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Original Article:

Overuse Injuries in Professional Road Cyclists

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Abstract

Background: Little epidemiological information exists on overuse injuries in elite road cyclists. Anecdotal reports indicate anterior knee pain and lower back pain may be common problems.

Purpose: To register overuse injuries among professional road cyclists with special focus on anterior knee and lower back pain.

Study Design: Descriptive epidemiology study

Methods: We attended training camps of seven professional teams and interviewed 109 of 116 cyclists (94%) on overuse injuries they had experienced in the previous 12 months. Injuries that required attention from medical personnel or time loss from cycling were registered. Additional information on anterior knee pain and lower back pain was collected using specific questionnaires.

Results: We registered 94 injuries; 45% were in the lower back and 23% in the knee. 23 time loss injuries were registered; 57% in the knee, 22% in the lower back, and 13% in the lower leg. Fifty-eight percent of all cyclists had experienced lower back pain in the previous 12 months, and 41% of all cyclists had sought medical attention for it. Thirty-six percent had experienced anterior knee pain and 19% had sought medical attention for it. Few cyclists had missed competitions due to pain in the lower back (6%) or anterior knee (9%).

Conclusion: Lower back pain and anterior knee pain were the most prevalent overuse injuries, with knee injuries most likely to cause time-loss and lower back pain causing the highest rates of functional impairment and medical attention.

Clinical Relevance: Future efforts to prevent overuse injuries in competitive cyclists should focus on lower back pain and anterior knee pain.

Introduction

Road cycling has been a part of the Olympic Games since their inception in 1896, and the sport's annual centrepiece race, the Tour de France, is currently one of the world's most popular sporting events. Despite the history and popularity of the sport, surprisingly little attention has been paid to the epidemiological study of overuse musculoskeletal injuries among competitive cyclists, although anecdotal reports suggest that certain injuries such as patellofemoral pain[16-17, 25] and lower back pain[24] may be prevalent.

Several studies have investigated overuse injuries among participants of non-competitive recreational cycling events.[11, 22, 29, 31] These investigations have unanimously found knee injuries to be prevalent, affecting between 24% and 62% of subjects, whereas reports of other injuries such as lower back pain and neck pain, are more variable, with prevalence rates of 3-31% and 3-66%, respectively, for the two conditions. Whilst they may give a general idea of the types of overuse injuries that cyclists experience, the results of these studies may not be directly applicable to competitive cyclists, largely due to vast differences in cycling exposure between non-competitive "recreational" cyclists, and elite professionals. One study of recreational touring cyclists reported an average annual training volume of 7114km, and an average participation rate of 2.9 non-competitive events per year.[31] Professional cyclists, on the other hand, have been reported to ride between 25000 and 35000 km, and complete 50-110 days of intense racing each year.[18, 26] It would therefore be reasonable to assume that the overuse injury load experienced by these two cohorts may be substantially different.

There is only one in-depth report on overuse injuries in professional cyclists, a retrospective review of the patient records of two professional teams over a 13-year period.[7] The likelihood that all injuries sustained by this study's subjects were treated, and thereby recorded, by their team medical staff may be questionable, given that members of professional cycling teams are typically based over a very large geographical area and riders tend to have their own local medical support, outside of the official team structure. Although the validity of the results may be questioned, the results of this study

are of interest, especially given the paucity of research in this field. While knee injuries were found to clearly be the most common problem, representing 62% of all overuse injuries, few cases of lower back pain and no cases of neck pain were reported. This contrasts significantly with the findings of a brief survey on overuse injuries among members of the British national cycling team,[10] which reported a lower back pain prevalence of 60% and a neck pain prevalence of 19%. Unfortunately, a lack of detail in this report prevents any analysis of the potential reasons for such differing results. The need for further investigation of the general pattern of overuse injury among competitive cyclists is therefore clear.

There is also some evidence that competitive cyclists may be particularly predisposed to a range of leg symptoms including pain, numbness and loss of power caused by flow limitations of their external iliac arteries.[1, 8] This has been referred to by several names in the literature, including sports-related flow-limitations of the iliac arteries,[8] exercise-induced arterial endofibrosis,[1] and cyclists' iliac syndrome.[30] While several high-profile cyclists have undergone surgery for this condition, very little is known as to the magnitude of the problem among elite cyclists.

The primary aim of the present cross-sectional study was to investigate the patterns of overuse musculoskeletal injuries in a cohort of professional road cyclists. As lower back pain and anterior knee pain may be particular problems in this cohort, the secondary aim was to collect additional information on each of these problems through the use of specific questionnaires. Finally, questions on iliac artery flow limitations were also included in an attempt to improve knowledge of the prevalence of this condition in professional cycling.

Materials and Methods

Recruitment methods and data collection procedures

Eleven road cycling teams, certified to take part in international competitions by the Union Cycliste Internationale (UCI), were invited to participate in this study. These teams were targeted either because we had prior contact with members of the medical staff or management, or because they were based in a convenient geographical location. Seven teams responded positively and were included in the study (n=116). These were based in Australia, Denmark, France, Norway and Switzerland, and included riders from 23 different nationalities. Two teams (n=49) were from the highest level of professional cycling (one UCI Pro-Tour team and one UCI Pro-Continental team with wildcard status), competing in all major races including the UCI World Tour and the Tour de France, while the remaining five were UCI Continental-level teams, competing in the UCI Europe tour (n=67).

We visited team training camps during the period between October 2008 and February 2009 and invited all cyclists in attendance to complete a 10-20 min interview on overuse injuries. Attempts were then made to conduct interviews by telephone with all team members who were not present at the camps (n=7), as well as all riders who were listed in the 2008 team rosters and who retired from international competition during or following the 2008 season for any reason (n=11). All cyclists were informed that participation in the study was voluntary and the information they provided could not be traced back to them or their team. The study was approved by the South-Eastern-Norway Regional Committee for Research Ethics and the Norwegian Data Inspectorate, and all subjects gave their informed consent prior to participation in the study.

Athlete Interviews

All athlete interviews were conducted by physical therapists with experience working within professional cycling. The interviewer went through a standardised questionnaire verbally with each subject, providing further explanation or translation of the questions

where necessary. All participating teams had an official language of either English or French, and interviews were conducted in one of these languages. Written material was also available in both languages. In two cases it was necessary to call upon a team staff member to assist in translation of the interview questions into Spanish. The interview was divided into the following sections:

1. Subject Characteristics

Subjects were questioned about their age, height and weight, the number of years they had been riding in a UCI registered team, the number of days of racing they had completed in the 2008 season, and the number of hours of training they had completed in the preceding twelve months. They were encouraged to use training records to assist in estimation of training and racing exposure.

2. Overuse Injury Registration

Subjects were asked to give information about all overuse injuries they had experienced in the preceding 12-month period. A schematic representation of the time period, including all major competitions, was shown to the subjects to assist them to recall injuries as best possible. Subjects were asked to link specific dates and races with any periods of injury upon this form. The definition of an overuse injury was any pain or discomfort that was not directly associated with a traumatic event and was different from the normal aches and pains associated with competitive cycling. We elected to use this broad definition in order to capture as many potential injuries as possible; however, only injuries that required attention from qualified medical personnel were subsequently recorded. They were further classified as “time-loss” injuries if they caused the subject to miss one or more days of training or competition.

The anatomical location of the injury was recorded using the system proposed by Fuller et al for injury surveillance studies in football (soccer).[13] Two separate methods of classifying injury severity were used; one for all registered injuries and another for those leading to time loss. The severity of medical attention injuries was assessed by classifying them into (a) injuries that did not disrupt normal training and racing

performance, (b) those during which the athlete could continue to train and compete, but with either a reduced intensity or volume, and (c) those during which the subject could not ride at all. Time-loss injury severity was assessed by using the absolute number of days of time lost from training or competition, and grouped according to the UEFA model,[15] into slight (1-3 days), mild (4-7 days), moderate (8-28 days) or severe (>28 days).

3. Low Back Pain and Anterior Knee Pain Questionnaires

After the completion of the Overuse Injury Registration, the interviewer went through two questionnaires specifically asking about lower back pain and anterior knee pain. All questions and injury definitions were based on a questionnaire from a previous study analysing lower back problems in cross-country skiing, rowing and orienteering[5] that had been developed and validated for the study of occupational injuries.[3, 23] Lower back pain was defined as "pain, ache or soreness in the low-back with or without radiating pain to the gluteal area or lower extremities" and anterior knee pain was defined as "pain, ache or soreness on the front of the knee." We chose to use the broad term "anterior knee pain" as the retrospective design made it difficult to distinguish between individual diagnoses. The standard questions in each questionnaire included the following:

- Have you ever experienced low back/anterior knee pain?
- Have you experienced low back/anterior knee pain in the previous 12 months?
- How many days in total have you had low back/anterior knee pain over the past 12 months? (none, 1-7 days, 7-30 days, >30 days but not daily, daily)
- Have you been examined or treated for low back pain/anterior knee pain by a physician, physical therapist, chiropractor or other medical personnel in the previous 12 months? (not including regular post-race massages)
- Have you taken pain-killers or non-steroidal anti-inflammatory medications for low-back/anterior knee pain in the past 12 months?

- Have you ever been hospitalised for low back/anterior knee pain?
- Have you ever had surgery for low back/anterior knee pain?
- How many days of training have you missed due to low back/anterior knee pain in the past 12 months? (none, 1-7, 8-30, >30 but not daily, daily)
- How many races have you missed due to low back/anterior knee pain in the past 12 months? (none, 1-3, 4-10, >10)

Subjects were also asked whether they had had low back or anterior knee pain symptoms during each of four season periods; (a) the period in which they are not riding their bicycle (off-season), (b) the period in which they are training on the bicycle but not yet racing (pre-season), (c) the period in which they have commenced racing but not in peak condition or competing in their most important races (early season), and (d) the period during which they are in peak condition and during which they compete in their major races of the season (peak season).

The low back pain questionnaire contained an additional question asking subjects to indicate whether they had experienced pain radiating into their gluteal area, thigh, knee, lower leg or foot. The knee pain questionnaire contained an additional question asking whether riders used pedals that allowed a degree of rotation, commonly referred to as "float," or if they preferred completely fixed pedals.

4. Sports-related iliac artery flow limitations

Subjects were asked whether they had ever been assessed a vascular specialist for leg pains related to bicycling, and if so whether they had subsequently received surgical treatment for iliac artery flow limitations.

Data Analysis and Statistical Methods

It is unknown whether subject characteristics, cycling exposure or overuse injury prevalence differs between riders in racing at the UCI World Tour/Tour de France level

and the UCI Europe Tour level and therefore all data were compared between groups. Chi square tests (Pearson's chi square and Fisher's exact tests where appropriate) were used to detect differences between non-parametric categorical variables and unpaired t-tests were used to detect differences in parametric variables. Differences were considered statistically significant if the p-value was less than 0.05.

Results

Response Rate

The seven teams included in the study included 105 active cyclists, as well as eleven former team members who had retired during or following the 2008 season. We were able to complete questionnaires with 101 of the active riders and seven of the retired riders, giving us a total response rate of 94%. Through interviews with team medical staff we were able to confirm that the three retired riders whom we were unable to contact did not end their careers due to overuse injuries. Similarly, we were able to confirm that the four active riders whom we were unable to contact were not unavailable due to overuse injury.

Subject Characteristics

Subject characteristics are shown in Table 1. Significant differences existed between the World Tour level and the Europe Tour level riders in age ($p<0.001$), the number years spent riding for UCI teams ($p<0.001$), the number of annual race days ($p<0.001$) and in annual training hours ($p<0.001$). The proportion of riders able to give exact exposure information based on their training records was 46% for the number of race days and 40% for the number of training hours, while the remainder provided an estimate. No significant differences were found however, between accurate and estimated exposure data.

(Table 1 near here)

Retrospective Injury Registration

No significant differences were observed between the World Tour and Europe Tour riders for any injury data, therefore these data are presented as for a single cohort.

During the athlete interview 63 subjects recorded a total of 94 overuse injuries for which they had received medical attention, details of which are shown in Table 2. Thirty-nine percent of medical attention injuries did not affect the subject's ability to complete normal training and racing, 36% led to a reduction in either racing performance or training volume, and 24% caused the subject to miss one or more days of training or competition. The most common medical attention injuries were lower back pain (46% of all medical attention injuries), knee pain (23%) and neck pain (10%). Time-loss injuries (Table 3) had a slightly different pattern, with knee pain the most common (57% of all time loss injuries), followed by lower back pain (17%) and lower leg or Achilles tendon injuries (13%). Seventeen percent of time-loss injuries were classified as slight, 17% as mild, 43% as moderate, and 17% as severe, whilst one case of lower back pain was sufficiently severe to end the competitive career of the subject. The average duration of time loss was 13.5 days (SD 10.1), not including the career-ending injury.

(Table 2 near here)

(Table 3 near here)

Low Back Pain Questionnaire

No significant differences were observed between cyclists competing in the World Tour and the Europe Tour in low back pain data and therefore these data are presented for a single cohort. There was a high prevalence of low back pain (Table 4), with 58% of subjects reporting symptoms in the past twelve months and 41% having sought outpatient medical assistance; however, relatively few had missed racing due to pain (6%). Symptoms were more prevalent during the pre-season preparation periods and competitive season than the off-season (Fig 1).

Anterior Knee Pain Questionnaire

No significant differences were observed between cyclists competing in the World Tour and the Europe Tour in anterior knee pain data and therefore these data are presented for a single cohort. The 12-month prevalence of anterior knee pain (36%) was lower than low back pain (Table 4). Fewer subjects sought medical assistance (19%) but more missed training (27%) and competition (9%) due to knee pain. The prevalence of anterior knee pain also fluctuated throughout the year, peaking during the pre-season (Fig 1). Twenty-eight percent of subjects reported using fixed pedals, and 72% using floating pedals.

(Table 4 near here)

(Figure 1 near here)

Iliac artery flow limitations

Six subjects (5.5%) had been investigated by a vascular specialist at some stage during their professional career for exercise-related leg pains. Two of these (1.8%) had been diagnosed with unilateral sports-related flow-limitations of their external iliac artery and had undergone surgery for the condition.

Discussion

We found that symptoms of both lower back pain and anterior knee pain were common among elite cyclists, with an annual prevalence of 58% and 36%, respectively. More than half of all time-loss injuries were located at the knee, whereas cyclists were unlikely to miss training or competition due to lower back pain. Despite this, a large percentage suffered from performance-limiting lower back pain symptoms and sought medical attention for it. Other injuries previously reported to be common in recreational cyclists, such as neck pain and hand numbness, were generally mild or non-existent in this group with only four cases of neck pain affecting cycling performance and only one leading to significant time-loss from cycling participation.

To our knowledge, this is only the second epidemiological study investigating overuse injuries in elite competitive cyclists. While we consider this to be a methodological improvement on the one existing study, it does have some limitations which much be taken into consideration when interpreting the results. Instead of using a prospective design, currently considered the gold standard in injury surveillance research,[13] we conducted a cross-sectional study with retrospective data collection. This was primarily due to doubts over the quality of the data we were likely to be able to collect prospectively from a large group of professional cyclists, each of whom compete in an individualised and highly variable international race program. Recent evidence suggests that in such logistically difficult situations, retrospective athlete interviews may capture a greater amount of injury data than prospective collection based on team medical staff reporting.[9, 11] The main explanations for this are thought to be that minor injuries are not always reported to and examined by team medical staff, and that team medical staff are not always travelling with the athletes. This is particularly true for professional cycling teams, where riders and support staff rotate to take part in the various competitive events the team takes part in. However, the major problem with retrospective studies is that they are subject to the threat of recall bias. Previous studies investigating the effects of recall bias show a general under-reporting of injury occurrence, particularly for milder injuries,[19] and an over-estimation of exposure data.[21] Interestingly, in this study no significant differences were found between exposure estimates and data from accurate training records when the data were subjected to statistical analysis, however it is impossible to know for certain how accurate the estimates were. We attempted to minimise recall bias during the general injury registration by presenting a graphical representation of the previous competitive season and asking subjects to link specific dates and races with any periods of injury. This technique has been used before in a study of beach volleyball injuries with apparent success;[4] however, the recall period of that study was only eight weeks and the effect of using the same strategy over a one-year period is uncertain. Despite this, it remains likely that there is an element of injury underreporting in the current study due to recall bias. For example, while 27% of riders reported having missed training due to knee pain in the anterior knee pain questionnaire, only 13 time-loss knee injuries were identified during the retrospective injury

registration. This discrepancy is most likely explained by a number of time-loss injuries being forgotten during injury registration, and then recalled when subjects were prompted by specific questions within the knee questionnaire. The question of whether location-specific questionnaires may be more accurate than general retrospective injury registration in dealing with recall bias could therefore be asked.

The fact that data were collected through direct athlete interviews by medically trained personnel allowed for a greater level of detail, and presumably accuracy, than for example had they been collected through an internet-based survey. However this introduced a risk that the opinions or expectations of the interviewers may have biased the results. Interviewers were therefore instructed to remain as objective as possible and not to attempt to influence the data given by each subject. Nevertheless, this source of bias cannot be ruled out.

The lower back and knee pain surveys were included in this study as recent evidence shows that questionnaires of this type may give additional information on overuse injury problems that is not captured by normal injury registration methods.[6] However, the particular focus on these two injury areas introduces the potential for bias in the general injury registration data. To eliminate this source of bias, the specific questionnaires were conducted after the general registration was completed.

Cross-sectional studies are also subject to the threat of sampling bias, for example data collected at a competitive event may underestimate true injury levels, as more seriously injured subjects may be absent. We expected this to be a particular problem in professional cycling, as only a small percentage of each team may be present at any given race. For this reason we chose to collect data when entire teams were gathered together, regardless of riders' fitness or injury status, and made a substantial attempt to contact any missing or recently retired riders by telephone. As we were able to include a high percentage of targeted riders, and given the geographic diversity of this study's sample, there is good reason to believe that this study's subjects are a representative sample of road cyclists competing on an equivalent level.

The high prevalence of anterior knee pain in this study is consistent with previous epidemiological investigations of professional[7] and recreational cyclists,[11, 22, 29, 31] and appears to confirm anecdotal reports that knee pain is a common injury affecting competitive cyclists.[16-17, 25] If, in accordance with currently recommended sports epidemiology methods,[13-14, 20] time loss is used as the sole measurement of injury severity, then it would seem that knee injuries are clearly the most significant problem affecting professional cyclists. Lower back pain on the other hand, would according to these methods seem to be a far milder complaint, given the comparatively low number of time-loss injuries it caused. However, although time loss was a relatively rare consequence, lower back pain was clearly the problem leading to the greatest amount of medical attention. While some degree of lower back discomfort may be considered a normal part of such a physically demanding sport, more than one in five riders reported back pain causing reduced cycling performance. The injury load posed by the problem should therefore not be so easily dismissed. A reduced capacity to train and race could in itself be considered a serious injury outcome in a cohort such as this, for whom career and financial success is so dependent on optimum physical performance. Furthermore, a significantly greater percentage of cyclists reported long-term (>1 month) symptoms from lower back pain than knee pain and one rider ended their professional cycling career due to lower back pain. In fact, results from the low back pain questionnaire were highly comparable with results from other sports where lower back pain is considered to be a significant problem, such as cross-country skiing and rowing.[5] Clearly, lower back pain represents a significant injury load on competitive cyclists, yet current recommended injury-surveillance methodology, developed primarily for the study of acute injuries, is unequipped to adequately measure it. The development of novel methods to quantify overuse injury problems, with focus on prospective measurement of functional impairment and exercise exposure, is needed.[6]

In analysing the prevalence of symptoms throughout the year, lower back pain is relatively even during periods of racing or training, and markedly lower during the off-season. This indicates a strong relationship between cycling and lower back pain. For knee pain, symptoms were also lowest during the off-season and most prevalent during

the pre-season preparation period. This could perhaps be explained by rapid increases in training load over this period, or perhaps other factors such as cold weather conditions, as this season period occurs during winter for a vast majority of subjects. Prospective investigations including risk factor analysis and accurate exposure measurement would be necessary to ascertain this with more certainty.

There was generally a low prevalence of upper-body complaints, and with the exception of one serious case of neck pain, almost all those reported were without functional consequence. This finding is in contrast to several studies of recreational cyclists, among which neck pain prevalence has been reported to be as high as 66%.[29] Parasthesia of the ulnar nerve, sometimes known as “handlebar palsy” has also been reported to be highly prevalent in cyclists,[2, 22, 27] however no cases were recorded in this study. One explanation for this, favoured by Barrios et al,[7] is that to elite cyclists these conditions are familiar and of such little consequence that they are regarded as a normal part of the sport. Alternatively it could be speculated that these athletes have, by this stage in their cycling career, either adjusted their bicycle position to minimise discomfort on upper body structures, or physically adapted to the ergonomic demands of the sport.

Arterial claudication problems would perhaps not normally fall under the umbrella of overuse sports injuries; however, we felt the inclusion of iliac artery flow limitations in this study was indicated, as the condition has been linked to cycling exposure and has frequently been reported to be a common problem in elite cyclists. Despite this, the only information available on the magnitude of the problem among cyclists is a suggestion that 20% of all top-level cyclists may suffer from the condition.[8] However, as this was based on a study by a group of surgeons that regularly treat the condition,[28] it may be subject to sampling bias. Having only identified two athletes who had received surgery for flow limitations, our results suggest a far lower prevalence than this. Investigations involving greater numbers of cyclists would be necessary before more definitive conclusions could be made.

Conclusion

This article provides new information on the pattern of overuse injuries sustained by professional road cyclists. Lower back pain and anterior knee pain were found to be the most prevalent overuse injuries, with knee injuries most likely to cause time-loss from cycling and lower back pain leading to the highest rates of functional impairment and medical attention. Future efforts to prevent overuse injuries in competitive cyclists should focus on these injuries.

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Tables

Table 1 Subject Characteristics

	Europe Tour (n=60)	World Tour (n=49)	Total (n=109)
Age	25 (4)	28 (5)	26 (4)
Height (cm)	182 (6)	181 (6)	181 (6)
Weight (kg)	71 (6)	69 (6)	70 (6)
Years Professional	3.2 (2.5)	6.0 (3.9)	4.5 (4.0)
Annual Racing Days	53 (19)	77 (16)	64 (21)
Annual Training Hours	869 (134)	952 (99)	904 (127)

Values shown are mean (SD)

Table 2 Location and Severity of Medical Attention Injuries (number of injuries)

	Normal training and racing	Reduced performance	Could not ride bicycle	Career ending	Total
Lower Leg / Achilles Tendon	2	1	3	0	6
Knee	4	5	13	0	22
Thigh	1	4	1	0	6
Hip / Groin	0	1	0	0	1
Lower back / Pelvis / Sacrum	20	19	3	1	43
Abdomen	1	1	0	0	2
Sternum / Ribs / Upper back	0	1	0	0	1
Hand/ Finger / Thumb	1	0	0	0	1
Forearm	1	0	0	0	1
Shoulder / Clavicle	1	0	0	0	1
Neck / Cervical spine	6	2	2	0	10
Total	37	34	22	1	94

Table 3 Location and Severity of Time Loss Injuries (number of injuries)

	Slight (1-3 days)	Mild (4-7 days)	Moderate (8-28 days)	Severe (>28 days)	Career Ending	Total
Lower Leg / Achilles Tendon	1	1	1	0	0	3
Knee	1	3	7	2	0	13
Thigh	0	0	1	0	0	1
Lower back / Pelvis / Sacrum	1	0	1	1	1	4
Neck / Cervical spine	1	0	0	1	0	2
Total	4	4	10	4	1	23

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Table 4. Responses (number of riders) to low back pain/anterior knee pain questionnaires (n=109)

	Lower Back Pain	Anterior Knee Pain
Symptoms ever	71	61
Symptoms in previous 12 months	63	39
Total symptom duration		
1-7 days	21	11
8-30 days	23	21
>30 days but not daily	16	7
Daily	3	0
Outpatient medical assistance	45	21
NSAIDs in previous 12 months	15	20
Hospitalisation	8	7
Surgery	2	3
Missed training in previous 12 months	12	29
Number of days of missed training		
1-7 days	9	21
8-30 days	2	8
>30 days	2	0
Missed races in previous 12 months	6	10
Number of missed competitions		
1-3 races	3	7
4-10 races	0	2
>10 races	3	1
Referral of symptoms		
Gluteal region	5	-
Thigh	7	-
Knee	7	-
Lower leg or foot	13	-

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Figures

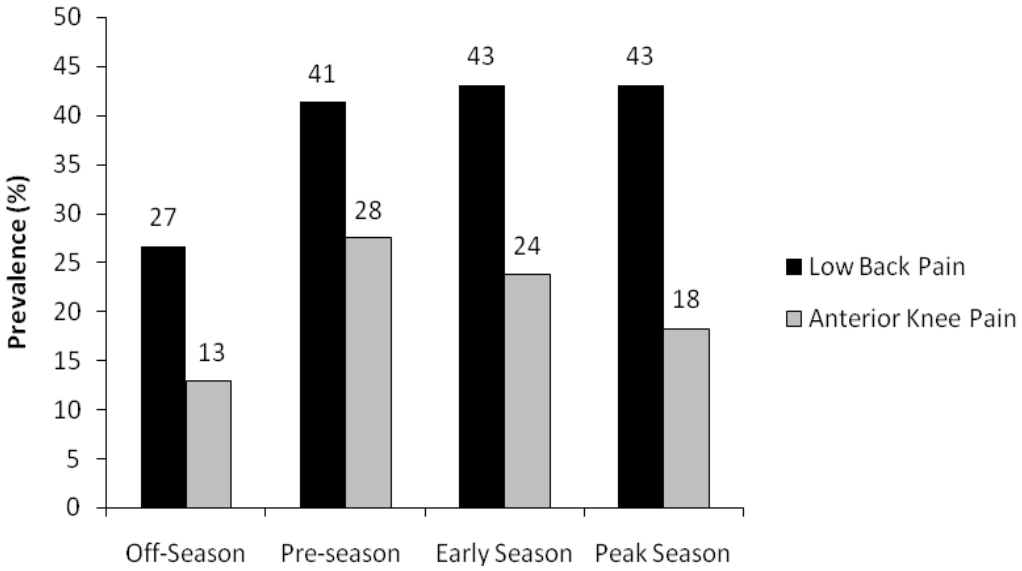

Figure 1. Prevalence of anterior knee pain and lower back pain throughout the season