MAWLICHANÓW, Maciej, PNIAK, Michał, SIERADZKA, Aleksandra, RÓŻYCKI, Adrian, MIKLIS, Paweł, CIESIELSKA, Aleksandra, SZEREJ, Krzysztof, KOT, Alicja, WOJTCZAK, Marta and MYŚLIWIEC, Natalia. Injuries in triathlon: a review of the literature. Quality in Sport. 2024;36:56869. eISSN 2450-3118.
https://doi.org/10.12775/QS.2024.36.56869
https://apcz.umk.pl/QS/article/view/56869

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 10.12.2024. Revised: 24.12.2024. Accepted: 24.12.2024. Published: 24.12.2024.

Injuries in triathlon: a review of the literature

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Abstract:
Triathlon is a sport consisting of three consecutive disciplines. The popularity of this sport in the world is growing every year and in 2023 as many as 3.2 million Americans declared that they train triathlon[2]. A literature review was conducted adopting the criteria of works no older than 2003, concerning injuries in triathletes, by entering medical terms such as contusio in triathlon, triathlon injuries and health in triathlon in search engines. Studies were grouped according to the criteria adopted in them into seven sections: comparison of studies by country, epidemiology per thousand hours of training, type of injury depending on the given discipline,

injury risk factors, protective factors, conclusions from studies as a recommendation for competition organizers. Survey studies and official statistics of competition organizers were analyzed. It was shown that the most frequently used coefficient was the number of injuries per thousand hours of training, the authors presented lack of agreement on the discipline during which these injuries occur, and the lack of individual characteristics of a given athlete that could expose them to injuries. However, it was indicated that the greater the experience, the greater the susceptibility to injuries. Due to the lack of a single definition of injury and the small number of standardized studies, it is currently impossible to clearly assess which injuries are the most common in athletes around the world.

Key words: Contusio in triathlon, triathlon injuries, health in triathlon

Introduction:
Triathlon is a sport consisting of three consecutive disciplines: swimming, cycling, running. This multidisciplinary physical activity is becoming increasingly popular around the world. In 2014, 2.3 million people worldwide tried their hand at this discipline[1], while in 2023 as many as 3.2 million Americans declared that they train triathlon[2]. There are short, medium and long distance triathlons. Short distance is most often practiced in the form of the Olympic distance: 1.5 km swimming, 40 km cycling and 10 km running. Medium distance is 1.9 km, 90 km, 21.1 km and long distance 3.8 km, 180 km, 42.2 running. There are also varieties of ultra triathlon, which describe a multiple of the long distance triathlon described above, commonly called ironman and multiple ironman.

Search methods and strategies
The authors searched for materials on the above topic in the Internet browsers Pubmed, Google scholar, research gate. The keywords that were given to Internet medical sources were: contusio in triathlon, triathlon injuries, health in triathlon.
When analyzing the retrieved articles, exclusion criteria were adopted, such as: case reports, data on mortality of triathletes, articles older than 2003, so that the review would be a summary of data from the last two decades.

Objectives of the study
The aim of the study is to determine the current state of knowledge about injuries in triathletes, with particular emphasis on athletes practicing middle and long-distance triathlon.

Triathlon in Portugal versus Triathlon in Germany
According to Triathlon-related musculoskeletal injuries: a study on a Portuguese Triathlon Championship
after analyzing a survey of 174 athletes from a Portuguese triathlon club aged 18-70, where 75% were men, 130 people responded about experiencing various types of injuries since the

beginning of their amateur career. 31.5% + 19.2% indicated muscle injury or inflammatory changes, of which 1/5 concerned injuries in the knee joints, and the other 1/5 generally lower limbs. The respondents unanimously, as many as 71.5%, answered that the injury was caused by running, while only 17.7% answered that it occurred during swimming[3].

The authors of the "Analysis of injuries in long-distance triathletes" drew different conclusions from the questionnaires sent to German triathletes, because after analyzing 656 questionnaires, it was indicated that as many as 54.8% of respondents indicated that they had sustained an injury while cycling. A total of 33.1% indicated injuries to muscles and tendons, 11.9% bone fractures. A certain relationship was observed between the type of injury and the age of the athlete, the level of training and the training volume in hours. Older triathletes suffered fractures more often than more advanced ones, who most often reported abrasions. The summary indicated that more hours spent training led to more muscle injuries, older age to more fractures. Gender, use of professional trainer services or medical assistance were irrelevant[4].

Epidemiology of triathlete injuries per 1000 hours of training

Many studies based on questionnaires draw attention to the presence of injuries without specifying the specific characteristics of given groups of people and the time that the respondents devote to training. Triathlon enthusiasts outdo each other in the number of hours spent in the activity sports and it was easy to determine the rate of injury occurrence per 1000 hours of activity. Rates from several studies, different authors and places in the world were presented. The first study involved 49 amateur athletes who answered questions from the perspective of 1 year. The rate of acute injuries was 0.97 injuries per 1000 hours of training (36 cases) and 1.02 injuries per 1000 hours of competition (5 cases). Most moderate and severe acute injuries involved the knee joint, shoulder area, sternum or ribs. The dominant types of acute injuries were contusions, fractures and sprains. The rate of occurrence per unit of time was 5.3/1000 days [5]. The conclusion was the theory that most injuries in long-distance triathlon resulted from overloads, which occurred much more often than acute injuries, and the most common location was again the knee joint. Other authors indicate that 2.5 injuries/1000 hours of the preparation period and 4.6/1000 hours of the competition period were the conclusions of their study [6]. In triathlon training for extreme competitions held on the full ironman distance in Norway "NORSEMAN" the result is lower, because it is 0.97/1000 hours [7]. This is probably due to a different type of specific preparation for such competitions due to the need to devote more time to strength training, which has a beneficial effect on the effort in the mountains. Interesting and very systematic observations were provided by the authors of the annual surveys, which made up the conclusions of the organizers of Ironman Italy. Over the next three years, 2017, 2018, and 2019, a total of 10,653 participants in IM 70.3 and IM 140.6 competitions were assessed, determining that the rate of injury was 4/1000 hours for the long distance and 1.75/1000 hours for the shorter distance IM 70.3. The same conclusion indicated that women were more likely to be victims [8]. However, when a closer analysis was made of athletes from Australia who took part in the tournament in 2006 and 2007, attention was drawn to a much higher rate of 20.1/1000 competitions [9].

Determining the number of injuries per training hours has become a point of reference and in most cases the location of the sports event is irrelevant.

Type of injury and type of sport

"Epidemiology of Musculoskeletal Injuries in Adult Athletes: A Scoping Review" shows that

the mechanics of movement seem to be an important factor in potential abnormalities and health problems of athletes of all sports. There are publications looking for an ideal "anti-injury" pattern in the form of determining which movements in specific sports disciplines lead to overload or damage to anatomical structures in the human body. A group of researchers edited by Gimgliano conducted a study of published works for 2021, analyzing the occurrence of injuries. Triathletes and weightlifters were most exposed to injuries in the body, archers in the upper limbs and marathon runners in the lower limbs. Everyone unanimously emphasizes that there is currently too little information about injuries in sports in the reputable press [10]. Analyzing subsequent studies, it is not possible to clearly determine during which sports activity damage to muscle structures or the musculoskeletal system occurs. There are some reports that due to the greatest importance of cycling in triathlon, the risk of injury can be expected during this training. Not all authors agree on this. Analyzing the order and invasiveness of sports in triathlon, swimming can be considered the least injury-prone [11]. It is usually treated as rehabilitation and return to full health, weight-bearing activities, recreation, and according to research, this discipline, in addition to its beneficial effect on the human body, has the lowest injury rate. Most often, triathletes cover the water course using freestyle, the so called crawl. This is the most popular style due to the possibility of effectively observing competitors and the surroundings, effectively maintaining the course in open water bodies, and due to the highest speed of freezing of the route. The authors who analyzed the swimming technique of this style indicated that the only injury mechanism may result from overload caused by lifting the arm above the head and causing numerous micro-injuries leading to inflammation, for example inflammation of the rotator cuff tendon [12]. The treatment of this condition is individualized and depending on the patient's age and etiology, surgical or conservative methods can be used without the use of a scalpel. Scientists publishing "Triathlon: running injuries" emphasize that triathlon injuries are most often caused by running [13], while the authors of "Triathlon considerations" have a different opinion, specifying that these injuries are more common in people training triathlon (15-91%), including running, than running as a separate discipline. They also indicate that the most common location of injuries is the lower limbs, without a clear indication of whether injuries occur while cycling or running by a triathlete [14].

It is undoubtedly that the body of an athlete in such an engaging sport is subjected to enormous effort and load. Thanks to this, the human body and its sports disposition, results constantly change for the better. Injuries classified by the athlete himself as injuries may, however, be caused by the cumulative effect of training in these several disciplines. Analyzing the history of each competitor, only a few of them professionally or semi-professionally practiced these sports as children as regularly as in adulthood. Analyzing biomechanics, environment and nutrition, these three features can most likely be blamed for the subject of these considerations [15].

Exhausting cycling training is one of the most common in the life of a triathlete. The mechanics of movement, thousands of repetitions activating almost all muscles in the human body can also lead to overload. They are defined as the most common as patellar tendinopathies and iliotibial band strains.[12][16]

In the retrospective and prospective analysis in the Zwingenberger study, injuries were divided according to their location in the body. The majority of injuries in participants occurred while running (50%), followed by cycling (43%) and swimming (7%). 54% retrospective and 22% prospective were minor injuries such as contusions and abrasions, while 38% (retrospective) and 46% (prospective) were ligament injuries and 7% (retrospective) and 32% (prospective) were muscle and tendon injuries, while 1% (retrospective) and 0% (prospective) were fractures. It was determined that in this group the incidence of injury related to 1000 hours of training was 0.69 (retrospective) and 1.39 (prospective) during training. The main risk factor was

indicated as participation in triathlon competitions[5]. Referring to another study entitled "High prevalence of overuse injury among iron-distance triathletes", the authors analyzed the ailments of participants in an extreme triathlon competition called "Norseman" and indicated that 56% reported ailments. The location of injuries is the knee joint (25%), lower leg (23%) and lumbar spine (23%)[7]. Running - as rhythmic and jumping shifting of the lower limbs above the individual barrier created by the body can lead to dysfunction. The most common detailed causes of these injuries are indicated as knee joint injuries, with particular attention paid to the final running stage of the competition, because that is when they most often occur[12]. An additional condition mentioned is lumbar spine injuries[16].

In search of a clear cause, another factor was implemented and the study divided the people into professional and non-professional athletes. In people aged an average of 35, it was responsible for 37-91% of overload ailments, and only 24-25% for acute injuries. Professional athletes presented significantly fewer, 37%, overload changes, but it was emphasized that acute injuries occur much more often in amateurs of these three sports. However, it is emphasized that there is a lack of professional literature and standardization of studies with a high degree of reliability [16].

By subjecting even greater screening, researchers tried to determine which movements, activities or behaviors are risky. They took into account football players, a team sport with direct competition on the stadium, beach volleyball players in two-person teams on both sides of a net placed on the sand, and triathletes. The only conclusion they managed to draw was the fact that both adults and children were exposed to injuries with a frequency of 2/1000 hours of play, and the most common location of injury was the knee joint [17].

Risk factors of injuries

Another survey discussed training and ailments reported in the surveys by triathlon athletes. A prospective and retrospective study of 131 individuals was performed and the presence of injuries in the past of a given individual was analyzed. Half of the study participants had suffered an injury within six months before the summer competition season, with an injury risk rate of 2.5 per 1000 training hours. More than one third had suffered an injury within 2.5 months before the competition, with an injury risk rate of 4.6 per 1000 training hours. Anatomical overload was demonstrated by 68% of the participants in the pre-competition period and 78% during the competition period. After a thorough analysis, it was concluded that more experienced competitors and a history of previous injuries only had individual associations with the frequency. The more years of experience, the greater the risk predictor before the season, while a previous medical history and high training volume increased the risk of injury during the competition season [18]. An attempt at an even more detailed analysis aimed at determining the actual risk factors for injuries took into accountweight, gender, age, morphological features, height, body mass and body mass indices. It has been proven that they do not affect the risk and it is not possible to determine one factor [19]. According to the authors of "Training on a knife's edge how to balance triathlon training to prevent overuse injuries", the most important factor is mileage, i.e. the number of kilometers covered during training, history of previous injuries, lack of attention to warm-up and so-called pre-training cool-down and the experience of the athlete. The higher the number, the greater the risk of the disease [20].

Data[9]:
AUSTRALIA TRIATHLON SEASON 2006-2007
235 cases of medical assistance = 2.3% of all competitors

20.1h/1000h of racing
38.4% were injuries during running
14.3% were injuries during cycling

Protective factors

Developing a model describing injury statistics provides information to doctors, physiotherapists, rehabilitators and competitors themselves about their status quo.

Difficulties in conducting research lead to the creation of other criteria for surveys and subjects of articles. The material was subjected to statistics in order to develop protective factors against injuries in triathlon. However, difficulties were encountered in the form of a lack of proper definition, consistency, standards for research and surveys. The result is conclusions that can be applied in a very general way. It was theorized that the inclusion of strength training can reduce the rate of injuries [21]. Other authors are unable to clearly state whether there are protective factors and issue recommendations due to the insufficient number of standardized and qualitative studies at a high level. The scientific gap in knowledge about triathletes is too large [22].

Triathlete triad

Definitions are created for the purposes of defining certain phenomena in medicine and science. The presence of characteristic recurring disease symptoms in humans allows for the description of a given disease entity. Using the questionnaire "The leaf questrionaire", a study was conducted among women to define a given disease entity called the triathlete triad. The set of symptoms induced by practicing this discipline allows for consideration of whether the set of symptoms can be classified as an injury or whether the set can lead to an injury. A decrease in energy availability, a nutritional disorder, and a bone health disorder make up the triad of female athletes. The test shows 78% sensitivity and 90% specificity and helps determine the cause, among others, oligomenorrhoea (hypothalamic amenorrhea) and sports training [23].

Injury study as a recommendation for triathlon competition organizers

Conducting scientific research in search of risk factors, protective factors and injury indicators, the collected material allows for appropriate preparation and medical support provided by the organizers of sports competitions. By analyzing competitions in the USA[24], Italy and Australia, scientists help to determine the direction of medical needs during a given event. One of the studies in the conclusions contains recommendations regarding medical support and assistance in triathlon.

The cases of 10,653 participants in the Ironman Italy competition in 2017, 2018, 2019 were analyzed in detail, indicating the level of people requiring medical care at 3.3%. 68% of patients presented general exhaustion or dehydration, and 10.2% were injuries. 8.1% required hospitalization. The Maven algorithm was used to calculate the need for the necessary medical equipment to safely conduct the competition[8]. Additional conclusions were shared by the team edited by Terry Rimmer, providing statistics covering the percentage of injuries depending on the duration of the competition. 72% of injuries occur in the 6th and 7th hour of effort in the IM 70.3 distance, and after the 14th hour during the IM 140.6 competition. The recommendation of this team is to increase the number of personnel by 20% in the later stages

to 3 doctors and 9 nurses so that the competition can be safely conducted and its participants can be helped in the event of a crisis.

Conclusions

The above review of the literature shows that there are large gaps in knowledge about the occurrence of injuries, a lack of quality research, standardization of coefficients and a clear answer to the question of how to avoid injuries in triathlon.

Available studies are based on surveys completed by competitors online, so there is a high risk of false conclusions.

There is inability to determine protective factors.

The greater the experience, the greater the risk of injury.

Discussion

When analyzing a topic as complex as injuries in triathlon, the authors encounter a number of different types of ways to seek an answer to the question of whether triathlon is safe for health. The work only summarizes the negative feelings of athletes, and does not analyze the positive effects of practicing sports and leading a healthy lifestyle, starting with sleep hygiene, proper nutrition, and performing preventive tests. According to the authors, only after referring to the relationship of how many internal diseases can probably be avoided by being a triathlete, each patient and doctor will be able to assess whether in their case this demanding sport will bring more positive effects than the risk of injury.

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Visualization: M.P., P.M., M.M., A.C., A.S., K.S., Z.C.P., A.K., M.W., N.M., A.R. Supervision: M.P., P.M., M.M., A.C., A.S., K.S., Z.C.P., A.K., M.W., N.M., A.R. Project Administration: M.P., M.W., M.M.
Funding: -

All authors have reviewed and consented to the publication of the final version of the manuscript.
Conflict of Interest Statement: The authors declare no conflicts of interest.
Funding Statement: This study did not receive any specific funding.
Informed Consent Statement: Not applicable.
Ethics Committee Statement: Not applicable.