indicated how representative the data collected were of the whole population. The higher the response rate, the more representative the data are of the population.\textsuperscript{13} Response rates for triathlon injuries ranged from 29\% to 72\%. The type of data the survey is trying to obtain also reflects the results produced. Retrospective studies are easier to produce as they examine existing data, while prospective studies involve looking at what happens from a set time forward for a defined period of time.\textsuperscript{14} The prospective study is harder to institute owing to increased costs and time spent on the study, as well as having problems associated with participant dropout. However, productions of such studies produce stronger conclusions.\textsuperscript{15} The triathlon literature is primarily retrospective in nature and despite the potential for a great deal of data to be gathered, many retrospective studies ask the

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**Table 2 (Continued)**

<table>
<thead>
<tr>
<th>Author</th>
<th>Injury definition</th>
<th>Injury mechanism (%)</th>
<th>Combined legs (%)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaw et al.\textsuperscript{8}</td>
<td>Pre-season</td>
<td>Overuse</td>
<td>68</td>
<td>Injury which reduced sport participation, medical advice, adverse social effects and alteration to training</td>
</tr>
<tr>
<td>Competition</td>
<td></td>
<td>Acute</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Swim</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cycle</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Run</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combined</td>
<td>73</td>
<td></td>
</tr>
</tbody>
</table>

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A. McHardy et al.
participant about injuries sustained throughout their career, which gives rise to the phenomenon of recall bias. Recall bias is the inaccurate reporting of data that results from alteration in recollection of events that occurred in the past. For example, interpretation of injury and injury site may vary slightly between athletes despite instruction and/or assistance of the author during survey interviews. Also, athletes may report injuries not confirmed by medical diagnosis. As a result, the difficulty involved with self-reporting of injuries by athletes is acknowledged, with information obtained by this form of data collection being interpreted with due consideration of these limitations. The use of prospective studies would dramatically reduce recall bias. Another limitation included the difficulty in comparing injury incidences across studies when methodology and especially injury definitions were not standardised. Future research should use standardised methods of defining, grouping and assessing injury. Finally, data produced by a study need to be large enough to be able to draw conclusions. Small sample sizes were reported in most triathlon studies. The more subjects in a study sample, the more representative is that study sample of the population it is trying to represent.

### Swimming phase and injury mechanisms

The swim leg is the first leg of the triathlon. It consists of an open water swim (in either an ocean or lake) and presents the unique problem of a tangle of competitors in a small area (at the start), who are jostling and competing to get to the turning buoy first. The water temperature is often cold and the use of wetsuits prevents hypothermia. Wetsuits also increase buoyancy and decrease drag forces experienced when swimming, by reducing the friction coefficient of the surface in contact with the water. Thus, less effort is required to keep afloat and more energy can be used in the propulsion of the body through the water.

Determining the mechanism of injury requires practitioner awareness of the correct biomechanics of the swimming stroke, particularly of the shoulder. The swimming stroke (freestyle) can be divided into the propulsive and the recovery stages. In the propulsive stage, as the hand enters the water, the shoulder goes through continual adduction and internal rotation. Out of the water, the recovery phase involves shoulder abduction and external rotation. The path of the hand in the water follows an ‘S’ shaped movement in order to propel the body. Hydrodynamic lift forces are said to
result from this pattern and assist in propulsion. For further discussion of the swimming stroke, the reader is directed to Pollard and Fernandez.21

Owing to the overload nature of the swim stroke, the rotator cuff (particularly the supraspinatus tendon) is at risk in repetitive overhead stroke activity.23 The long head of the biceps is also susceptible. This occurs as a result of repetitive microtrauma of the relative avascular region of the supraspinatus tendon on the anterior edge of its insertion on the greater tuberosity of the humeral head, possibly leading to an impingement syndrome.24 This position occurs in the recovery phase of the swim stroke. There are three stages of impingement.25,26 Initially there is edema, aching pain at rest, decreased range of motion and point tenderness. As the problem progresses, there is bursal thickening, fibrosis and recurring tendinosis (secondary stage). Eventually, the tertiary stage is well advanced with resultant rotator cuff tear, biceps rupture and bony changes.25,26 This scenario can be further complicated if there is inadequate thoracic spine extension mobility. This will accentuate the classic ‘swimmers posture’ and expose the shoulder in a position that functionally predisposes impingement and tendinopathy.21

The shoulder of the triathlete may become subject to instability, particularly if long swim training hours are combined with faulty technique. Instability is a condition in which unwanted translation of the humeral head on the glenoid compromises shoulder function.27 The most common direction of instability is anterior/inferior. This is the position the arm adopts during the mid-recovery phase of the stroke and is further compromised by poor body roll. During freestyle the upper body should roll through approximately 160°.21 This allows for efficient swimming propulsion. Novice swimmers lack this body roll, and this position causes the humeral head to migrate forward against the glenohumeral ligaments anteriorly with the cuff muscles acting to push the head through the anterior capsule, while the supraspinatus and long head of biceps act to stabilize the translation of the humeral head.23,25

The kicking action of the swim stroke is divided into a downbeat/propulsive phase and the upbeat/recovery phase. The recovery phase is mostly hip extension with the knee fully extended and ankle slightly plantar flexed.22 The propulsive phase involves hip flexion at the beginning. The foot lags behind due to knee flexion at the start of the phase, with knee extension at the end while the ankle stays plantar flexed.22 The kick component of the swim leg may predispose the triathlete to injury in the cycle and run components, as the ankle is kept in a plantar flexed position. This indirectly results in shortening of the gastrosoleus muscles and Achilles’ tendon, causing a predisposition to overuse injury to the calf, which is predominately concentric in the bike leg and largely eccentric in the running component of triathlon training and competition.28 Liaising with a qualified swim coach will help the practitioner understand the unique contributions of the upper and lower extremity in swimming. The practitioner should note that triathletes tend to reduce the contribution of their legs for propulsion in the swimming phase in order to conserve energy for the bike and run phases.9 Triathlete swimmers may rely primarily on the upper limb for swimming propulsion, reducing their efficiency in the water. Emphasis should be placed on body roll as this is perhaps the greatest difference between elite and novice swimmers.21

Other injuries that may occur in the swim leg include ear, eye and throat irritation or infection. Depending on race location, marine life such as jellyfish may also present problems.29 Water temperature during the swim leg may cause hypothermia and, with the use of wetsuits, hyperthermia could theoretically occur. Discussion of these possibilities is beyond the scope of this review. The reader is directed to Trappe and Kerr for further information.18,30

Cycling phase and injury mechanisms

The cycle leg is raced along city streets, even highways and, as a result, triathletes may share the road with regular traffic (a situation that predominately occurs during training). The types of bikes used have changed considerably since the first triathlon occurred. Bikes are now often equipped with aerodynamic rims, tyres and handlebars (aerobars).31 This is in addition to the lighter, more aerodynamic frames now used.31 The aerobars put the rider into a more aerodynamic position to reduce head-on wind resistance.31–33 The sacrifice of this arrangement is the reduction in stability and control of the bike. This, combined with large groups of riders at high speeds (30—40 km/h plus), is a significant factor in crashes (not involving cars) whilst on the bike. The severity of such injuries varies from simple cuts and grazes to fractures and even death. Fractured clavicles are common.7 In training and in competition, the triathlete should wear an approved helmet to reduce the chance of serious head injury. During training, the triathlete should follow road rules and wear brightly colored clothing, thus being clearly visible to the passing traffic.

Bike set-up is very important to the efficiency of the cycling action and is a large factor in bike-related overuse injuries. The seat height, saddle
position and arm reach/handlebar height are the main components. In relation to correct seat height, if it is too low the triathlete will have a reduced range of motion of the hip joint, likely resulting in reduced gluteal power in the downphase of the pedaling action. Also, as a result of greater knee flexion, patello-femoral tracking problems occur more readily owing to increase compression forces. If the seat is too high, again a loss of power may result from the muscles not functioning in their optimal length-tension range. Also, the stability of the action is lost owing to loss of the stable core as a result of rocking the body from side to side. Tilting of the pelvis side to side over the extended leg can be a potent source of stretch injury to the lumbosacral region. When the seat is too high, the knee tends to fall into full extension and beyond (hyperextension), which may result in impingement anteriorly, especially when applied over prolonged periods. For discussion on proper bike fit, the reader is directed to the paper by Burke on this subject.

Overuse injuries that may occur include neck pain and low back pain from the prolonged bent over position on the bike, and patello-femoral dysfunction from poor technique or riding position. The triathlete’s riding position can predispose to low back pain, and this can be dependent on the race duration, as the triathlete may be in the ride position for up to 7 h in an Ironman distance competition and even longer in training. To achieve cycling aerodynamic form, a large amount of flexibility and stability at the hips, back, thorax and neck is required. These factors need to be considered by the triathlete, especially with the use of aerobars, which promote increased lumbar flexion and draw the rider forward. The intervertebral disc may be subjected to overuse in the cycling component. Pedaling in high gears (harder to push and typically used for going across flat territory or down hills), excessive hill climbing and faulty foot pedal placement can sprain/strain the patello-femoral joint along with the supporting ligamentous structures of the knee. A common cause of patello-femoral dysfunction is riding in heavy gears resulting in high leg force and lower cadence, which results in high forces being transmitted through the patella with resultant anterior knee pain. The rider could adopt a process known as ‘spinning’ by using lower gears (easier to push and typically used for going up hills), lower force output and increased cadence. Heavy gear usage is further increased with a large amount of hill work. Triathletes with minimal cycling experience may be particularly vulnerable in this situation. Additionally, poor biomechanics during cycling, such as having the heel in an ‘out’ or ‘in’ position with respect to the foot, or having the seat at the incorrect height can result in anterior knee pain. Another position associated with hill work, using higher gears, is iliotibial band syndrome. The Achilles’ tendon is also stressed through hill climbing in the standing position and may be worsened with incorrect toe clip fitting (which does not allow the foot to be placed far enough into the pedal).

In such cases, the triathlete should work with a cycling coach to correct riding technique. Alternatively, referral to a qualified cycle shop for proper bike fit may be appropriate. The treating practitioner should examine training schedules, noting dramatic training changes for clues to overuse injury mechanisms. Another factor to consider, particularly in Ironman events, is that the majority of the cycle leg takes place during the middle of the day. As a result, sunburn becomes a possible factor as well as chafing between the thighs and buttocks. Dehydration and hyponatremia and are also conditions that need addressing and will be considered in more detail in the running injuries section.

Running phase and injury mechanisms

The run is the final leg of the triathlon. Epidemiological studies reveal the majority of triathlon injuries occurred during running and may be due to the high impact loads the legs and feet experience while pounding on the road. With the accumulative effects of the previous two legs, the triathlete can be under a moderate amount of both physical and mental stress. Hence, there is a greater chance of sustaining fatigue-based injuries, particularly in longer events. In shorter events, epidemiological investigations revealed the incidence of running injuries in triathlete is similar to that of non-triathlon runners.
Following the cycle leg, lower limb muscle fatigue can result in a decrease in speed of contraction and peak force of muscle fibers, particularly the plantar and hip flexors from the swim and bike legs, respectively. With respect to the cycling leg, often there is a build up of local lactate in the thigh due to the bike leg being non-weight bearing and the legs being used heavily in a limited range of motion. At the start of the run leg, muscles are most likely unable to produce the same amount of power as would otherwise have been the case if the run leg had been performed first. The result is a decreased stride length, yielding a slower pace and a subjective feeling of a harder run. Various studies have looked at the effect of a bike ride immediately preceding the run leg and have found the most effective way to combat the heavy feeling and possible cramping sensation is to start the run at a slower pace before building up the pace, allowing the body time to adapt to the new demands placed on it. Other possible reasons include going from a non-weight bearing position to performing an activity which has impact forces of two to five times body mass. Guezennec found that completing the run leg at the end of the Olympic distance triathlon (10 km) takes 8% longer than undertaking the run alone. This can be attributed to fatigue and running economy modifications, such as decreased stride length, increased trunk flexion and decreased knee range of motion in the running stride. Understanding and taking into account these practical tips has the potential of reducing the chance of injury suffered by triathletes.

In training, running overuse-related injuries frequently affect the lower extremity. These include patello-femoral pain, iliobibial band friction syndrome, Achilles tendinosis, stress fractures, compartment syndrome, tibial periostitis and plantar fasciitis. These conditions are the result of a combination of factors including the type of training undertaken, footwear utilized and running biomechanics.

Consulting with a running coach (when examining the triathletes’ training habits or diary) may reveal subtle training errors. Increased running speed and downhill running can dramatically increase foot impact. Other injury threats include the triathlete rapidly increasing training volume or intensity (hill training), poor scheduling of training sessions, selecting poor pacing strategies and allowing little recovery time between sessions. The ground used for run sessions (for shock absorption purposes) should also be addressed.

Running shoe design is an important consideration in foot and ankle movement patterns along with loads transmitted to lower limb during ground contact. Specific emphasis should be placed on dorsiflexion and pronation to lessen injury. Consideration should also be given to amount of mileage each pair of shoe does, as research has found a correlation between infrequent change of running shoes and injuries. Running shoes may lose between 30% and 50% of their shock absorption after about 250 miles of use. Another study has shown 400—800 km may reduce the shoes’ shock absorption capacity by 60%. As a result, shoes should be replaced every 400 to 600 miles or every 6 months. A podiatrist may be sought to examine the triathletes foot, particularly arch integrity. Burns et al. found that, while foot type was not a major risk factor for injury, triathletes with a supinated foot type had a four-fold increased risk of overuse injury during the competition season. Podiatrists may also identify particular shoe wear patterns, proper fit and shape of shoe. Various arch types (high, flat and normal) will determine which type of shoe will likely benefit the triathlete. These may include cushioned, stability or lightweight shoes. Injuries may also be prevented with the help of properly prescribed orthotics. Orthotic devices are inserts that are placed in shoes to influence the pattern of leg movement through a combination of mechanical control and biofeedback, especially if standard running shoes do not provide adequate correction.

Injury may be associated with, or purely related to, the triathletes’ running biomechanics, particularly abnormal mechanics of the foot, knees, hips and lumbopelvic complex. Video analysis of heel contact, forward lean, arm swing, pelvic motion and stride length, viewed by the treating practitioner, running coach and/or a podiatrist may be beneficial.

In the Ironman events, dehydration and hyponatremia are common in the triathlete. Dehydration is defined as loss of water due to excessive sweating during exercise, particularly in hot, humid weather. This may occur in any of the triathlon distances, but the Ironman event sees more cases than any other race type. Symptoms include dry mouth, sunken eyes, wrinkled skin, weight loss, confusion, inability to urinate and low blood pressure. Dehydration will also lead to a decrease in maximum aerobic output and physical work capacity. It may cause cramps, exhaustion and, in severe cases, hyperthermia due to a loss of the body’s thermoregulation. Laird noted 71% of all medical care visits in ultra endurance triathlons were at the finish line and due to dehydration and exhaustion-related factors.

Hyponatremia is a serious condition where the concentration of sodium in the blood falls to less than 135 mmol/L. Excess consumption of water
(leading to water intoxication) may strain the kidneys and cause loss of mineral salts. Symptoms of mild hyponatremia are nonspecific and include malaise, confusion, nausea and fatigue. More specific symptoms include seizures, coma, pulmonary edema and death, which may occur with severe untreated hyponatremia. Not all athletes with plasma sodium concentrations less than 135 mmol/L are symptomatic or present for medical care. These are recognised to have asymptomatic hyponatremia. The etiology and prevention of these two conditions is beyond the scope of this review. For further discussion, the reader is directed to Speedy, Hiller and Montain.

Conclusion

Triathlon is a growing sport with wide participation. It incorporates three different disciplines, swimming, cycling and running, into one event. This requires the attending practitioner to consider a number of different injury mechanisms, both in training and in competition. Apart from injuries that may occur in each phase, there are injuries that result from an accumulation of the three phases. These include various overuse sports-specific musculoskeletal injuries and exhaustion-related conditions such as dehydration and hyponatremia. The practitioner is encouraged to liaise with relevant coaches to assist them with the unique components of each discipline. The basis of this paper was to review the epidemiology of triathlon injuries and to aid the practitioner in identifying the practical mechanics of each of the three disciplines and relating them to the different types of injuries generally seen in triathletes. With this knowledge and understanding, their ability to diagnose and provide treatment is enhanced.

References

30. Kerr CG, Trappe TA, Starling RD, Trappe SW. Hyperthermia during Olympic triathlon: influence of body heat storage...