

# Triathlon-related musculoskeletal injuries: a study on a Portuguese Triathlon Championship

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## SUMMARY

**BACKGROUND:** A triathlon consists of 3 modalities: swimming, cycling and running. Its higher training frequency, the environmental factors and extrinsic factors (technique and equipment) may lead to injuries. This study aimed to determine injury epidemiology in triathletes, as well as their type, location, mechanism of injury, and risk factors.

**METHODS:** The sample was constituted of 174 triathletes who participated in the Triathlon Club Portuguese Championship, being 131 (75.3%) male, aged 18 to 70 years old ( $36.09 \pm 11.03$ ). The measurement instrument was a questionnaire concerning the characterization of the population and aspects related to the modality and injuries.

**RESULTS:** One hundred and twenty (69%) athletes reported one injury since the beginning of their practice, and 95 (54.6%) had an injury in the previous year, with a total of 130 injuries. There were 2.39 injuries per 1,000 hours of triathlon training. The most common injuries were muscle contusion (31.5%) and inflammatory injuries (19.2%), located in the knee (22.3%) and the leg (18.5%). Overtraining (43.1%) was the mechanism that led to the highest occurrence of injuries. Fourteen (10.8%) injuries occurred during swimming, 23 (17.7%) during cycling, and 93 (71.5%) during running. No statistical significance was observed between the risk factors analyzed and the occurrence of injuries.

**CONCLUSIONS:** Triathlon practice is associated with a high prevalence of injuries, being contusions, knee, and overtraining the most common type, location, and mechanism of injury respectively. It is necessary to create injury prevention strategies, including specific training and suitable materials for use by athletes.

**KEYWORDS:** *Bicycling/injuries. Running/injuries. Swimming/injuries. Epidemiology. Prevalence. Wounds and Injuries.*

## INTRODUCTION

Triathlon includes swimming, cycling and running, which are performed consecutively in that order<sup>1</sup>. The most common formats for triathlon competitions are Short Distance (Sprint and Olympic) and Long Distance Triathlon (Half-Ironman and Ironman)<sup>2,3</sup>.

The number of triathletes and their performance level has increased. The Portuguese Federation of

Triathlon had 3,100 affiliated athletes and 115 associated clubs in 2018, demonstrating a huge growth of the sport in the country<sup>4</sup>.

Triathlon competitions are performed outdoors, thus several factors may predispose to injuries, such as the weather conditions of some competitions, hyperthermia, and other heat-related illnesses marked

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by collapse, followed by severe muscle cramping that impedes the athlete to continue the activity because of fatigue installation<sup>1</sup>. Besides that, a higher training frequency can also cause injuries. Triathletes train for more hours on average than single-sport athletes, averaging 10 to 14 hours, 8 to 10 times of training per week, which leads to a higher incidence of injury<sup>1,5</sup>.

The poorer technique, which leads to training errors, and inadequate equipment are considered to be the most common extrinsic causes of injuries<sup>1</sup>.

Overall, there is a limited number of investigations focusing on triathlon-related injuries, thus this study aimed to determine injury epidemiology in triathletes, as well as their type, location, mechanism of injury, and risk factors.

## METHODS

A cross-sectional study was performed to determine the epidemiology of musculoskeletal injuries in triathletes. The study was approved by the Piaget Institute's Research Unit RECI - Research in Education and Community Intervention.

### Population

The population was composed of triathletes who participated in the "Triathlon Club National Championship" (Olympic Triathlon format) held in the South of Portugal.

The sample size was determined using an estimated prevalence of injuries of 50%, a population of 321 triathletes who participated in this championship (259 male and 62 female), and assuming an error margin of 5% with a 95% confidence interval (CI). Using these assumptions, the minimum sample size was 173 triathletes.

The inclusion criteria involved triathletes of both sexes and any age, who had been training for at least six months, who trained at least 2 times per week, and who freely agreed to participate in the research and thus duly signed the informed consent form.

### Measurement instrument

The measurement instrument consisted of a structured questionnaire applied as an interview form by evaluators, in a single moment.

Since measurement instruments for assessing the presence of injuries in triathletes are unknown, this questionnaire was developed by the researchers and subsequently assessed by a panel of experts. In

addition, a pre-test was performed on 10 athletes to understand the difficulties of understanding and to measure the time of completion.

The questionnaire consisted of 2 parts: 1. questions about the socio-demographic characterization of the population and modality, and 2. specific questions about injuries related to triathlon practice.

The athletes who presented an injury in the previous 12 months were asked to continue to fill in the questionnaire regarding the injury characteristics. The interviewees were allowed to specify the characteristics of a maximum of three injuries (those considered most serious and/or needed more time for recovery) for all sports (swimming, cycling and running).

### Statistical analysis

Descriptive statistical data were obtained regarding all the variables in the study. Injury proportion (IP) and injury rate (IR) were calculated.

The influence of the included variables on the presence of injury in the previous 12 months was assessed using binary logistic regressions, based on the Enter methods, and crude odds ratios, and the corresponding confidence intervals (CI) were calculated. Statistical significance was set at 0.05.

Data analysis was performed with Statistical Package for Social Sciences (SPSS), version 24.0.

## RESULTS

The sample was constituted by 174 triathletes, being 131 (75.3%) male and 43 (24.7%) female athletes, ages between 18 and 70 years old (36.09±11.03).

Regarding the years of triathlon practice, most athletes practiced the sport between 3 and 5 years (56; 32.2%), 42 (24.2%) for 10 years or more, 31 (17.8%) between 6 and 7 years, 27 (15.5%) between 1 and 2 years, 16 (9.2%) between 8 and 9 years, and 2 (1.1%) between 6 to 11 months.

Most of the athletes trained every day (92;52.9%), 33 (19%) trained six times a week, 25 (14.4%) trained 5 times a week, 11 (6.3%) four times, 7 (4%) three times, 3 (1.7%) twice a week, and 3 (1.7%) trained only once a week. One-hundred-and-thirty (74.7%) athletes trained between 1 to 2 hours, 38 (21.9%) for 3 hours or more, and 6 (3.4%) up to 45 minutes per session.

One-hundred-and-fifty-six (89.7%) athletes reported performing some type of warm-up before training or competing, and 140 (80.5%) performed a cool-down.

One-Hundred-and-one (58%) athletes participated

in the Sprint modality with more frequency, 22 (12.6%) in Olympic, 48 (27.6%) in Half-Ironman, and only 3 (1.7%) in Ironman competition.

One-hundred-and-twenty (69%) athletes reported having suffered from some type of injury since the beginning of their triathlon practice, 29 (16.7%) were injured at the day of competition, 74 (42.5%) referred having injuries in a 6-month period.

Ninety-five (54.6%) athletes referred to having injuries in a 12-month period. Of these athletes (95; 100%), 63 (66.3%) reported one injury, 29 (30.5%) two injuries, 3 (3.2%) three injuries. Of those, 14 (10.8%) occurred during swimming, 23 (17.7%) during cycling, and 93 (71.5%) during running, totaling 130 injuries.

The average number of injuries per athlete (total number of injuries/total number of athletes) was 0.74, and the average of injuries per injured athlete (total number of injuries/total number of injured athletes) was 1.36.

An injury proportion of 0.55 (CI 95%: 0.05-0.09) injuries per athlete, per 12 months, was obtained. The injury rate was 2.39 injuries per 1,000 hours of triathlon training.

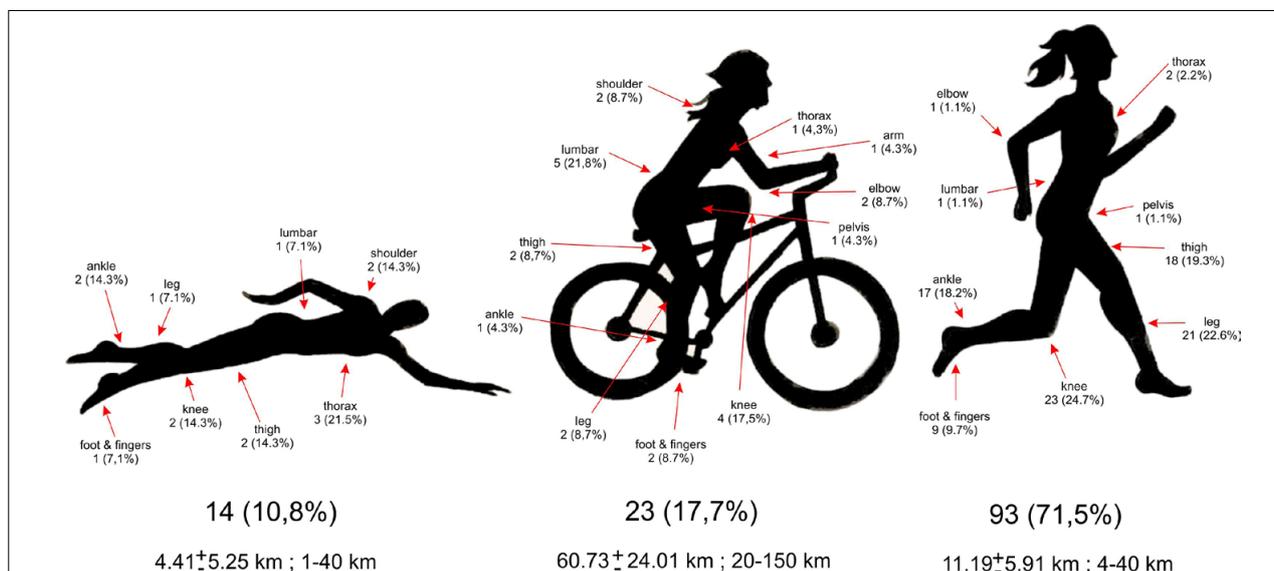
Figure 1 shows the location of injuries distributed by sport modality, as well as the frequency and percentage of injuries that occurred in each modality and the values of the average, standard deviation, minimum, and maximum of the training course of each modality.

Table 1 shows the frequency and percentage of types and the mechanism of injuries distributed by the sports category.

Table 2 shows the relationship, obtained from the application of the binary logistic regression model, between the occurrence of injury over the previous

**TABLE 1.** TYPE AND MECHANISM OF INJURIES

Variables	Sport			Total
Type of injury	Swim- ming	Cycling	Running	
Fracture	1 (20%)	4 (80%)	0	5 (3.8%)
Muscle contusion/ strain/rupture	6 (14.6%)	5 (12.2%)	30 (73.2%)	41 (31.5%)
Meniscal injury	0	0	6 (100%)	6 (4.6%)
Luxation	1 (14.3%)	1 (14.3%)	5 (71.4%)	7 (5.4%)
Sprain/Ligament injury	3 (15%)	1 (5%)	16 (80%)	20 (15.4%)
Tendinopathy	2 (9.5%)	2 (9.5%)	17 (81%)	21 (16.2%)
Inflammatory injury	1 (4%)	6 (24%)	18 (72%)	25 (19.2%)
Low back pain (symptomatology)	0	3 (75%)	1 (25%)	4 (3.1%)
Laceration	0	1 (100%)	0	1 (0.8%)
Mechanism of injury	Swim- ming	Cycling	Running	Total
Excess training	5 (8.9%)	8 (14.3%)	43 (76.8%)	56 (43.1%)
Temperature	1 (100%)	0	0	1 (0.8%)
Irregular floor	2 (10.5%)	1 (5.3%)	16 (84.2%)	19 (14.6%)
Bike (equipment)	-	2 (100%)	-	2 (1.5%)
Fall	0	5 (50%)	5 (50%)	10 (7.7%)
Impact with another athlete	1 (50%)	0	1 (50%)	2 (1.5%)
Overexertion	1 (6.3%)	3 (18.8%)	12 (74.9%)	16 (12.3%)
Does not know	4 (16.7%)	4 (16.7%)	16 (66.6%)	24 (18.5%)
Total	14 (10.8%)	23 (17.7%)	93 (71.5%)	130 (100%)



**FIGURE 1.** LOCATION OF INJURIES, TOTAL INJURIES AND TRAINING ROUTE BY SPORTS CATEGORY

**TABLE 2.** RELATIONSHIP BETWEEN THE EVENT OF PRESENCE OF INJURY AND VARIABLES ABOUT NON-MODIFIABLE SAMPLE FACTORS AND TRIATHLON PRACTICE CHARACTERISTICS

Variables	OddsRatiocrude (CI 95%); p-value
Gender (female*) male	1.2 (0.6-2.4); 0.602
Age group ( $\geq 40$ years old*) until 39 years old	1.3 (0.71-2.4); 0.392
Years of practice (until 5 years*) $> 5$ years	1.4 (0.8-2.5); 0.300
Weekly training (until 4 times*) $\geq 5$ times	1.0 (0.4-2.4); 0.964
Duration of training per session (until 2 hours*) $> 2$ hours	1.4 (0.7-2.8); 0.407
Coach supervision (no*) yes	1.7 (0.9-3.5); 0.116
Formats of triathlon competition (Short Distance*) Long Distance	1.3 (0.7-2.5); 0.471

\* Class reference

12-month period and the gender, age group, years of practice, weekly frequency and duration of the training, coach supervision, and formats of triathlon competition. No statistically significant probabilities were obtained in any of the variables analyzed.

## DISCUSSION

The main finding of this study was a higher prevalence of injuries in the triathlete sample analyzed. Attention is drawn to the fact that the sample of this study may involve amateur and professional triathletes since the only criterion for the power of this national competition is to be federated into a triathlon club. When comparing the similar period of data collection, our data of a 12-month period (55%) are close to those obtained by Korkia et al.<sup>6</sup> that showed a prevalence of 47% of injuries in the last year, in 155 British triathletes. The Galera et al.<sup>7</sup> study also revealed a high prevalence (52.4%) in 309 triathletes from a French league in the past season (2007-2008).

Egermann et al.<sup>8</sup> analyzed a lifetime prevalence of 656 triathletes who participated in Ironman Europe 200 and at least one injury was experienced by 74.8% of triathletes. Similar data were obtained by the Bertola et al.<sup>9</sup> study that evaluated 190 triathletes and revealed 76% of injured athletes during training. Our data revealed a value of 69% during the whole triathlon practice.

The data of injury incidence is difficult to compare across studies because of methodology, design, and particularly the injury definition are different. Our results showed an injury rate of 2.39 injuries per 1,000 hours of triathlon training. Korkia et al.<sup>6</sup> revealed a value of 5.4 injuries per 1,000 hours of triathlon

training. Andersen et al.<sup>10</sup> showed an incidence of illness of 5.3/1,000 athlete-days and Zwingerberger et al.<sup>11</sup> an incidence of 0.69 (retrospective) and 1.39 (prospective) per 1,000 training hours.

The most common type of injury observed in our study was muscle contusion/strain/rupture (31.5%), followed by inflammatory injury (19.2%), tendinopathy (16.2%), and sprain/ligament injury (15.4%). Bertola et al.<sup>9</sup> revealed similar data, showing a higher percentage of injuries classified by muscle injuries. The Galera et al.<sup>7</sup> study reported 44.5% of tendinopathies and 35% of muscle injuries. Andersen et al.<sup>10</sup> reported that the most prevalent types of acute injuries were contusions, fractures, and sprains. The classifications of injury types are different between studies, making it difficult to compare them.

Acute injuries are relatively rare in triathlon, and muscle contusion can occur due to a large number of athletes very close to crossing the buoys during the sea race, the falls during cycling, and to mounting and dismounting the bicycle at the start and finish of the cycling leg. Lower limb muscle strains may occur during water or beach exit, or during running in transition area<sup>12</sup>.

Chronic injuries are the most common and may be caused by longer training hours, poor technique or equipment, a lack of running experience, and poor muscle elasticity<sup>5,12</sup>. Besides that, the lack of time to regain the neuromuscular and elastic efficiency indispensable for proper running style can be factors for chronic injuries. The change from concentric to eccentric contractions and the unloaded cycling phase to pass to the transition for the running cycle is a delicate phase that makes athletes more prone to knee pain during the first kilometers of running (the change between muscle activation of concentric contractions in cycling to stretch-shortening in running)<sup>12,13</sup>.

Regarding the site of injury, our data showed a higher prevalence on the knee (22.3%), followed by the leg (18.5%), thigh (16.9%), and ankle (15.4%), i.e., the lower limbs. The lower limbs are requested in the three triathlon modalities and are increasingly required because of the order of the sports categories (swimming, cycling, and running), which may lead more rapidly to high levels of fatigue in these anatomical parts than in others.

Many knee injuries from running are the same as those observed while cycling and include patellofemoral stress syndrome, iliotibial band, and patellar tendinosis<sup>5</sup>. Injuries on the knee may result from impact,

positioning on the bike, and errors in the execution of movements during the race. The cycle-run transition, sudden increases in training distance or intensity, the high impact during the running style, the hill running, and running on steeply cambered roads maybe increase the stress on the iliotibial band (iliotibial band friction syndrome during long-distance running). Besides that, the combination of an anatomical variant of the lower extremities with improper use of a racing bicycle, the use of an inadequate frame, incorrect cleat pedal alignments, the excessive height of the saddle, or too far-back saddles can stress the tensor fasciae latae and iliotibial band muscle<sup>12</sup>.

Lower-leg injury can result from the lower leg's shock-absorbing forces progressing from the foot to the knee. Thigh pain can result from overuse injuries of the hamstrings<sup>5</sup>.

Data from the Galera et al.<sup>7</sup> study revealed that ankle (20.6%), knee (18.3%), and thigh (15%) were the anatomical sites that presented the most injuries. The most prevalent sites of overuse injuries in the Andersen et al.<sup>10</sup> study were the knee (25%) and lower leg (23%). The Korkia et al.<sup>6</sup> study reported that 38% of all injuries affected the ankle/foot, 32% the knee, and 22% the lower leg.

Our study revealed that the main mechanism of injury reported by athletes was excess training (43.1%), and some athletes (14.6%) told that the irregular floor was the factor that caused the injury. The same was observed in the Korkia et al.<sup>6</sup> study that revealed that overuse was the main cause of injury in 41% of cases, and in the Zwingenberger et al.<sup>11</sup> study, overuse was responsible for 29% of injuries.

To reduce the number of overuse injuries, it is important to develop techniques in the three disciplines of triathlon, which includes training at an optimal frequency and load interspersed with an adequate rest phase and correction of biomechanics technique<sup>12</sup>. Besides that, excessive downhill running must be avoided, varying the direction, track, and changing the mechanics of one's running stride. All these considerations may decrease the applied load to the lower extremities<sup>1,12</sup>.

Running was the sports category responsible for the highest percentage of injuries in our study (71.5%), followed by cycling (17.7%) and swimming (10.8%). The same was observed in other studies<sup>6,7,9,11</sup>. The running stage of a triathlon is considered to be the most important leg of the race. Swimming has a significantly lower injury rate than the other two

disciplines in a triathlon, probably because in this triathlete sample the amount of time spent swimming was significantly smaller than the time spent cycling or running, and the triathletes usually devote less time to swimming training than to the other disciplines.

Training errors, anatomical factors, training surfaces, transition, shoes, and training equipment can be responsible for running injuries<sup>12</sup>. The running phase is the category that finishes the triathlon race, when the triathlete has already been subjected to physical and psychological stress and fatigue in the preceding stages<sup>1,13,14</sup>. Further, to start the running race, the triathlete has to prepare their "running legs" for the impact after a period of lower-extremity exertion suspended in water and then fixed on the radius of bicycle pedals<sup>13</sup>.

This study presents some limitations, including the application of a questionnaire based on self-reporting that depended on the participant's memory. The difficulty involved with the self-reporting of injuries by triathletes is acknowledged. The risk of recall bias is high for retrospective information. Besides that, a self-reporting system by lay-persons can lead to misinformation, which makes the reliability of their injury classification questionable. The ideal would be for the injuries to be evaluated by health professionals.

It is suggested that further studies are carried out to verify whether triathletes perform specific exercises to avoid injuries and which training programs are carried out to develop their strength, flexibility, and muscle power valences.

## CONCLUSIONS

Our data demonstrated a high prevalence of injuries in triathletes in this analyzed sample. The most prevalent type of injuries included muscle injuries (contusion/strain/rupture), and the most affected body area were lower limbs (knee, leg and thigh). Overuse was the main mechanism of injuries.

It is important to understand the type, site, and mechanisms of injuries to develop appropriate injury prevention programs.

## Conflict of interest

None

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### Author's Contribution

Beatriz Minghelli: Elaboration of the article; statistical analysis; literature review; article writing; formulation of methodological questions.

Catarian Jesus, Ilvanda Martins and Joana Jesus: Data collection; assistance in statistical analysis, and bibliographic review

## RESUMO

**INTRODUÇÃO:** O triatlo é constituído por três modalidades: natação, ciclismo e corrida. Uma maior frequência de treinamento, fatores ambientais e fatores extrínsecos (técnica e equipamento) podem levar a lesões. O objetivo deste estudo foi determinar a epidemiologia de lesões em triatletas, bem como seu tipo, localização, mecanismo de lesão e fatores de risco.

**MÉTODOS:** A amostra foi constituída por 174 triatletas que participaram do Campeonato Português de Clubes de Triatlo, sendo 131 (75,3%) do sexo masculino, com idades entre 18 e 70 anos ( $36,09 \pm 11,03$ ). O instrumento de medida foi um questionário referente à caracterização da população e aspectos relacionados à modalidade e lesões.

**RESULTADOS:** Cento e vinte (69%) atletas referiram ter tido uma lesão desde que iniciaram a sua prática e 95 (54,6%) sofreram uma lesão no último ano, totalizando 130 lesões. Verificaram-se 2,39 lesões por 1.000 horas de treinamento em triatlo. As lesões mais comuns incluíram contusão muscular (31,5%) e lesões inflamatórias (19,2%), localizadas no joelho (22,3%) e na perna (18,5%). O excesso de treinamento (43,1%) foi o mecanismo que levou à maior ocorrência de lesões. Quatorze (10,8%) lesões ocorreram durante a prática de natação, 23 (17,7%) durante o ciclismo e 93 (71,5%) durante a corrida. Não foi observada significância estatística entre os fatores de risco analisados com a ocorrência de lesões.

**CONCLUSÕES:** A prática de triatlo esteve associada a uma alta prevalência de lesões, sendo a contusão, o joelho e o excesso de treinamento, o tipo, a localização e o mecanismo mais comuns de lesão. É necessário criar estratégias de prevenção de lesões, incluindo treinamento específico e adequação do material utilizado pelo atleta.

**PALAVRAS-CHAVE:** Ciclismo/lesões. Corrida/lesões. Natação/lesões. Epidemiologia. Prevalência. Ferimentos e lesões.

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