Triathlon Injury - An update.

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Abstract

Although the variety of distances, formats and age-groups that are involved in triathlon make it a useful model to investigate the effects of multi-discipline endurance training and competition on injury risk across the life-span, this opportunity has not been taken advantage of. Most studies are limited by their retrospective nature, recall periods; and failure to consistently or adequately report subject age-group, gender, ability level, and event focus; injury occurrence, distribution, outcome, and or potential risk factors. The sudden death rate for competition is 1.5 (0.9–2.5) deaths per 100 000 participations but 29–91% of triathletes may be affected by injury 'causing cessation or reduction of training or seeking of medical aid' at any one time. Most such injuries are minor to moderate severity overuse, or abrasion injuries. The knee, ankle/foot and lower back are commonly afflicted, with increasingly less effect on running, cycling and swimming training. As many injured athletes continue training, recurrence is likely to be high. A consensus statement on the definition and reporting of both first time and recurrent injury must be developed, and longitudinal prospective studies need to be conducted, before the extent of, and ways to ameliorate, the injury problem can become clear.

Keywords:
triathlon, triathlete, injury, risk factors, multi-sport.

Résumé

Bien que la variété des distances, des formats et des tranches d'âge qui sont impliqués dans le triathlon en font un modèle utile pour étudier les effets de l'entraînement en endurance multi-discipline et la compétition sur le risque de blessures au fil du temps, cette possibilité n'a pas été mise à profit. La plupart des études sont limitées par leur nature rétrospective, les périodes de rappel, leur manque de consistance et ne tiennent pas compte des groupes d'âge, du sexe ou du niveau de capacité, ni des particularités telles que la survenue des blessures, leur distribution, leur évolution et ou des facteurs de risque potentiels. Le taux de mort subite en compétition est de 1,5 (0,9 à 2,5) décès pour 100 000 participants, mais 29 à 91% des triathlètes peuvent être affectés par une blessure, cause d'une cessation ou d'une réduction de l'entraînement et rechercher l'aide médicale à un moment donné. La plupart de ces blessures sont de gravité mineure à modérée et sont en relation avec un over-use, ou sont des blessures d''abrasion. Le genou, cheville/pied et le bas du dos sont souvent concernés, avec de plus en plus d'impact sur la capacité à s'entraîner en course, en cyclisme et en natation. Malgré leurs blessures, de nombreux triathlètes poursuivent leur entraînement, le risque de récidive est potentiellement élevé. Une déclaration de consensus sur la définition et la survenue des blessures récurrentes doit être développée, et des études prospectives longitudinales doivent être réalisées dans le but d'améliorer les connaissances et de prévenir la récidive des blessures en triathlon.

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Introduction

Injury research can be said to undergoing a quantum shift. Work presented at the 2011 IOC World Conference [1] on the Prevention of Injury and Illness in Olympic Sports demonstrated increased awareness of the need both for increased quality in research design and to persuade sports policy makers to support ensuing attempts to translate research results into improvements in practice.

Triathlon encompasses three of the highest participation sports worldwide and is itself becoming an increasingly popular 'lifestyle' sport [2]. Although no supporting evidence for this exists in the academic literature, it is said that those who start triathlon tend to stay with it. Not only Elite athletes, but also 'age-group' athletes- from under fourteen to over eighty five years of age- compete in the various triathlon formats and distances that are available to them [3]. The sport therefore provides a model not only for the effects of cross-training [4], but also for the influence of long-term endurance swimming, cycling and running exercise on injury risk both across, and at various stages of, the life-span.

Although training and competition focus may change with both age and years of competitive experience, at any given life stage the triathlete is likely to be focusing on performance over either short (Sprint- Olympic distance (OD) or long (half-Ironman (½IM) – Ironman (IM)) distances. The relative extent to which such athletes may be participating in other single and multi-sport competitions has only been reported for OD athletes [5]. Nevertheless, several intrinsic and extrinsic differences likely exist between short (SD) and long distance (LD) specialists [5, 6]. It is unclear to what extent these differences may impact on the extent, distribution and severity of training related injury in these groups. The different durations and work intensities that SD and LD athletes compete at [7, 8], do, however, have a differential effect on their race injury profiles.

Previous triathlon specific reviews published in 2001 [9], 2006 [10], 2008 [11], and 2010 [12], have all detailed the methodological problems with the literature that are the main reason for the exact extent of the injury problem in triathletes being unclear. Said problems include inconsistencies in the definition and recording of injury, as well as inadequate differentiation of study subject groups by age, gender, ability, experience, and or distance specialization. Mainly case studies, and few original papers, have been published, since the last major such analysis was conducted. The impact of the various problems that have already been acknowledged on the triathlon injury literature therefore remains relatively unchanged [9–12]. We consequently refer the reader to said reviews for the details of the aforesaid problems, rather than repeat them extensively here.

Methodology

A total of fifty five peer reviewed original publications and eight reviews were sourced via PubMed and Google Scholar using combinations of the terms 'triathlon', 'triathlete', 'injury', 'overuse', 'traumatic', 'hydration', and 'medical', as well as by hand-search of the reference lists of all the work so obtained. Only papers in English, French, Portuguese, or those with an English abstract that had their main text in any of the aforesaid languages were used to compile this document.

Injury Data

Prevalence/incidence.

Prevalence of injury 'causing cessation of training for at least one day, reduction of training, or seeking of medical aid' has been reported to be between 29% [6] and 91% of adult triathletes [12, 13]. Only one, retrospective, study has directly compared prevalence of overuse and traumatic training related injury (using the same injury definition) between 25-45 year old males and females, top 50 finishers at their non-drafting National Championships and competitive age-groupers, and OD and IM specialists [5, 6], and found it not to differ between said groups. No comparative data for training related injury prevalence exist across all the various triathlon age-groups. Age, gender, and years of competitive experience do not appear to affect the proportions of athletes who report for medical aid at Sprint distance events [14] but it has not been fully established [15] whether this also applies to other distances and formats.

The procurement of injury incidence values has also proved problematic, partly because of the inherent difficulties that exist with prospective data collection, and partly because of difficulties in quantifying overall training stress across the various disciplines and intensity levels that are involved in triathlon training. No sudden death rates for triathlon training exist but sudden death rates for United States triathlete sanctioned events over the period 2006-2008 [16], involving 959 214 participants, were estimated by Harris et al. [16] at 1.5 (0.9–2.5) deaths per 100 000 participations. The majority of such deaths occurred during the triathlon swim (*i.e.* 1.4 (0.8–2.3) deaths as opposed to cycle and run rates of 0.1 (0.01–0.07), and 0.0 (0.0–0.3) deaths per year per 100 000 participations, respectively). Slightly higher death rates were recorded for the races that involved short (<750m) or longer (>1500m) swims than for those with swims from 750 to 1500m in length.

Incidence rates of self-assessed overuse and traumatic injury per 100 athletes of 0.74–76.7, and of 10.0–23.8 per 1000 training hours (depending on the month of the year) have been obtained prospectively for small (n=11–43) samples of OD triathletes [5]. Presentation rates for medical assistance of 20.1 per 1000 hours of Sprint, OD and or fun distance competition have also been recorded [15]. No prospective inter- or intra- (age, gender, ability or event distance-) group comparisons of injury incidence rates, using the same injury definitions and data collection methods, exist for the endurance base, base transition, pre-competitive and competitive periods of the athlete's year. Injury rates are thought to be higher within competition than within training, however [17, 18], as may be the incidence of (traumatic) crowding-, hydration- and or heat- related injuries. However, none of the training studies thus far appear to have obtained any hydration and heat stress related data. These tend to be reported by the studies that involve clinical assessment- and most of these are race studies. The discrepancy between training and race related studies in the relative proportions of reported injuries that have been self-assessed by non-specialists as opposed to by a clinician complicates the comparison of their results.

Only one study [19] has tracked the temporal prevalence and incidence of injury within competition, in this case for non-elite participants in ½-IM and IM triathlons conducted at the same location. The weather for the event was dry with wind speeds from 1–8 miles per hour, humidity from 37–87%, and temperature from 16–28 ºC; but it is not clear from the paper to what extent environmental conditions differed between the two events. Injury affected 10.8% of ½IM and 37.7% of IM age-groupers, respectively, as compared with previously reported values of 15 to 25% of Elite IM competitors [20, 21]. The normal finishing time window, across both the ½IM and the IM, was 5 to 9 hours. A total of 72.2% of ½IM injuries, corresponding to 78 per 1000 race starters, were sustained during hours 6 and 7. The IM had a much higher rate of severe injuries than the ½-IM, at 38.2% ± 6.0% (95% confidence interval), and longer average treatment durations. Although average injury treatment duration increased with finishing time the highest proportion of severe injuries were seen in those ½ IM athletes who took longer, or in those IM athletes who were faster, to finish than the rest of their cohort.

Injury distribution.

Over the Sprint distance and OD distances, contusions, and abrasions/grazes blisters are the most commonly reported race [15]. The most common primary medical diagnoses over the ½IM format appears to be dehydration followed by muscle cramps (50.8% vs. 36.1 %). Muscle cramps and dehydration occurred in almost equal proportions (38.9 vs. 37.7%), in an IM event occurring at the same location [19]. Gradual onset overuse injuries are the most common training injuries and occur in three times as many athletes as do acute injuries [22–24].

Although there is an issue with the existing literature as regards both grouping and restriction of injury to only some anatomical areas, clearly most overuse injuries are lower extremity injuries. The most detailed incidence rates per 1000 training/racing hours thus far available for the anatomical locations that are most commonly assayed by the literature. The risk areas for which the highest prevalence values are usually reported, accounting for up to 43% [18], 23% [25] and 31% of injuries [18], are the knee, ankle/foot and lower back. The only retrospective study to directly compare anatomical distribution of injury between small (<50) numbers of athletes in different event distance, ability and gender groups [5] found the most commonly injured sites (expressed as a % of the total number of athletes affected over the previous five years) to be the Achilles tendon (50.0%), knee (41.7%) and lower back (41.7%) in Elite OD males; the calf, knee and 'other' (than the Achilles tendon, ankle, anterior thigh, calf, hamstring, knee, lower back, upper back, shoulder and neck) in Elite OD females; the knee (47.1%), lower back (29.4%) and shoulder (23.5%) in sub-elite males, and the calf (30.0%), Achilles tendon (30.0%) and knee/other sites (20.0% each) in sub-elite females. IM males and females were most affected by knee (44.0%), lower back (20.0%) and calf (20.0%) injuries; and by knee (50.0%) injuries, respectively. The anatomical distribution of traumatic injury is likely to be somewhat different from that of overuse injury but no direct comparisons have been carried out by any of the studies to date.

Of 17 studies undertaken before 2010 [12] that listed the anatomical sites that were affected by injury in their athletes, less than a quarter appear to have involved clinical diagnosis of said injury in question. According to Korkia et al. (1994) [25], 35%, 25% and 22% of ankle/foot, knee and lower leg injuries involve a strain, tendinitis and a tear, respectively.

Discussion of the potential mechanisms of development of triathlon injury, including how this may be due or exacerbated by the demands of cross-training, can be found in the December 2012 special issue of 'Sports Medicine and Arthroscopy Review' [26-29]. The latter articles are mostly 'Level 5' discussions (*i.e.* expert opinions without explicit critical appraisal, or based on physiology, bench research or 'first principles'). Little supporting information has been obtained from the original research studies thus far conducted, other than that running, followed by cycling and then swimming, is the triathlete's first time choice of blame for (?) (non differentiated) triathlon training and/or racing knee, lower back and shoulder injuries [12]. However, in the only study thus far to track multiple occurrences of injury to a given location over time, some athletes were found to attribute the first occurrence of the injury to training/racing in one discipline and its subsequent occurrences to exercise in another or more than one discipline [5].

The extent to which reported injuries may be first time as opposed to recurrent injuries has barely been acknowledged by the triathlon injury literature. Few studies to date appear to have discriminated between them, making it difficult to get a true picture of both the actual extent and the chronology of triathlon related injury. For example, the extent to which race injuries are actually existing training related injuries that have been exacerbated by the demands of competition [5] is unknown.

Injury outcome.

In addition, the extent to which injury leads to modification or time off training/competition, as well as average treatment duration, is under-described. Running, cycling and swimming training appear to be increasingly less affected (i.e. in 17–21%, 26.2–75% and 42–78% of cases [12]), with most athletes rating their injuries as 'minor' (i.e. resulting in <7 days off) to 'moderate' (*i.e.* leading to 7–21 days off).

However, the information thus far available may only represent 'the tip of the iceberg.' Injuries that are not serious enough to be recorded within the time-span that the athlete is on the race site, or to be remembered over the recall periods that are used in many training studies, go un-reported. Many studies focus on injury to one or several specific anatomical locations, rather than report severity for all the sites that have been seen to be affected in triathletes. It is therefore difficult to assess which anatomical sites are usually most severely injured, or which types of injury have the worst consequences. Moreover, only a minority of the athletes who sustain injury whilst training consequently seek professional help [18, 30], and many triathletes may continue to train whilst injured [5, 24, 30, 31]. Anecdotal reports that athletes may react to injury that has been sustained in one discipline by increasing their training in one or more of the remaining triathlon disciplines over what they would otherwise have done are widespread- but the extent to which this phenomenon actually occurs is unreported. Although injuries may lead to cessation of work, or to permanent loss of function, in 15.3% and 4.2% of cases, respectively [22], the extent to which this is due to first time or to recurrent injury has not been determined. Recurrent injury appears to be a widespread issue [12].

Risk Factors

Minimal examination of what specific aspects of triathlon training may engender an increase in rehabilitation time, or to injury risk, has been carried out. Those data that do directly link specific risk factors to the occurrence of specific injuries are insufficiently detailed, and although various potential mechanisms of injury have been speculated upon [9, 10, 26-28], it is not yet possible to verify them. For example, drowning was the reported cause of death for each of the swim fatalities reported in a 2010 study [16], but drowning lacks the accurate methods of risk exposure that are needed to establish aetiology [32]. Most injuries are broadly attributed to 'a result of failure to adjust pace within safe limits for specific environmental conditions' [22–23] or to 'inadequate implementation of (race) safety precautions' [33]. The risk factors that have been directly investigated are detailed in the first author's 2010 review [12].

Intrinsic risk factors

Pre-event cardiovascular screening is not standard practice. Although the percentage of triathletes who are likely to have an inherent genetic susceptibility to cardiac problems is likely to be very low, most of those athletes who have died suddenly within the swim section of competition have been found on autopsy to possess an cardiac abnormality. Type 1 long QT syndrome [34], and to a lesser extent catecholaminergic polymorphic ventricular tachycardia, may be associated with malignant arrhythmias during swimming [35]. The one athlete reported by Harris et al. [16] who died within the cycle section of competition did so as a result of cervical injuries sustained from a fall. The degree to which said fall was due to insufficient technical ability on either or both the part of the athlete or his co-competitors is unknown.

Nevertheless, the strongest correlate with overuse injury in triathletes is previous injury occurrence [13, 17].

Table 1: Percent comparison of injury type in triathlon (updated from [11])

Site/Paper		Murphy 1987	O'Toole et al. 1987	Ireland & Micheli 1987	Massimino et al. 1988	Hiller et al. 1989	O'Toole et al. 1989	Jackson 1991	Migliorini 1991	Korkia et al. 1994	Egermann et al. 2003	Villavicencio et al. 2006	Gosling et al. 2007^{i}	Junge et al. 2009	Rimmer & Coniglione 2012	
															½IM	IM
Neck pain		–	–	–	–	–	–		–	–		48.3	–			
Contusions		–	–	4.7	–	–	–		–	–12	40.9$^{82\%B, 77\% Tr}$	–	3			
Abrasions		–	–	1.9	–	–	–		–			–	28 [21.3, 17.8]		2.4	6.5
Capsule/ligament/ joint		–	–	1.9	5.5	–	–		(4.2)^{R}	–3.4 –28	23.2	–				
Tendinitis/ tenosynovitis/ tendonitis	Foot	–	Tendonitis most common	All 6.9	15.3 tendonitis	–7	(≈60)	Mc	–	6.9	–	–	Sprain 4 [3.3, 8.9]			
	Ankle	–				(6)^{g}	–		–	–	–	–	–			
	Achilles	–				–	–		(6.5)^{R}	–	–	–	–			
	Supraspinatus	–				–	–		(3.2)^{S}	–	–	–	–		1.18	4.3
	Knee	–				(19)^{e,b}	(≈ 60)^{c}		(9.7)$^{Tr, b}$	–	–	–	–	(1/109)		
Shin splints		–	–	13.1	8.6	–	9						–			
Patellar chondromalacia		–	Maybe	4.7	3.7	–	–	–	(16.1)$^{Tr, 20\%B, 60\%R, 20\%B+R}$	–	–	–	–			
Muscle tendon injury		–	–	–	–	–	–		–	–	26.4$^{66\%r, 14\%b, 14\%s}$	–	–			
Muscle sprain		–	–	–	–	–	–		–	12.6		–	–			
Muscle strain		–	Yes	15	31.3	–	–	–	–6.5	25.3	–	–	10 [3.3, 8.9]			
Inflammatory pain syndrome	Iliotibial band syndrome	–	–	2.8		(10)^{b}	–	–	(19.3)$^{Tr, 33.3\%r, 33.3\%b, 33.3\%R+B}$	16.1	–	–	–			
	Patello-femoral	–	–	–	All 15.3	(14)^{b}	–	–	–	–	–	–	–			
	Plantar fasciitis	–	–	1.9	PF 8.0	–15	–	–	(6.5)^{R}	–	–	–	–			
Sesamoiditis		–	–	–	–	–	–	–	1^{R}	–	–	–	–			
Fracture		–		–	–	–	–		–	–	9.5$^{89\%Tr, 76\%B, 12\%R}$	–	–	(2/109)		2.2
Stress fracture	Foot and ankle	–	–	4.7^{d}	12.3	(10)^{M}	–	–	–	–	–	–	–			
	Lower leg	–	–	4.7	–	(7)^{M}	–	Yes	(13)^{R}	–	–	–	9			
	Hip/pelvis/spine	–	–	–	–	(<1)	–	–	–	–	–	–	–			

Site/Paper		Murphy 1987	O'Toole et al. 1987	Ireland & Micheli 1987	Massimino et al. 1988	Hiller et al. 1989	O'Toole et al. 1989	Jackson 1991	Migliorini 1991	Korkia et al. 1994	Egermann et al. 2003	Villavicencio et al. 2006	Gosling et al. 2007[i]	Junge et al. 2009	Rimmer & Coniglione 2012	
Low back pain	With sciatica	–	–	1.9	–	S±BP(15)	(72)[b]		–	–	–	21.8+s, 46.0–S[62%SR, 65%B]	–			
	Without sciatica	–	–	–	–		–		–	–	–		–			
	Not clear	–	–	–	–	–62	–		2 (6.5) [R]	–	–	–	–			
Sciatica ± back pain		–	–	12.1	–	–15	–		–			–	–			
Unknown		–	–	12.1	–	–	–		–	–	–	–	–			
Multiple		–	–	12.1	–	–	–		See paper	–	–	–	–			
Laceration		–	–	–	–	–	–		–	–		–	9 [11.5, 15.6]			
Temperature related problem	Non-severe	–	–	–	–	–	–		–	–		–	4		36.5	21.7
	Severe	2	–	–	–	–	–		–	–		–	1		1.2	
Envenomation		–	–	–	–	–	–		–	–		–	4 [0, 24.4]			
Blister		–	–	–	–	–43	–		–	4.5		–	15 [27.9, 4.4]		4.7	2.2
Costochondritis																2.2
Metatarsalgia																2.2
Other		8.6	JI/ bursitis	13.1	–	–	–	–	4.2 [R]	–		9	15 [8.2, 15.6]		25.9	30.4

* Values are expressed as % of cases unless they are enclosed in round () brackets, in which case they refer to % of athletes. Superscripts denote % of cases attributed to each discipline. See [11] for references.

Key: M male, F female; PF plantar fasciitis, S sciatica, LB Low back pain, BP back pain, NP neck pain, JI joint inflammation, SR sports related pain, Tr Training related; S, B, R, R + O attributed to swim, ('bike') Cycle, Run, Other, or Run + Other training, respectively.

[b] More common in females
[c] Approximate values from figure,
[d] Worst cases,
[e] (patella/ popliteal)
[f] Of the 3 most common injuries (i.e. ankle/foot, knee and lower leg) 35% involved a strain, 25% tendinitis & 22% a tear,
[g] More common in males,
[h] Details given in paper as to normal recovery times/ recurrence.
[i] dislocation and rupture of tendon or ligament.
[I] Values in square brackets are for 2 sprint races in the same dataset

Extrinsic risk factors

Exercise induced oxidative stress in an IM competitor was recently linked [36] to the occurrence of acute lung injury. Most of the literature relating to any potential relationship between specific injury types/sites, and or intensities of training and injury occurrence is, however, equivocal. This is unsurprising given its general lack of quality [10-12]. (Individual specific) inappropriate increases in training load and or stress, and higher intensities of run and cycle work, may, however, be more likely than other types of training to engender overuse injury occurrence. In OD athletes, negative links have been reported between overuse injury number and both percentage of total typical bike hill repetition race training time and number of sessions. In IM athletes, who may generally do lower volumes of intensive sessions than OD athletes, overuse injury number has been negatively correlated with total 'speed' run and 'speed bike' sessions [5–6]. It is not yet known what specific aspects of the differences in training that exist between these two groups of distance specialists have most influence on the slight differences in anatomical distribution of overuse injury that have been reported for them, or even whether such differences are widespread or were study-group specific.

Conclusion and recommendations for future research.

The size of the triathlon injury problem and its public health burden is relatively unknown. Most triathlon research addresses only Stages 1 and 2 (injury surveillance, aetiology and mechanism of injury) of Finch's 'Translating Research into Prevention Practice' (TRIPP) framework [11]. The first step that is required for the quality of the triathlon research literature to improve is to develop a consensus statement on the definition and reporting of both first-time and recurrent injury [37–39]. This should be used to establish comparative injury prevalence data for the various age-groups that exist, qualified by gender, athlete ability level and event distance specialisation. We recommend that an ongoing prospective longitudinal survey of injury at ITU sanctioned events then be established, so as to better identify those who are most at risk and what medical services are needed for their injuries. Determination of what changes to the rules, equipment and so on should consequently be implemented [40], is as yet a long way away, 'a situation that must be rectified if gains are to be made in reducing the burden of triathlon related injury.'[11]

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