Changes in Sports Injuries Incidence over Time in World-class Road Cyclists

Authors C. Barrios[1], N. D. Bernardo[2], P. Vera[3], C. Laíz[4], M. Hadala[4]

Affiliations Affiliation addresses are listed at the end of the article

Key words
- road cycling
- epidemiology
- injury incidence
- overuse
- traumatic injuries

Abstract

This is a descriptive epidemiologic survey on all traumatic and overuse injuries which occurred in 2 groups of male elite road cyclists based on retrospective clinical interviews and physical examinations. The historical group consisted of 65 professional road cyclists surveyed from 1983 to 1995. The contemporary group included 65 elite racers still active and reporting injuries from 2003 to 2009. Injury/cyclist ratio was 1.32 in the historical group and 2.13 in those still active. Traumatic injuries increased from 39.5% (historical) to 53.9% (contemporary) ($p<0.05$). Severe traumatic lesions decreased from 49.9% in the historical group to 10.5% in the contemporary group ($p<0.01$). Patellofemoral pain decreased from 28.8% (historical) to 6.1% (contemporary) ($p<0.01$). Muscle injuries substantially increased from 13.4% to 44.9% ($p<0.01$). In the historical racers, the rates of risk for traumatic injury were 0.104 per year per cyclist, and 0.003 per 1000 km of training and competition. These figures increased to 0.287 and 0.009 respectively in the contemporary group. In summary, contemporary professional road cyclists are exposed to double the risk of traumatic injuries than those competing in the 80s and early 90s. However, these lesions have less severity. Overuse injuries had a completely different clinical pattern, with the currently active cyclist exhibiting more muscle injuries and less tendinous lesions.

Introduction

Certain top-level road cycling competitions characterized either by the stages modality (Tour of France, Giro of Italy) or as classic one-day races (Paris-Roubaix, Amstel Gold Race, Liege-Baston-Liege) have become popular sporting events. Despite over 100 years of tradition in a number of these competitions, sports medicine literature has not addressed in depth the epidemiology of injury incidence and risk in top-level cyclists.

Elite road cyclists are exposed to very high physical demands because they are accustomed to riding an average of 30000 km per year, including in the range of 50–110 intense racing days [20,27]. It would therefore be assumed that these sportsmen are exposed to a high risk of both traumatic and overuse injuries. Instead of reporting the true incidence of these injuries, the literature has been mainly focused on merely descriptive studies about possible cycling-related lesions (especially overuse injuries) and suggesting different theoretical preventive methods [17,19,25,26,37]. Only 2 exhaustive epidemiologic studies on professional road cycling have reported different clinical injury patterns [4,7]. The first study described a retrospective review of all traumatic and overuse injuries in 2 professional teams over a 13-year period. This study covered lesions occurring between 1983 and 1995 in a group of 65 top-level cyclists who were members of 2 of the most prestigious teams at that time [4]. Traumatic injuries accounted for 39.5% of all injuries. Fractures located at the clavicle and upper extremities were found in half of these cases. Overuse lesions were more frequent in the professional cyclist, including patellar and Achilles tendinopathies, as well as anterior knee pain being the most frequent diagnosis.

The second survey specifically illustrated the one-year occurrence of overuse injuries among 109 cyclists who were members of 7 professional teams interviewed during the 2009 pre-season training camps [7]. Injuries due to trauma were not considered. Lower back pain and anterior knee pain were the most prevalent overuse injuries. Because this study was conducted 14 years after the previous work, it would be reasonable to assume that the injury occurrence in these 2 cohorts may be substantially different due to the

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Correspondence
Prof. Carlos Barrios
Institute for Research on Musculoskeletal Disorders
School of Medicine
Valencia Catholic University of Valencia
Quevedo 2
Valencia 46001
Spain
Tel.: +34/610/408 001
Fax: +34/963/944 590
carlos.barrios@ucv.es

notable technical and conditioning changes experienced by road cycling during these years.
In the last decade, professional road cycling has undergone major transformation not only in the form of technical advances in bicycles but also new conditioning protocols [10,11,21]. In addition, new developments in preventive injury methods have been incorporated into road cycling over the last few decades. The most recent program for injury prevention with a remarkable impact was the mandatory use of a helmet during racing in all categories and was incorporated as a rule in early 1990s [26,28,29]. As for training methods, the volume of work is commonly determined by means of different loading protocols expressed in Watts [21,28,30]. This may induce muscle and tendon injuries due to overuse.
While all of these issues might have an influence on injury occurrence in professional cycling, this possible influence has been not documented. The need for further investigation of the potential impact of all these aspects on injury occurrence among competitive cyclists is clear.
Based on clinically oriented interviews and clinical examinations, this retrospective epidemiologic study was aimed at comparing injury incidence rates and clinical patterns between a group of still active elite cycling racers and those reported in an historical group competing in the 1980s and early 1990s [4]. The analysis of changes in incidence and clinical patterns might enhance the understanding of the effect of the transformations and advances of modern road cycling on sports injuries.

Materials and Methods

Participants

Historical group (HG): This group consisted of 65 professional road cyclists surveyed from 1983 to 1995 to analyze the incidence and type of injuries occurring in this sports specialty. The data from these elite road cyclists were previously reported by Barrios et al. [4]. The characteristics and profile of this cohort are summarized in ▶ **Table 1**. The average duration of their exercising at professional level was 5 years (range, 3–7). All were male racers competing for 2 well-known professional teams and participating in road races all over Europe at that time. Among them were winners of the Tour of France, Tour of Spain and Giro of Italy. The road cyclists belonged to 6 different nationalities.

Contemporary group (CG): This group included 66 top-level road cyclists reporting injuries occurring from 2000 to 2009. They had been involved with a professional team for an average period of 4 years (range, 1–9). The characteristics of this group are also given in ▶ **Table 1**. At the time of the injury register, these road cyclists belonged to 4 top-level teams: 2 Pro-Tour teams and 2 UCI Pro-Continental teams participating in the most important cycling competitions, mainly in Europe. This team classification was not in use when the HG cyclists were competing. The CG group comprised cyclists from 8 different nationalities.
Approval for this study was obtained from the ethics committee of the senior author's institution. In addition, the study meets the ethical standards of the International Journal of Sports [16].

Table 1 Patient characteristics.

	Historical group n = 65	Contemporary group n = 66	Significance * (p)
age, years	25 (21–32)	25.8 (20–36)	ns
height, cm	172.4 (162–190)	177.9 (164–196)	< 0.001
BMI, kg/m^2	22.2 (20.5–24.1)	21.5 (20.1–23.6)	ns
years as professional	5 (3–7)	4 (1–9)	ns
annual cycling distance, km	34 000 (24 000–36 000)	30 000 (28 000–34 000)	< 0.01
annual competition days	90 (60–130)	70 (50–90)	< 0.001
training and competition time (h/wk)	30.4 ± 3.1	27.4 ± 3.2	< 0.001

BMI: Body Mass Index; * Unpaired t test; ns: non-significant

Injury register and interviews

All traumatic and overuse injuries suffered by these 2 groups of top-level road cyclists were collected by retrospective interviews including personal clinical examinations. The interviewer went through a standardized written questionnaire previously designed to ensure that all required questions were directed to each participant. The interviews were held in either English or Spanish, which were the official languages of the teams under study. The interviewer completed the questionnaires and every injury reported was clinically examined at the time of interview to evaluate their healing status.
In the HG, some of the injuries were also directly diagnosed and treated by the research team leader, who at that time acted as one of the team physicians. This applied only for lesions occurring when the cyclists were involved in the same team in which the research leader acted as physician. However, in this HG group, the vast majority of sports injuries were registered by retrospective interviews when the cyclist joined the team for the first time as a part of the clinical history recording. The research leader also conducted these retrospective interviews. In this group, the interviews covered a mean 5-year period of injuries (range, 3–7 years).
For the CG cyclists, the injury register was obtained also by means of personal retrospective interviews and clinical examinations performed during the 2010 and 2011 preseason training camps. The period of injuries covered the entire professional athletic career of the cyclist, i.e., a mean of 4 years (range: 1–9). The same team research leader as in the HG, assisted by other current coauthors, interviewed all of these cyclists. The direct involvement of the same research leader in both groups minimized the possible bias related to the interview methods considering the time between the 2 sets of data collection.
After a detailed explanation about the importance and clinical significance of the interviews, all participants gave their written informed consent to use the results for scientific purposes. The injury register attempted to cover all traumatic and overuse injuries the cyclists had suffered since their debut as professionals, and the most frequent answers involved either forced rest or the complete or partial interruption of their sports practice. That is, all injuries that forced them to lose at least one day of training or competition were reported. Minor traumatic injuries, such as simple skin abrasions or muscle overuse with no functional repercussions, were not considered in either of the 2 periods of data collection.

Injury classification

Injuries were classified as traumatic or overuse lesions according to their mechanism [3] and as new or recurrent lesions according to the number of registered episodes. Thus, an injury was considered new when it was registered for the first time.

However, a relapse of previous episodes (i.e., the same type of injury at the same anatomic location within 2 months after the treatment of the previous lesion) was then considered a recurrent injury. In cases of 2 or more injuries in the same athlete, these were recorded independently so as not to alter the final calculation of reported injuries [3].

The severity of the injuries was classified according to the Abbreviated Injury Scale (AIS) [22] as minor, moderate, severe but not life-threatening, severe and life-threatening, and severe with uncertain survival.

The injury impact in terms of absence from sports activity due to a lesion was assessed using the Ekstrand 3-point scale, which is used to classify injuries into minor (injuries needing less than 7 days of rest), moderate (7–28 days) and acute (over 28 days) [9]. To perform these calculations, cyclists were considered injured as long as medical services denied their participation in training sessions or competitions.

Statistical analysis

Results were analyzed using standard descriptive statistical data. Injury incidence was calculated as the number of injuries per cyclist, the injuries per cyclist per year, and the injuries per cyclist per 1 000 km of cycling (training or competition). The participants' characteristics, injury prevalence and exposures rates were compared between the HG and the CG group. The exposure ratio was obtained by dividing the total amount of kilometers cycled (average) by the average period of injuries analyzed in both groups of cyclist. Pearson Chi-square and Fisher exact tests were used to detect differences between nonparametric categorical variables, and unpaired t tests to detect differences in parametric variables. Differences were considered statistically significant if the p value was less than 0.05.

Table 2 Injury profile.

	Historical group n=65	Contemporary group n=66	Significance * (p)
total injuries	86	141	<0.05
trauma	34 (39.5%)	76 (53.9%)	
overuse	52 (60.5%)	65 (46.1%)	
cyclists free from injuries	9 (13.8%)	8 (12.1%)	ns
only traumatic lesions	19 (29.2%)	19 (28.8%)	ns
only overuse injuries	29 (44.6%)	12 (18.2%)	<0.01
both traumatic and overuse	8 (12.3%)	27 (40.9%)	<0.01
injury-cyclist ratio	1.32	2.13	
cyclists with >1 lesion	–	38 (57.5%)	

* Chi-square test with Yates' correction

Results

There were no differences between the 2 groups regarding average age and mass, but the CG cyclists were taller ($p<0.001$) (▶ **Table 1**). The HG road racers dedicated significantly more training and competition hours per week ($p<0.001$), participated in a higher average number of competition days ($p<0.001$), and hence cycled a greater distance per year ($p<0.01$). Taking into account the mean cycling distance per year and the mean number of years involved in competitions per cyclist, the exposure time to sports injuries was 1.47 fold higher in the historical group.

Although the mean period covered by interviews, the annual cycling distance and the competition days per year were lower in the current group (lower exposure time), the total number of recorded injuries was higher than in the historical group. In fact, the injury-cyclist ratio increased from 1.32 to 2.13 (▶ **Table 2**). Traumatic injuries increased from 39.5% in the reference HG to 53.9% in the CG ($p<0.05$). Traumatic injuries affected 41.5% (27/65) of the cyclists in the HG, and 69.7% (46/66) in the CG, being significantly different ($p<0.005$). Differences were bigger if values were adjusted to the exposure time. There was almost the same number of cyclists free from injuries in both groups. Interestingly, the percentage of cyclists suffering only from overuse injuries was clearly lower in CG riders even after adjusting the exposure time (44.6% vs. 27.7%; $p<0.01$).

As for the distribution of traumatic injuries according to the affected anatomical region, more than half of the lesions occurred at the upper extremities and shoulder girdles in both groups, with a slight increase in the CG cyclists (52.8% vs. 61.7%) (▶ **Fig. 1**). This increase was due to the higher number of fractures at the upper extremities recorded in CG cyclists, almost double that of HG riders.

Bone fractures were found to be slightly less frequent in CG riders than in HG cyclists (56.8% of all traumatic lesions vs. 64.7%; $p=0.643$), but this difference lacked statistical significance

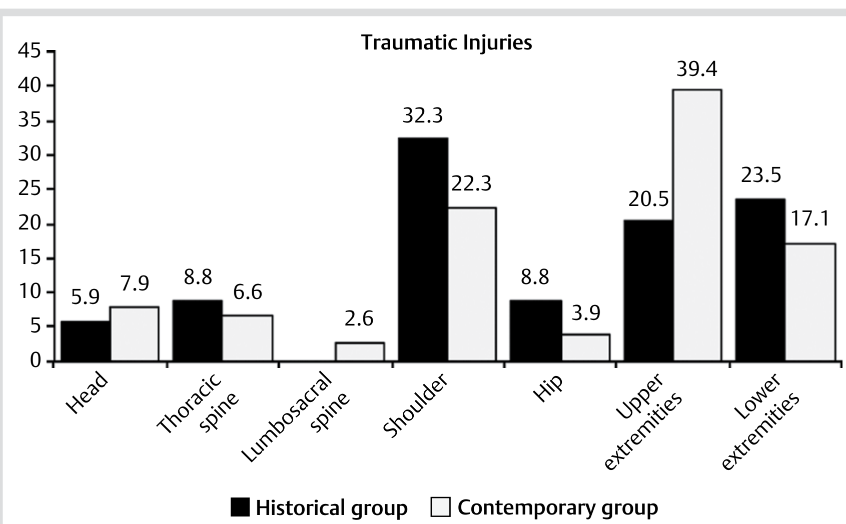

Fig. 1 Distribution of traumatic injuries according to the affected anatomical region in both groups of elite road cyclist (numbers indicate percentage).

(▶ **Table 3**). There were also small variations between the 2 groups of cyclists concerning the occurrence of other traumatic injuries, such as skin lacerations and contusions, ligament sprains, muscle ruptures, etc. No glenohumeral dislocations were observed in the historical group.

The incidence of head injuries was slightly higher in the CG group (6 cases; 7.9%) compared to the HG group (2 cases; 5.9%). However, their injuries were less severe. There were no life-threatening injuries in the CG group. 4 of these cases were craniofacial injuries without severe head trauma. The other 2 cases involved brain concussions requiring less than 48 h of inpatient observation. All of these cyclists wore helmets at the time of injury. However, one of the 2 cases in the HG group died due to a severe head injury (AIS-5) after being run over by a car during training. The other cases had Lefort's maxillary fractures. These HG cases did not wear helmets at the time of injury.

Table 3 Clinical diagnosis of traumatic injuries.

Injury clinical diagnosis	Anatomic location	Traumatic injuries n (%) Historical group	Contemporary group
fractures	clavicle	9 (26.5%)	13 (17.1%)
	coracoid process	2 (5.9%)	
	trochanter		1 (1.3%)
	olecranon		4 (5.3%)
	wrist	4 (11.8%)	9 (11.8%)
	finger		2 (2.6%)
	craniofacial	2 (5.9%)	4 (5.3%)
	ribs	1 (2.9%)	5 (6.6%)
	spine	1 (2.9%)	2 (2.6%)
	patella		1 (1.3%)
	hip	3 (8.8%)	3 (3.9%)
ruptures	PCL		1 (1.3%)
	MCL		1 (1.3%)
	meniscus	1 (2.9%)	3 (3.9%)
	muscle	1 (2.9%)	4 (5.3%)
	tendinous		1 (1.3%)
laceration/ contusion		8 (23.5%)	13 (17.1%)
sprain	wrist	1 (2.9%)	
	first metacarpophalangeal joint	1 (2.9%)	
	ankle		2 (2.6%)
dislocation	glenohumeral		3 (3.9%)
other	cerebral concussion		2 (2.6%)
	finger amputation		1 (1.3%)
	post-traumatic coccyx pain		1 (1.3%)
Total		34 (100%)	76 (100%)

Overuse injuries in the historical group were mainly located at the lower extremities (82.7%) (▶ **Fig. 2**). In CG cyclists, the percentage of lower extremity injuries due to overuse was slightly lower (67.7%; $p=0.102$). Overuse injuries at the lumbopelvic region were registered only in 7 HG cases (13.4%), and no cervical or thoracic spine overuse injuries were recorded. However, a total of 16 CG cyclists (24.2%) referred to muscular overuse complaints at the spine, with 7 of them (10.6%) citing the cervical and thoracic regions.

The most important differences between the groups of cyclists concern the clinical diagnosis of the overuse injuries (▶ **Table 4**). Lesions around the knee region decreased significantly from 33 out of a total of 52 overuse injuries (63.4%) in HG cyclists to only 24 out of 65 overuse injuries (36.9%) in CG cyclists ($p<0.05$). However, after adjusting values with the 1.47 exposure time factor, this decrease was not significant. More interestingly, the clinical nature of the injuries around the knee was completely different in both groups. There was a substantial decrease in the patellofemoral pathology in CG cyclists (4 cases out 65 overuse injuries; 6.1%) as compared to the HG cyclist (15 cases out of 52 injuries; 28.8%). The difference was statistically significant after adjusting the exposure time ($p<0.005$). In the HG cyclists, all these cases were diagnosed as patellar chondropathy or chondromalacia. In particular, iliotibial band syndrome was more often found in CG cyclists, although the difference had no statistical significance (▶ **Table 4**).

The most common clinical diagnosis of overuse injuries in the historical reference group was tendinopathy, with 28.8% around the knee and 15.4% at the Achilles' tendon (▶ **Table 4**). These figures decreased in CG cyclists, among whom only 16.9% of tendinopathies were located around the knee, and only 7.6% of cases at the Achilles' tendon. In both cases, the differences were not statistically significant.

On the other hand, 44.9% of overuse injuries were due to muscle lesions in the CG group as compared to 13.4% in the HG group ($p<0.0001$). Differences were also significant if data were adjusted to the exposure time: 30 overuse muscle injuries during a mean covered 4-year period in the CG (7.5 lesions per year), and 7 muscle lesions during the 5-year period analyzed in the HG (1.4 lesion per year) ($p<0.0001$). Most of these injuries

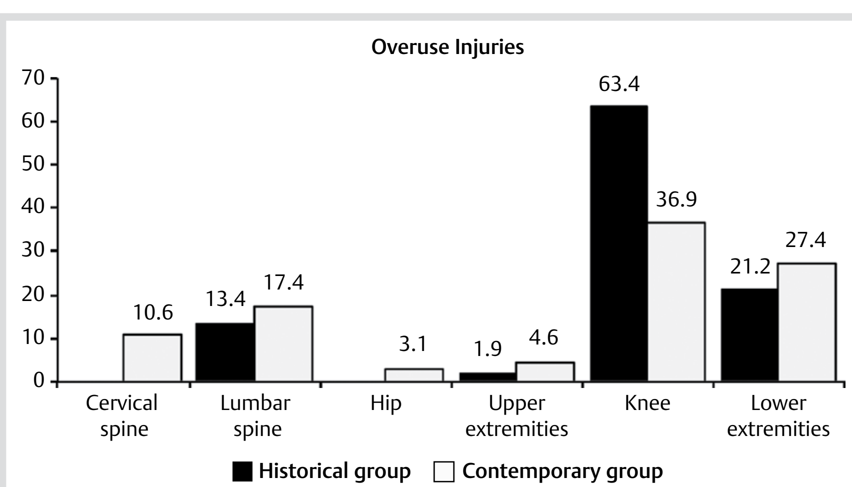

Fig. 2 Distribution of overuse injuries at the different anatomical regions in both groups of cyclist (numbers indicate percentage).

occurred in the proximal region of the lower extremities (hamstrings, quadriceps, gluteus major and pyramidal) and in the cervical and lower back spine. Most of these overuse injuries (89.6%) occurred during the training periods of this group. In HG cyclists, muscle pathology was very rarely recorded and was only associated with low back pain.

Despite the increase in traumatic injuries in the CG cyclist, this increase did not indicate a greater severity of the injuries. In fact, AIS severe lesions (classified as 3 or greater) decreased from 49.9% in the HG to 10.5% in the CG group ($p<0.001$) (▶ **Table 5**). However, according to Ekstrand's classification for the absence of competition, the occurrence of severe traumatic lesions remained constant (29.4% in HG and 32.9% in CG). Overuse injuries also had less severity in CG cyclists, according to the AIS classification. A total of 92.3% were classified as level 1 in the CG group compared to 65.4% in the HG ($p<0.001$). In Ekstrand's classification system, the number of lesions requiring fewer than 7 days of absence from competition was more than doubled in the CG group ($p<0.01$) (▶ **Table 5**).

The overall injury rates, as well as the rates regarding traumatic and overuse injuries in particular, are given in ▶ **Table 6**. Injury rates were corrected according to the different exposure time of both groups. In HG racers, all overuse injury rates were higher than those for traumatic injury (Chi-square test of proportions, $p<0.01$). On the contrary, in CG cyclists, injury rates for traumatic injuries were found to be higher than overuse rates (Chi-square test of proportions, $p<0.01$). Comparing both groups, there was a 2-fold increase in the overall risk of injury for the still-active CG cyclist. This increase was mainly due to the higher risk of traumatic injury for the latter group of cyclists.

Table 4 Clinical diagnosis of the overuse injuries.

	Historical group n (%)	Contemporary group, n (%)
Knee	**33 (63.4%)**	**24 (36.9%)**
patellofemoral pathology	15 (28.8%)	4 (6.1%)
patellar tendinopathy	10 (19.2%)	8 (12.3%)
quadriceps tendinopathy	4 (7.7%)	–
bicipital tendinopathy	1 (1.9%)	3 (4.6%)
iliotibial band syndrome	2 (3.8%)	9 (12.8%)
prepatellar bursitis	1 (1.9%)	–
Muscle pathology		**14 (21.5%)**
hamstrings contracture		6 (9.1%)
pyramidal syndrome		1 (1.5%)
gluteus major contracture		1 (1.5%)
quadriceps contracture		4 (6.1%)
triceps contracture		2 (3.0%)
Spine	**7 (13.4%)**	**19 (29.2%)**
mechanical low back pain	7 (13.4%)	9 (12.8%)
paraspinal cervical muscles contracture		7 (10.6%)
lumbar disc herniation		3 (4.6%)
Other lesions	**12 (23.1%)**	**8 (12.3%)**
Achilles tendinitis	8 (15.4%)	5 (7.6%)
D'Quervain's tendinitis		1 (1.5%)
wrist synovitis	1 (1.9%)	
dorsal midfoot ganglion		1 (1.5%)
plantar fasciitis	1 (1.9%)	
pubis osteopathy	1 (1.9%)	
iliac artery endofibrosis	1 (1.9%)	
Recurrent skin infection	1 (1.5%)	
Total	52 (100%)	65 (100%)

Table 5 Injury distribution according to the abbreviated injury scale (AIS) and the duration of absence from competition.

	Traumatic injuries		Overuse injuries	
	HG	CG	HG	CG
Abbreviated injury scale (AIS)				
1	2 (5.9%)	23 (30.2%)	34 (65.4%)	60 (92.3%)
2	15 (44.1%)	45 (59.3%)	16 (30.7%)	2 (3.1%)
3	13 (38.2%)	8 (10.5%)	2 (3.8%)	3 (4.6%)
4	3 (8.8%)	–	–	–
5	1 (2.9%)	–	–	–
		$p<0.01$ *		$p<0.01$ *
Absence of competition (days)				
1–7	2 (5.9%)	14 (18.4%)	13 (25.0%)	35 (53.8%)
7–28	22 (64.7%)	37 (48.7%)	36 (69.2%)	26 (40.0%)
More than 28	10 (29.4%)	25 (32.9%)	3 (5.8%)	4 (6.2%)
				$p<0.01$ *

* 3 × 2 Chi-square test

Discussion

This study is the first to report changes in the incidence and clinical patterns of musculoskeletal injuries affecting top-level road cycling riders. Professional cyclists who were still active at the time of data accumulation for this descriptive epidemiologic study (the 2008 and 2009 seasons) had an almost 2-fold greater risk of traumatic injury compared to their counterparts in the 1980s and early 1990s [4]. The injury/cyclist ratio for traumatic lesions increased from 0.523 to 1.151 over the last 15 years. Both groups were therefore similar in terms of their levels of road cycling performance.

Although traumatic lesions were more frequent in currently active cyclists, these lesions were less severe. The cyclists involved in competitions from 2000 to 2009 had only 10.5% of traumatic lesions classified as 3 or greater, according to the Abbreviated Injury Scale. In the historical group, these more severe lesions accounted for 49.9% of injuries. There were, in fact, 4 life-threatening injuries (11.7%) in the historical group [4]. In one case, the craniofacial injury caused the cyclist's death immediately after the trauma. This rider was not wearing a helmet at the time of injury because it was not mandatory at that time. No life-threatening injuries were registered among the group of currently active road cyclists.

Table 6 Adjusted exposure risk for traumatic and overuse injuries in elite professional cycling riders.

	Historical group (Mean exposure time: 5 years)			Contemporary group (Mean exposure time: 4 years)		
Risk for injury	**Traumatic injuries**	**Overuse injuries**	**Total risk**	**Traumatic injuries**	**Overuse injuries**	**Total risk**
per year/racer	0.104	0.160	0.264	0.287	0.246	0.533
per racer	0.523	0.800	1.323	1.151	0.984	2.135
per 1000 km	0.003	0.005	0.008	0.009	0.008	0.017
per day of competition/year	0.001	0.002	0.003	0.004	0.003	0.007

The protective effects of bicycle helmets for head and facial injuries have been confirmed by several studies conducted in different countries and including urban cycling populations of children and adults [2,6,29,32]. Some authors found that wearing a cycling helmet is estimated to prevent 60% of head injuries [8]. Moreover, there is evidence that helmet use reduces head injury risk not only in bicycling but also in skiing and snowboarding [6]. While there was a slightly higher frequency of craniofacial injuries in the group of currently active cyclists, none of the 2 cases reporting traumatic head injuries and none of the 4 cases reporting isolated facial fractures involved the risk of death. It is significant that during the 2000–2010 decade, helmets were mandatorily worn in all competitions. According to our results, the approval and observance of this regulation in top-level cycling has considerably improved safety and remarkably reduced serious traumatic head injuries [33].
Another interesting fact showing the change in injury patterns in the last decade was the lower percentage of fractures around the shoulder, while the incidence of traumatic injuries increased. Fractures of the clavicle and humeral head were approximately one-third less frequent. However, fractures of the distal upper extremity (elbow, forearm, wrist and hand) increased from 20.5% in the historical group to 39.4% in the more recent group [4]. A convincing argument to explain these differences is currently lacking. The falling mechanisms in road cycling have been implicated in the higher occurrence of traumatic injuries at the scapulohumeral girdle and the upper extremities [4,25]. This mechanism causes the shoulder to be the first contact point with the ground, thus exposing professional cyclists to higher risks of fracture of the shoulder and upper extremities.
When considering overuse injuries, the exposure risk rates also showed an increase over the past decade, but with a lower impact than was observed for traumatic lesions. The most relevant fact regarding overuse injuries was the completely different clinical patterns of these injuries affecting the currently active cyclist. There were many more muscle injuries and fewer tendinous lesions than in the historical group. In the historical group, muscle injuries requiring abstinence from training or competition were only reported for the low back in 7 cases (13.4%). None of the cyclists of this historical group claimed paraspinal neck muscles contractures or muscle disorders at the legs [4]. However, currently active cyclists complained of spinal muscle contractures in a higher proportion (29.2%) and were mainly related to neck paraspinal muscles.
In a recent study retrospectively analyzing overuse injuries in professional road cyclists during a specific season, low back pain was found to be the most prevalent symptom (58%) reported by the cohort [7]. According to the interviews, 41% sought outpatient medical assistance. However, relatively few had missed training days (11.9%) or racing days because of the pain (5.5%). Although these figures are slightly higher than those found in our cohort of currently active cyclists (12.8% losing training or competition days), the differences were not marked. One of the questionnaires in Clarsen's study [7] was specifically aimed at investigating low back complaints. Therefore, the results should be interpreted with caution, as the use of specifically oriented questionnaires might be conducive to the overestimation of these symptoms. Among other limitations of their work, these authors stated that the expectations of the interviewers might have biased the results. In our experience, some overuse injuries, such as neck and low back pain, and others related to the cycling position, such as buttock complaints and shoulder, wrist, ankle and foot discomfort, are not usually taken into consideration by the cyclist because they regard them as mild, familiar and not disabling conditions associated with highly competitive races and tours.
In the last decade, cyclist interviews confirmed 12 cases (18.5%) of contractures or muscle shortening at a lower extremity that limited their training and competition capacity for short periods of time. None of these cases were reported in the historical group [4]. Hamstring and quadriceps (muscles of the anterior and posterior thighs) were the most frequently affected muscle groups. The occurrence of these lesions, unreported before, might be explained by the high physiological demands of these muscles in current pedaling techniques and training protocols [28,30,38]. Furthermore, these overuse injuries at the thigh muscles represented only 6.4% of the cases in the study by Clarsen et al. [7], thus putting their figures in disagreement with those found in the present study. One reason for this discrepancy could be their highly specific questionnaires focusing on other injuries, making the methodological approach quite different than that used in our study.
The changes in the nature of overuse injuries during the last decade were clearly demonstrated in this study in the analysis of the incidence and type of knee injuries. In the historical group, the incidence of overuse injuries around the knee spanned 63.4% of the cases. Anterior knee pain was found in 57.7% of the injuries, with patellofemoral chondropathy being the most frequently diagnosed entity [4]. In the group of currently active cyclists, anterior patellofemoral pain requiring medical assistance decreased to 18.4% of the cases (in HG was 48.0%), and the primary diagnosis was infrapatellar tendinopathy (12.3%), with a much lower incidence of patellofemoral pathology (6.1%). Consistent with our study, Clarsen et al. [7] also found a lower incidence of anterior knee pain in their group of cyclists, even though these complaints were assessed by a specifically directed questionnaire. A detailed description of the clinical diagnoses underlying anterior knee pain would be desirable in the report of Clarsen et al. [7].
In any case, patellofemoral pain continues to be a relatively common overuse injury in cycling. Its etiology in cycling is not yet well understood, although several morphologic and biomechanical factors, such as patellar malalignment, leg-length discrepancies, muscle imbalance, varus or valgus knee misalignment, and poor muscle flexibility around the pelvic girdle, have been implicated [15,36]. Factors related to incorrect bicycle and equipment settings, including saddle and height, incorrect cleat position, the type of cleat and shoes, and gear lengths, are also considered to be relevant [36]. The lower incidence of anterior knee pain in our study can be explained by the special attention paid by cycling teams to the analysis of these factors as part of their injury prevention programs. In addition, the health practitioners of modern top-level cycling teams are more proactive in preventing and treating sports injuries. Even before symptoms arise, prevention strategies such as training modifications and physical therapy programs are commonly used [10,11,21].
The incidence of iliotibial band syndrome, an overuse injury around the knee, increased from 3.8% in the historical group to 12.8% in the more recent group of cyclists. This injury is representative of lateral and no anterior knee pain. Some authors suggested that the iliotibial band friction might be aggravated during pedaling by improper seat position (seat too high) and

training errors [12]. This pathology is gaining interest in the literature when addressing overuse injuries in different cycling modalities and performance levels [12, 18, 35, 37].

Among the 2 cohorts, only cyclist one suffered from thigh-muscle pain and loss of power related to what is referred to as iliac artery endofibrosis. This cyclist belonged to the historical group. The diagnosis was confirmed by digital arteriography, and the patient underwent angioplasty but never regained his previous performance level. Clarsen et al. also described a sole case in their cohort of 109 elite cyclists [7]. Although several studies have attributed a certain relevance to this condition among top-level cyclists, it seems that the magnitude of this problem has been overestimated [1, 5, 39].

When interpreting the results of the present work, several limitations should be considered. A cross-sectional study with retrospective data collection was used in the historical and in the currently active cyclist group. In injury surveillance research, it would be desirable to use a prospective design, but this is not always possible [13, 14]. As other authors have claimed, obtaining a prospective injury register from a large group of top-level cyclists is almost impossible due to the individualized and highly variable international race programs, as well as the different countries in which the cyclists habitually reside [7]. Under such circumstances, retrospective athlete interviews and data collection from the team medical staff records provide a good coverage of injury occurrence with little missing data.

2 other limitations must also be acknowledged when dealing with retrospective interviews of athletes. First, in this particular case, the cyclist's ability to remember the level of pain and the length of time he missed could have introduced some bias in the categorization of injuries. In any case, professional athletes are extremely conscious of the events that keep them from training or competing for any time. The length of time between the injury occurrence and the interview/examination was not considered in this study and could also introduce a limiting factor in the injury register. Finally, a difficult factor to evaluate in this study is how advances in clinical diagnosis and increased awareness of rider health would affect the results when comparing these 2 groups.

Only in the historical group were some injuries prospectively evaluated because at that time the research time leader was involved as physician in one of the cycling teams. This fact might have introduced some methodological bias, although most of the injuries were recorded by personal interviews conducted by medically trained personnel guided by this team leader. This circumstance permitted detailed descriptions of the cyclists' injuries, even those of lesser magnitude. Of course, it cannot be 100% assured that all athletes would remember of all their lesions over the past years. In addition, the use of specific questionnaires directed toward particular injuries should be interpreted with caution given the high risk of injury overestimation biasing the results [24].

In summary, active professional cyclists are exposed to double the risk of traumatic injuries of those competing in the 1980s and early 1990s. However, the cyclists' lesions seem to be less severe, and their exposure to overuse remains similar but presents a completely different clinical pattern. In the currently active cyclist, many more muscle injuries and fewer tendinous lesions were reported than in the historical group, indicating a change in the overuse injury patterns. From a speculative perspective, the new training and conditioning protocols in cycling and the introduction of injury-prevention programs might have contributed to changing the clinical pattern of injuries. Prevention programs should be reevaluated and geared to the current nature of injuries. Special consideration should also be given to muscle imbalance around the pelvic girdle and thigh.

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Affiliations
[1] School of Medicine, Institute for Research on Musculoskeletal Disorders, Valencia Catholic University, Valencia, Spain
[2] Department of Physiotherapy, University CEU-Cardenal Herrera, Valencia, Spain
[3] Podology Clinic, Clinica Artes, Valencia, Spain
[4] Physioterapy, Physical Therapy and Exercise Center, Valencia, Spain

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