

Review Article

Prevalence and causes of non-traumatic knee injuries in cyclists: a systematic review

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ABSTRACT: Cycling has been a part of the modern Olympic Games since its inception in 1896 (1). In addition to professional sports practice, the popularity of using bicycles has been increasing for various reasons, including not only its beneficial effects on physical exercise but also as a cheaper and more environmentally friendly means of transport

Key words:

INTRODUCTION

Cycling has been a part of the modern Olympic Games since its inception in 1896 (1). In addition to professional sports practice, the popularity of using bicycles has been increasing for various reasons, including not only its beneficial effects on physical exercise but also as a cheaper and more environmentally friendly means of transport (2). Several cities in Europe, Asia and America has encouraged the use of bicycles for several purposes and have even provided sharing systems to further popularize cycling in the urban environment (3).

The overall benefits of this popular exercise are well established in the literature and widespread in modern society, however, it must be weighed against the risk of traumatic and non-traumatic injuries that excessive or inappropriate practice can cause. Because of this large increase of cyclists, lesions caused by this activity are currently considered as a real public health problem (4). With regard to the total number of injuries in sports, cycling has the largest absolute number of injuries each year (614,594) followed by basketball (597,224) and football (372,380) (5). The causes and prevention of traumatic injuries have been well documented, and therefore, intervention strategies have been successful in reducing these injuries (6). Non-traumatic injuries in cycling are not directly related to trauma, but to overload exercise associated with inadequate techniques and bike settings (6,7).

The body segments that are more susceptible to non-traumatic injuries in cycling are: knee, leg, hand/wrist, neck/shoulders, back and perineum (8). Because of its anatomical location, the knee receives and delivers a tremendous amount of power in almost all types of physical activity. Some of the highest compression and tension loads are transmitted over the patellofemoral joint (9). Investigations have unanimously

concluded that knee injuries are prevalent among athletes, affecting between 24% and 62% of study participants (1).

Knowing the most common injuries in sports, the risk factors and other associated factors can assist the work of professionals in the process of prevention, diagnosis and treatment of these diseases.

OBJECTIVE

To determine the prevalence and the main non-traumatic knee injuries in cyclists;

To investigate potential collaborator factors of knee injuries in cyclists.

METHODOLOGY

Study design

Systematic review of the literature from 2006 until October 2016, based on criteria Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), of publications on the prevalence and causes of non-traumatic knee injuries in cyclists.

Inclusion criteria

The following inclusion criteria for analysis were used: (1) studies published in English, Portuguese and Spanish languages, (2) involvement of only human beings, (3) application only in athletes with non-traumatic knee injuries, (4) athletes with regular practice of cycling, (5) previously healthy cyclists.

Exclusion criteria

It was used as exclusion criteria: (1) studies based on secondary data (reviews), case reports, letters and editorials, (2) participants under 18, (3) athletes with traumatic injuries only (4) athletes with congenital malformations.

Information sources

An electronic search was conducted on MEDLINE, Scielo, LILACS and IBECS.

Systematic review

In the databases PubMed, LILACS, Scielo, IBECS authors used the terms "injury", "injuries", "contusion", "knee", "cycling" and "bicycling." The search strategy was detailed in the table below.

TABLE 1. Detailing the systematic search

Search terms		Syntax	Number of articles
Injuries	#1	“injury” OR “injuries” OR “contusion”	757,246
Knee	#2	“knee”	153,068
Cycling	#3	“cycling” OR “bicycling”	44,936
Combination of terms	#4	#1 AND #2 AND #3	109

Study selection

From the titles of the articles found, authors excluded those who were clearly not related to the subject, and the abstracts of the remaining studies were read independently by two reviewers. After this stage, articles that met the inclusion criteria were selected for full reading. Relevant publications were also searched manually in reference sessions of articles that completed the inclusion criteria.

Extraction of outcome measures

Two researchers performed the extraction of data manually and independently. In case of doubt, the solution was made by consensus among authors.

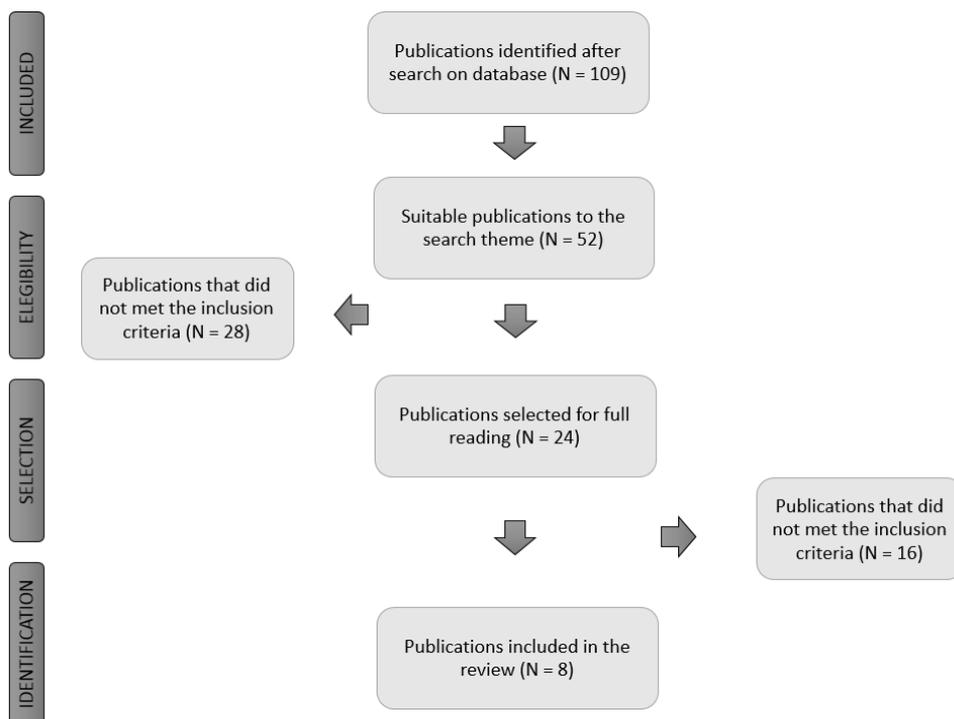
Collected data

The data collected were: country of origin, characteristics of the study sample, evaluation method, significant results, gender, age and experience level.

RESULTS

Study selection

Initially, 109 publications were identified in databases: 100 in PubMed, 4 in LILACS, 2 in IBECS and 3 in SciELO, among which 52 were considered relevant to the research theme. After reading the abstracts, 24 publications were selected. After full reading of the text, 8 were selected because they met the search criteria and therefore were included for final analysis (Flowchart 1).



Author / year	Study design	Study population	Evaluation methods	Prevalence of injuries	Main causes of injuries
Clarsen et al, 2010(1)	Descriptive epidemiological study	N = 109, all cyclists of 7 professional teams	Interview held at the headquarters of the teams	A total of 94 injuries were recorded, 23% in the knee. The patellofemoral syndrome represented 36% of cases.	The cause mentioned as provocative of injuries was the overload exercise (overuse).
N. de Bernardo et al, 2012(10)	Retrospective cohort (4 years)	N = 51, all professional athletes.	Interview with all athletes held by two of the co-authors.	Of the 53 non-traumatic injuries, 17 were in the knee. The Iliotibial Band Syndrome represented 8 (14.4%) of the injuries.	Injuries due to exercise overload were 51.5% of the reported injuries, configured as the main triggering of injuries.
Galera et al, 2011(11)	Cross-sectional study	N = 309, all professional triathletes in the French League.	A questionnaire was sent by email to athletes.	Of the 293 injuries, 201 were in the lower limbs, and 18.3% in the knee.	Large volume of practice was directly proportional to injury. Little heating, stretching and hydration were also analyzed variables.
Gosling et al, 2010(12)	Prospective cohort (2 years)	N = 217, all triathlon athletes in Australia in seasons 2006/2007.	Form filled out by athletes seeking medical care.	Of the 188 injuries in the lower limbs, 18.4% were during cycling and 24.1% were in the knee.	Excessive strain was considered the main cause of non-traumatic knee injuries among athletes.
Haapasalo et al, 2007(4)	Prospective cohort (1 year)	N = 3,129, random Finnish citizens between 15 and 74 years old	Telephone contacts to complete a questionnaire applied by the Finnish Central Statistical Office.	Of the 321 injuries in the knee, 28 were among cyclists. 84% of injuries occurred during recreation or competition.	In both genders the most common type of injury was overuse (40% of all injuries in men, 45% in women).
Zwinger et al, 2014(13)	Prospective cohort (1 year)	N = 212, triathletes registered in the "Moritzburg Schloss Triathlon", Germany, in June 2009	Retrospective online survey and prospective study for 12 months	Cycling was the sport practiced during 43% of injuries. The knee was the involved part in 20% and 33.33% in retro and prospective studies, respectively.	Cycling recorded the most serious injuries. The main risk factor for injury in triathlon was participating in a competitive event.
Kammerlander et al, 2012(14)	Cross-sectional study	N = 2635, aged over 65	Review of medical records of a trauma center in Tyrol, from December 1994 to February 2008.	Cycling corresponded to 30.2% of the injuries. Meniscus injuries and knee ligament represented 6.9% of injuries in that sport.	Half of the injuries occurred in the age group of 65-69 years. Cycling, as well as skiing, recorded the most serious injuries.
Bertola et al, 2014(15)	Cross-sectional study	N = 190, triathletes during training and competition in Caioba 2011 triathlon.	Application of a questionnaire identifying the profile of athletes and the types and locations of injuries	Of the 145 injuries, 16% were related to cycling. The knee was affected in 18% of injuries in both men and women.	68% of athletes reported that their injuries occurred during cold weather. 56% said that injuries occurred in the same place; and 70% of athletes indicate overuse as the main triggering factor of injury.

TABLE 2. Author and year; study design, study population, evaluation methods, prevalence of non-traumatic knee injuries

Country of origin

Studies were conducted in Norway (1), Spain (10), France (11), Australia (12), Finland (4), Germany (13) Austria (14) and Brazil (15).

Characteristics of the study sample

The total sample in the eight articles included 6,852 athletes, aged from 20 to 90 years.

Significant results

In the study of Clarsen et al (1), of the 94 lesions referred to in the last 12 months, 23% were in the knee and 45% behind the lumbar region. However, among the 23 injuries that resulted in

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time away from the sport, especially in more than eight days, knee injuries accounted for 57% of them. Among the lesions, the Patellofemoral Syndrome accounted for 36% of cases. Overuse was considered the main triggering factor of injury.

In N. de Bernardo et al (10), 51 professional athletes were interviewed. Of these, 43 reported 103 injuries related to cycling in that period. There were 53 (51.5%) non-traumatic injuries associated with overload exercise. The knee was reported in 17 of the injuries, and Iliotibial Band Syndrome represented 8 of these. The Patellofemoral Syndrome, the Patellar Tendinopathy and the Biceps Femoris Tendinopathy were reported three times each.

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Regarding the athletes who participated in the study of Galera et al (11) 309 (49.4%) two hundred of them reported 293 injuries in their career, of which 22.5% were related to cycling. Injuries in the lower limbs accounted for two-thirds (68.8%) of the total. The knee was the second site most commonly reported of injuries in the lower limbs, corresponding to 18.3%, only behind the ankle (20%). This study did not specify the types of knee injuries. Injuries due to overuse accounted for 61.7% of overall injuries. There was no significant relationship between the prevalence of muscle injuries and experience with time of stretching, heating and daily hydration.

In the study of Gosling et al (12), 322 lesions were documented by 217 athletes. During competitions with Olympic distances, 229 injuries were recorded and 22 (9.6%) of those were in the knee, characterized as the third most affected site. On the other hand, in competitions with reduced distances, 87 injuries were recorded and 21 (24.1%) were in the knee, considered the most affected site. It was observed that 20.6% of the injuries occurred during cycling, only behind the running.

In the study of Haapasalo et al (4), a total of 321 knee injuries (15% of all lesions) were reported during the study period. Cycling was the sport practiced in 28 of these lesions. Seven of them occurred during daily activities and the other 21 occurred during recreational or competitive practice. In both genders, the most common type of injury was due to overuse (40% of all injuries in men, 45% in women). 50% of injuries caused only mild pain or discomfort, requiring only change in duration or intensity of physical activity. 39% of injuries led to the absence of at least one session of physical practice, and 11% resulted in the absence of at least one day of work.

Zwingerberger et al (13) reported 101 retrospective injuries and 54 prospective injuries. Cycling was the sport involved in 43% of injuries. The knee was the site affected in 20% of cases in the first stage of the research and in one-third of cases in the second stage. It was, therefore, the most affected site. Overuse was responsible for 29% of injuries. The main risk factor for injuries in triathlon was related participation in a competitive event.

In the study of Kammerlander et al (14) there were 2,635 records of injuries. Cycling was responsible for 30.2% of injuries, and among them, only 6.9% were related to knee meniscus and ligament injuries. Half of the injuries recorded occurred in the age group between 65 and 69 years, and less than 1% of injuries were recorded in athletes aged more than 90 years.

The study of Bertola et al (15) included 190 athletes, of whom 80% were men. Most of them, 73%, competed in short distances in cycling, corresponding to 20 km or 5 km. 79% of the reported injuries occurred in the training period. Among men, 16% of injuries occurred during cycling, and the knee was affected in 18% of cases, behind only of the calves, which corresponded to 40% of cases. Among women, only 8% of injuries occurred during cycling, but they also had 18% of injuries related to the knee, which was the third most affected site. Regarding temperature, 68% of athletes reported that their injuries occurred during a cold weather. As for frequency, 56% reported having recurrent injuries at the same site; and when asked about the cause of injuries, 70% of the athletes cited overuse as the main triggering factor.

TABLE 3. Author and year; gender, age and experience level *. The values correspond to the average.

Author / year	Gender	Age	Experience Level
Clarsen et al, 2010(1)	-----	26 (±4) years old	4.5 years of experience as a professional
N. de Bernardo et al, 2012(10)	-----	25.8 (±4.4) years old	28.3 ± 2.4 weekly hours of training and/or competition
Galera et al, 2011(11)	M = 254 F= 55	Elite: 25.7 years old Recreative: 37.8 years old Competitive: 39.3 years old	Average volume of 8,9 weekly hours
Gosling et al, 2010(12)	M = 211 F= 96	Recreative: 26.2 (±11.2) years old Competitive: 32.6 (±11.6) years old	Recreative: 1.2 ±2.7 years Competitive: 5.5 ± 6.2 years
Haapasalo et al, 2007(4)	-----	-----	-----
Zwingerberger et al, 2014(13)	M = 169 F= 43	40.3 years old	5 years of professional experience Average volume of 4 weekly hours
Kammerlander et al, 2012(14)	M = 1647 F= 988	65 – 69 years old: 50.1% 70 – 74 years old: 27.1% ≥75 years old: 22.7 %	-----
Bertola et al, 2014(15)	M = 154 F= 38	Male.: 36 ±9 years old Female.: 33 ±9 years old	Male.: 18% < 1 year; 10% between 1-2 years, 18% between 2-3 years; 20% between 3-6 years; 16% between 6-10 years; e 18% > 10 years. Female.: 22% < 1 year; 16% between 1-2 years; 27% between 2-3 years; 19% between 3-6 years; 11% between 6 – 10 years; e 5% > 10 years.

* The level of experience will be based on the original criteria of the articles.

DISCUSSION

From this systematic review, researchers observed that there are few descriptive studies on the subject that address exclusively non-traumatic injuries in cyclists. Most studies have involved all types of injuries, traumatic and non-traumatic, and give emphasis to the first option. Cycling is one of the three sports that most cause non-traumatic knee injuries among its athletes (4). This fact is confirmed by the reviewed studies as to represent a variation ranging from a quarter of practices that triggered the injuries (10,11,12) to about forty percent of the cases (13). When compared to swimming and running within the studies involving triathletes, cycling was the second modality that most caused injury, only behind running(11,13,15).

It is well established that, considering the injuries involving the lower limbs in cycling, the knee is one of the most common sites that refers to non-traumatic injuries (6). The knee was the second most reported site during the studies, and is sometimes behind the ankle (11) and sometimes behind the pelvis (1). Mainly due to its anatomical position, the knee shows up in the literature as the most common site of injury related to sports (4). Despite showing a considerably high prevalence, there was no consensus on the severity of the injuries in this region. While the study of Clarsen et al (1) showed that 57% of knee injuries prevented athletes from practicing sports for more than eight days (1), the study of Haapasalo et al (4) stated that in half the cases the injury caused only minor pain or discomfort that did not require medical follow-up and only 11% of the athletes had to miss more than a day of work(4).

Only three studies specifically mentioned which non-traumatic knee injuries were the most prevalent in cyclists. Among these lesions, two were highlighted: Patellofemoral Pain Syndrome and Iliotibial Band Syndrome (1,6,10,4,1). The complaint of anterior knee pain, or Patellofemoral Pain syndrome was the most prevalent, affecting about a quarter of cyclists at some point in life (1). The two main factors contributing to this situation is the use and excessive strength of the quadriceps muscles and misalignment of both the muscles and the bike settings, causing an overload in the joint(16). The Patellofemoral Pain Syndrome is more common in women, resulting from a greater Q-angle, which consequently will change the resulting force on the displacement of the patella (16). The Iliotibial Band Syndrome was the most prevalent in the study of N. Bernard et al (10), corresponding to 47% of knee injuries.

Generally the cyclist feels the pain in the side edge of the

joint. It is more common among runners; however, it affects a considerable portion of cycling athletes (5). It is mainly caused by the repetition of impact, exacerbated by the placement of the seat either too low or too far from the handlebar (17). It was not possible to establish whether there was any difference between those who practiced cycling

exclusively and triathletes by the fact that the study on triathlon did not bring these specifications, so it is not possible to estimate how much running could influence the final results regarding the diagnosis of injuries.

Regarding the main triggers of non-traumatic injuries, all the reviewed studies come into agreement with the literature that is already well established. Overuse, or overtraining, is unanimously mentioned as the primary cause of injury (1,4,10,13,15). The prevalence in studies ranged from 40% in the study of Haapasalo et al (4) to 61.7% in the study of Galera et al (18). Although fairly common in cycling, injuries related to overuse usually do not require a long time away of the sport. Usually about 5% of the athletes will require a period of rest longer than one week (5). For professionals, this overexertion is even more damaging in the preseason because the muscles are less adapted in this period(18). The practice of exercise at lower temperatures was also cited as an important factor in the occurrence of injuries (15). Other findings were not observed in this review but are cited in literature as injury facilitators. They are higher patella, increased Q-angle, patellar tilt and positive J-sign (19). The bicycle seat height, especially when placed too low, is related to overload in the knee joint. However, the right height to prevent injuries is not known (17). The shoe/pedal axis is responsible for the transmission of muscle strength in the kinetic energy on the bike and when misaligned it can contribute negatively to the knee joint and thus contribute to overuse injuries (20). There was no significant relationship between the prevalence of muscle injuries and experience with time of stretching, heating and daily hydration(11).

Regarding the demographic profile of those who participated in this review, seven articles contributed to this information. It is noteworthy that as most of the evaluated studies addressed both traumatic and non-traumatic injuries, and so demographic data regarding the athletes were not discriminated according to the type of injury. This became a bias of result to be considered and emphasizes how much specific studies related to non-traumatic knee injuries in cyclists are still necessary.

It was observed predominance of male audience in practicing cycling. Male athletes accounted from about three quarters of the sample in the studies (11,12) to about 80% (13,14). There was no significant difference in the occurrence of gender-related injuries, and the knee was often cited among the three most common sites of cycling-related injury (15).

Regarding the average age of cyclists, there was no unanimity and the fact that most of the studies were carried out in cycling clubs or competitions contributed to maintaining the average age of athletes age relatively low. The average age of the athletes who participate in some team or club was 26 years (1,10). There was no significant difference in age between male and female athletes (15). As for the group practicing triathlon, the information given was more specific. The particularity of the study of Kammerlander et al (14), seniors over 65 years, showed that more than half of the injuries occur

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in the age range from 65 to 69 years. This fact is explained by the increase of the elderly in practicing physical activities, given that the rate of this population involved in some sport doubled between the years 1996 and 2001(21).

By analyzing the level of experience of the athletes involved in the research sample, it was not possible to establish a uniform analysis because the studies did not follow the same standard to evaluate this aspect. For professionals who practiced exclusively cycling, the average weekly volume of training was 28 weekly hours (10). As for those who divided time with swimming and running, consequently, the averages were lower, ranging between 4 to weekly hours (11,13). When the criterion used was "years of experience", values ranged from 4.5 to 6.2 years (1,12,13,15). There was no significant difference between men and women regarding experience in cycling(15).

CONCLUSION

The knee is one of the main injury sites for cyclists, mainly because of its anatomical location. However, most of the injuries that involve it do not cause prolonged periods away from the sport.

The etiologies of non-traumatic knee injuries that stood out were the Patellofemoral Pain Syndrome and the Iliotibial Band Syndrome. They are usually caused by excessive use of the adjacent muscles, impact repetition and aggravated by placing the seat either too low or too far from the handlebars. However, there is need of more studies that discriminate the etiologies of injuries.

The overuse is the main risk factor for non-traumatic knee injuries among cyclists. Other variables were identified, such as: weather conditions, higher patella, increased Q-angle, patellar tilt and positive J-sign, bicycle seat height and misalignment of pedals. However, further descriptive studies are requires to confirm these findings.

The demographic profile of the athletes showed that most cyclists are young men aged between 20 and 40 years. Most studies were performed in clubs, so it was not possible to associate the level of experience to the general population. There was no relationship established between gender and ease of injuries.

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