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Annals of Sports Medicine and Research

Research Article

The Prevalence and Factors Associated with Knee Pain in a sample of Cyclists within the United Kingdom: A Cross Sectional Study

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Submitted: 29 September 2023
Accepted: 30 October 2023
Published: 31 October 2023
ISSN: 2379-0571

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OPEN ACCESS

Keywords
- Knee Pain
- Cyclists
- Prevalence
- Injury

Abstract

Purpose: The study aimed to determine: (i) the lifetime and period prevalence of knee pain, (ii) the prevalence and nature of medical attention cycling-related injuries, (iii) and the risk factors associated with knee pain and in a sample of competitive and non-competitive cyclists in the UK.

Methods: A cross-sectional questionnaire was used to collect data on knee pain, medical attention injuries, and potential risk factors associated with knee pain. Participants were competitive and non-competitive cyclists aged 18 years and older and were recruited through cycling clubs and online advertisement. Binary logistic regression was used to assess for potential risk factors associated with knee pain. Crude and adjusted odds ratios were reported in staged adjustment models, controlling for potential confounders of age and sex. Keele University Ethics Committee approved this study.

Results: A total of 115 respondents completed the questionnaire. Lifetime knee pain prevalence was 48%, with period prevalence 26.1% (past-month) and 18.3% (past-week). Aged 40 and over was the only factor found to be associated with knee pain, although this was no longer significant after adjustment for female sex. The most prevalent site and type of injury was the lower back and fracture (traumatic), respectively.

Conclusion: Knee pain prevalence is high in this sample of cyclists, particularly in those aged 40 years and over. Injury prevention strategies should target the lower back and fractures. Longitudinal research is needed to identify if there are modifiable risk factors that may reduce the occurrence of both knee pain and traumatic fractures in cyclists.

INTRODUCTION

Cycling is becoming an increasingly popular sport in the UK as a form of recreation, transport, and competition [1]. The sports rise in popularity can be attributed to both the governments' investment in cycling transport infrastructure and because of recent British success in the Olympic Games and the Tour de [2].

The repetitive nature of the pedal stroke means that cyclists are at particularly high risk of developing knee pain resulting from overuse injuries [3]. An overuse injury has been defined as pain resulting from cumulative tissue damage and is caused by the gradual transfer of kinetic energy [4]. Similarly, cyclists are at risk of traumatic injuries resulting from high impact and often result from incidents caused by external factors [4]. Previous studies confirm that overuse injuries are the most prevalent cause of knee pain in cyclists [5,6].

Generally, studies investigating the prevalence of both knee pain and injury in cyclists either focus on non-competitive cyclists, those who cycle for pleasure or fitness, or competitive cyclists, those who partake in cycling races as a form of competition [7]. The most comprehensive epidemiological study looking at the prevalence of injuries in professional competitive cyclists took place between 1983 and 1995 and reported the knee as the site with the highest severity of injury [5]. Similarly, Collagen and Jarvis [8], performed medical screenings at the British Cycling Performance Centre and reported the knee as the second most prevalent injury in the Great Britain Cycling Team. A more recent Norwegian study by Clarsen and Bahr [9], conducted interviews with 109 professional competitive cyclists over a 12-month period and estimated knee pain prevalence at 23%. Their study also reported the knee as being the site most likely to cause a time-loss injury. Similarly, a later epidemiological study by Clarsen et al. [10], found the knee to be the most prevalent site of injury amongst 98 national level cyclists.

Similar cross-sectional studies have looked at the prevalence of knee pain in recreational cyclists. An early study by Weiss [11], predicted knee pain prevalence at 20% in a group of recreational cyclists who took part in a 500-mile, eight-day bicycle tour. Contrary to this, a more recent study reported that only 2.5% of cyclists reported knee pain during a cycling sportive event in Cape Town [3]. Suggesting that knee pain may be more likely to occur in cyclists who have a high accumulative training load, rather than in individuals who take part in a single day event.

Few studies have looked at factors that are associated with knee pain in cyclists. A recent systematic review by Visentini et al. [12], reported no strong evidence of a relationship between any bike, body, or load parameter and knee pain in any of the 18 studies included in their analysis. However, they did report moderate evidence of an association between overuse knee pain with increased cycling volume, having a professional bike-fit, and riding a mountain bike. Another systematic review [13], discussed biomechanical factors which may be associated with knee pain in cyclists, and reported that larger knee adduction, increased ankle dorsiflexion, and rotation forces at the knee, caused by 'float' at a bicycles pedal are potential risk factors. However, they found no association between saddle height, design, or angle, having had a bike-fit, and occurrence of knee pain. Althunyan et al. [14], investigated numerous potential risk factors associated with knee pain in cyclists in Saudi Arabia, and concluded that running, football participation, and being underweight are potential risk factors.

The high prevalence of knee pain and injury in cyclists combined with the increasing number of cyclists is likely to lead to an increase in cyclists presenting to physiotherapy clinics. Therefore, it is becoming of increasing importance for physiotherapists to understand the prevalence of both knee pain and injury in cyclists and their associated risk factors. A greater understanding of associated risk factors can help inform physiotherapists treatment and in turn prevent cyclists from developing time loss injuries, whereby individuals are unable to ride their bike for twenty-four hours or more [15]. One limitation of studies looking into both knee pain and injury prevalence in cyclists is that they only focus on one singular cycling population, such as competitive or non-competitive cyclists. Furthermore, the only two known systematic reviews investigating factors associated with knee pain in cyclists have recommended a need for high quality studies that investigate cycling related knee pain and its potential associated risk factors. Moreover, to the best of the researcher's knowledge, there has been no study to date focusing on the prevalence of knee pain and its associated risk factors in cyclists in the UK. Therefore, the objectives of this study are to determine: (i) the lifetime and period prevalence of knee pain; (ii) the prevalence and nature of medical attention cycling-related injuries; (iii) and the risk factors associated with knee pain and in a sample of competitive and non-competitive cyclists in the UK.

MATERIALS AND METHODS

Study Design

This cross-sectional study gave cyclists the opportunity to complete an online questionnaire. Anonymity in the study was ensured by omitting identifiable characteristics from the questionnaire. The study gained ethical approval from the Student Projects Ethic Committee at Keele University in August 2022. All participants gave informed consent to participate in the study, by clicking 'I agree' to both the participant information sheet and consent form on the first page of the questionnaire.

Recruitment, Setting, and Eligibility Criteria

Recruitment took place between October 2022 and January 2023. Participants were recruited through emails sent to their cycling club, or online advertisement on cycling specific social media channels. Cycling clubs were initially sent a first email, and if they agreed to participate, they were sent a second email, which they could distribute amongst their members. No follow-up emails were sent to cycling clubs. To participate in the study individuals had to be over the age of 18, be a self-declared cyclist and, give informed consent to participate. The only specified exclusion criterion was the failure to give informed consent.

Data Collection and Management

The questionnaire was developed for the purpose of this study and collected data on the following demographics: personal and cycling characteristics, history of knee pain, and history of cycling related injuries. Personal characteristics were collected on self-reported measures of age (age group, years), sex (male/female/enter other), height (cm), weight (kg), and ethnicity [16]. Knee alignment was recorded using self-reported mal-alignment drawings (straight-legs; bow-legged; or knock-knees. Prevalence of occupational knee loading was based on activities at work (lifting-heavy loads, kneeling, and squatting = never; seldom; sometimes; often; or always [17]. Cycling characteristics were collected on cycling status (competitive vs non-competitive), number of kilometres and hours cycled on average per week (both outside and virtual), having undertaken a professional bike-fit, whereby an expert adjusts bicycle dimensions to optimise the bike for an individual's body (yes/no), having a coach or following a set training plan (yes/no), and crank length (cm) and pedal type (by brand) used.

Knee pain prevalence questions were based on the Keele KNEST questionnaire [18], and determined lifetime prevalence by asking participants 'have you ever had pain in and around your knee?' (Yes, right knee; yes, left knee; yes, both knees; no never). Two further questions were asked to obtain knee pain period prevalence over the past month and past seven days: 'have you had pain around your knee on most of the days over the past month?', and 'Have you had knee pain over more than half of the days in the past seven days?'. If participants answered 'yes' to the lifetime prevalence question, it was followed up with the question 'Thinking back to your knee pain, how long did this knee pain last? (Less than 7 days; 1-4 weeks; more than 1 month but less than 3 months; more than 3 months). If the participants answered 'Yes' to either lifetime or period prevalence questions they were asked the following about the characteristics of the knee pain; whether cycling aggravated their knee pain (by asking participants to rate their pain from zero to ten at rest and while cycling on a Numerical Rating Scale [19], their age when they had their knee pain started (age group, years), which treatments they sought for their knee pain, and if and for how long their knee pain preventing them from riding their bike (Yes, for up to 7 days; yes, for more than 7 days but less than 1 month; yes for more than 28 days; or no).

Participants were asked about their history of cycling related injuries. The presence of a significant cycling related injury was adapted from Cooper et al. [20], whereby participants were asked 'Have you ever suffered an injury, which either occurred during cycling or was as the result of cycling that caused pain for most days for one month or more and for which you consulted a medical professional or healthcare provider such a general practitioner'. If a participant answered 'Yes', they were asked to self-report the following information on their injury or injuries based on International Olympic Committee recommendations [21]: anatomical location of injury, type of injury (diagnosis if able), training or competition injury, and amount of time lost as result of injury. Participants were asked the following additional medical questions: 'Have you received any form of surgery within the past five years' (yes/no), if yes, they were then asked to provide details on anatomical location, type, and the age at time of surgery. Participants were also asked to report relevant history of medical conditions (comorbidities). Participants were able to input multiple injuries and surgeries into the questionnaire.

Age categories were merged and coded into those at risk of developing knee pain (40 years and older) and those not at risk (18-40 years [22]. A competitive cyclist was defined as an individual who has a British Cycling (2023) race license, and a non-competitive cyclists someone who cycles with a club, individually or commutes for pleasure or fitness. Lifetime knee pain was defined as pain in either both, left or right knees that lasted longer than one month. The type and location of injuries were coded based on the work of Fuller et al. [23], for recording injuries in football. Numerical variables remained uncoded. BMI was calculated by dividing an individual's weight (kg) divided by their height (m) squared. The number of injuries per participant was found by calculating the mean number of reported injuries per participant.

Cleaning of the data took place on Microsoft Excel [24]. Kilometres and hours cycled per week were cleaned to ensure that all participants had a weekly rather than a yearly value, as it was evident some participants had mistakenly entered how many kilometres and hours they cycle on average per year rather than per week. This was done by dividing yearly values by fifty-two.

Statistical Analysis

Data was analysed in SPSS version 27.0 [25]. Descriptive statistics were presented as frequencies (percentages) for categorical variables and as mean and standard deviation or median and range for normal and non-normally distributed continuous data, respectively. Normal distribution was confirmed by a histogram with a normally distributed bell-shape curve, a Kolmogorov-Smirnov significance score of >0.05, and if data was distributed close to a linear line on a normal Q-Q plot (Appendix F).

The Independent-sample t-test and Mann-Whitney U Test were used to test for significant association between numerical variables with normally and non-normally distributed data, respectively. The Chi-squared Test for independence was used to test for association between categorical variables. Crude odds ratios with 95% confidence intervals were used to test for factors related to lifetime knee pain prevalence and injury. Factors were adjusted with staged adjustment for the potential confounders of age and gender. Significance was accepted at p = <0.05.

RESULTS AND DISCUSSION

A total of 115 respondents completed the online questionnaire. The characteristics of the participants are reported in [Table 1]. A Chi-Squared test for independence (with Yates Continuity Correction) indicated no significant association between age (X^2 (1, n = 115) = .351, p = .553, Phi = - .077), gender (X^2 (1, n = 115) = .006, p = .940, Phi = -.028), having had a bike-fit (X^2 (1, n = 115) = .58, p = .810, Phi = -.041), having a comorbidity (X^2 (1, n = 115) = .70, p = .792, Phi = -.043), having a history of surgery (X^2 (1, n = 115) = .232, p = .630, Phi = -.069) and cycling status . Competitive cyclists were more likely to have a coach (X^2 (1, n = 115) = 10.356, p = .001, Phi = -.320). A Pearson Chi-Square Test for independence indicated an association between pedal type used (X^2 (5, n = 115) = 14.25, p = .014, Cramer's V = .352) (medium effect size), the crank length used (X^2 (4, n = 115) = 16.453, p = .002, Cramer's V = .378) (medium effect size), angle at the knee (X^2 (2, n = 115) = 10.276, p = .006, Cramer's V = .299) (small effect size), and cycling status. No association was detected between occupational knee loading prevalence (X^2 (4, n = 115) = 5.076, p = .280, Cramer's V = .210) and cycling status. An independent-sample t-test indicated no significant association between height (Competitive: M = 176.32, SD = 9.37; Non-competitive: M = 175.8, SD = 9.88. t (113) = .268, p = .574 (two-tailed)), weight (Competitive: M = 76.44, SD = 13.68; Non-competitive: M = 74.12, SD = 11.70. t (113) = .937, p = .076 (two-tailed)) and cycling status. A Mann-Witney U Test indicated a non-significant association between BMI (U = 1326.50, p = .565) and cycling status, however, did indicate a significant association between kilometres (U = 691.00, p = <.001) and hours (U = 823.50, p = <.001) cycled per week and cycling status.

Table 2 shows the lifetime, monthly, and weekly knee pain prevalence amongst participants. 48.7% (n = 56) (competitive cyclists = 52.8%, n = 19; non-competitive cyclists = 46.8%, n = 37) of participants reported having experienced knee pain within their lifetime that lasted longer one month, with 64.3% (n = 36) of those reporting it lasted longer than 3 months. Of those who reported lifetime knee pain, 69.6% (n = 39) reported that it was aggravated by cycling. 41.1% (n = 23) reported that it occurred between the ages of 18-40 years, with 55.4% (n = 31) above the age of 40, and 3.6% (n = 2) reporting they could not remember. There was inconsistency between which knee was most likely

Table 1: participant characteristics of a sample of competitive and non-competitive cyclists

Characteristic	**All (n = 115)**	**Competitive cyclists (n = 36, 31.3%)**	**Non-competitive cyclists (n = 79, 68.7%)**	***P* values**
Age (years) †				.553
- 18-40	28 (24.3)	17 (47.2)	11 (13.9)	
- 40+	87 (75.7)	19 (52.8)	68 (86.1)	
Gender †				.940
- Male	82 (71.3)	31 (86.1)	51 (64.6)	
- Female	33 (28.7)	5 (13.9)	28 (35.4)	
Height (cm) ‡	176 (9.69)	177.28 (7.69)	175.36 (10.46)	.574
Weight (kg) ‡	74.85 (12.34)	73.61 (11.93)	75.40 (12.55)	.076
BMI (kg/m^2) §	23.5 (14.34)	22.80 (11.60)	24.04 (13.79)	.565
Ethnicity † ¶				-
- White British	101 (87.8)	35 (97.2)	66 (83.3)	
- Other white	5 (4.3)	-	5 (6.4)	
- White Irish	7 (6.1)	1 (2.8)	6 (7.7)	
- White and Asian	1 (.9)	-	1 (1.3)	
- African	1 (.9)	-	1 (1.3)	
Kilometres cycled per week §	150 (537)	202.50 (498)	120 (449)	**<.001**
Hours cycled per week §	7 (25)	10 (22.5)	7.39 (25)	**<.001**
Bike-fit †				.810
- No	61 (53.0)	18 (50.0)	43 (54.4)	
- Yes	54 (47.0)	18 (50.0)	36 (45.6)	
Coach †				**.001**
- No	74 (64.3)	15 (41.7)	59 (74.7)	
- Yes	41 (35.7)	21 (58.3)	20 (25.3)	
Pedal type (brand) †				**.014**
- Flats	4 (3.5)	-	4 (5.1)	
- Look	32 (27.8)	13 (36.1)	19 (24.1)	
- Shimano	37 (32.2)	14 (38.9)	23 (29.2)	
- Shimano SPD	34 (29.6)	4 (11.1)	30 (38.0)	
- Speedplay	7 (6.1)	4 (11.1)	3 (3.8)	
- Time	1 (0.9)	1 (2.8)	-	
Crank length (cm) †				**.002**
- 167.5	10 (8.7)	6 (16.7)	4 (5.1)	
- 170	38 (33.0)	18 (50.0)	20 (25.3)	
- 172.5	40 (34.8)	10 (27.8)	30 (38.0)	
- 175	8 (7.0)	1 (2.8)	7 (8.9)	
- Does not know	19 (16.5)	1 (2.8)	18 (22.8)	
Knee alignment †				**.006**
- Normal	104 (90.4)	29 (80.6)	75 (94.9)	
- Bow legged	4 (3.5)	1 (2.8)	3 (3.8)	
- Knock-knee	7(6.1)	6 (16.7)	1 (1.3)	
Occupational knee loading †				.280
- Never	51 (44.3)	13 (36.1)	38 (48.1)	
- Seldom	32 (27.8)	12 (33.3)	20 (25.3)	
- Sometimes	15 (13.0)	4 (11.1)	11 (13.9)	
- Often	13 (11.3)	4 (11.1)	9 (11.4)	
- Always	4 (3.5)	3 (8.4)	1 (1.3)	
History of surgery †				.630
- No	94 (81.7)	28 (77.8)	66 (83.5)	
- Yes	21 (18.3)	8 (22.2)	13 (16.5)	
Comorbidity†				.792
- No	58 (50.4)	17 (47.2)	41 (51.9)	
- Yes	57 (49.6)	19 (52.8)	38 (48.1)	

† n (%)
‡ mean (SD)
§ median (range)
¶ Unable to test for association as variable violates minimal expected cell frequency (>80% cells have a cell frequency < 5)

Table 2: lifetime and period knee pain prevalence of a sample of competitive and non-competitive cyclists

Knee pain prevalence	All (n = 115)	Competitive cyclists (n 36)	Non-competitive cyclists (n = 79)	*P* values
Lifetime prevalence †				
- No	59 (51.3)	17 (47.2)	42 (53.2)	.696
- Yes	56 (48.7)	19 (52.8)	37 (46.8)	
Lifetime knee pain by effected knee (n = 56)†				
- Both knees	24 (42.9)	11 (57.9)	13 (35.2)	
- Left knee only	11 (18.5)	3 (15.8)	8 (21.6)	-
- Right knee only	21 (37.5)	5 (26.3)	16 (43.2)	
Period prevalence (past month) †				
- No	85 (73.9)	29 (66.7)	56 (70.9)	.451
- Yes	30 (26.1)	7 (19.4)	23 (29.1)	
Period prevalence (past month) by effected knee (n = 30) †				
- Both knees	4 (13.3)	-	4 (5.1)	-
- Left knee only	10 (33.3)	2 (28.6)	8 (10.1)	
- Right knee only	16 (53.3)	5 (71.6)	11 (13.9)	
Period prevalence (past week) †				
- No	94 (81.7)	33 (91.7)	61 (77.3)	.990
- Yes	21 (18.3)	3 (8.3)	18 (22.7)	
Period prevalence (past week) by effected knee (n= 21)†				
- Both knees	4 (19)	-	4 (22.2)	-
- Left knee only	5 (23.8)	1 (33.3)	4 (22.2)	
- Right knee only	12 (57.2)	2 (66.7)	10 (55.6)	

† n (%)

to be affected for lifetime, monthly, and weekly knee pain prevalence, with both knees most likely to be affected in those who reported lifetime knee pain (42.9%, n = 24), whereas the right knee was most likely to be affected for both monthly and weekly knee pain (Monthly = 53.3%, n = 16; Weekly = 57.2%, n = 12). A Chi-Squared Test for independence (with Yates Continuity Correction) indicated no significant association between lifetime (X^2 (1, n = 115) = .152, *p* = .696, Phi = -.055), monthly (X^2 (1, n = 115) = .569, *p* = .451, Phi = .104) and weekly knee pain prevalence (X^2 (1, n = 115) = 2.727, *p* = .99, Phi = .201) and cycling status.

Tables 3 and 4 report injuries by location and type of injury, respectively. 46.1% of participants experienced a medical attention injury that directly resulted from cycling (53/108). Each participant reported a mean of 0.96 injuries, across 19 anatomical locations. Amongst all participants, the lower back was the most effected site of injury (13%, n = 14,), followed by the shoulder (12%, n = 13), followed by the knee (9.3%, n = 10). Non-competitive cyclists reported the shoulder as the most effected site of injury (14.5%, n = 9,), whereas competitive cyclists reported the lower back as the most effected site of injury (15.2%, n = 7). Of the 108 injuries, there were 13 different types of injuries reported [Table 5]. Across all groups, Fracture (traumatic) (All = 39.8%, n = 43; Competitive = 43.5%, n = 20; Non-Competitive = 37.1%, n = 23) was the most frequently reported type of injury followed by contusion / hematoma (All = 17.6%, n = 19; Competitive = 17.4%, n = 8; Non-Competitive = 17.7%, n = 11).

Tables 5, 6, and 7 report the constitutional and biomechanical factors contributing to lifetime, monthly, and weekly knee pain prevalence, respectively. [Table 8] reports potential factors associated with self- reported injury. Being aged 40 years and older was associated with lifetime knee pain (OR = 3.01 (1.22, 7.74) *p* = .017), but not monthly or weekly knee pain. No other factors including, gender, BMI, cycling status, kilometres and hours cycled per week, having a coach or bike-fit, crank, or pedal type used, having a comorbidity, and history of surgery were associated with lifetime, monthly, and weekly knee pain. Similarly, being aged 40 years and older was also associated with self-reported injury (OR = .36 (.15, .86), *p* = .022). Following adjustment for gender, age was no longer associated with both lifetime knee pain and injury (Lifetime knee pain: OR = 1.57 (.67, 3.66) *p* = .30; Injury: OR = 1.11 (.48, 2.56) *p* = .804). Non-competitive cyclists were more likely to report an injury (OR = .39 (.17, .88) *p* = .022), even after adjustment for age and gender (aOR = 0.34 (0.15-0.79) *p* < 0.05)

DISCUSSION

This study aimed to determine: (i) the lifetime and period prevalence of knee pain; (ii) the prevalence and nature of medical attention cycling-related injuries; (iii) and the risk factors associated with knee pain and in a sample of competitive and non-competitive cyclists in the UK. The main findings of this study are: (i) lifetime knee pain prevalence was 48%, (ii) period prevalence of knee pain was 26.1% (past-month), and 18.3% (past-week), (iii) those aged 40 years and older had a higher period prevalence of knee pain, although this was no longer significant after adjustment for female sex, (iv) injuries were more prevalent at the lower back, shoulder, and knee for all cyclists, whereas the shoulder was the most common location of injury in non-competitive cyclists, and (v) the most prevalent injury type was traumatic fracture, contusion, and tendinopathy.

This study demonstrated cyclists have a high prevalence of

Table 3: Self-reported medical attention injuries by location of a sample of competitive and non-competitive cyclists

Injuries by location	Injuries in all (n = 108) †	Injuries in competitive cyclists (n = 48) †	Injuries in non-competitive cyclists (n = 62) †
Lower back	14 (13.0)	7 (15.2)	7 (11.3)
Shoulder	13 (12.0)	4 (8.7)	9 (14.5)
Knee	10 (9.3)	5 (10.9)	5 (8.1)
Ribs	9 (8.3)	3 (6.5)	6 (9.7)
Hip	8 (7.4)	5 (10.9)	3 (4.8)
Collarbone	7 (6.5)	2 (4.3)	5 (8.1)
Head	7 (6.5)	2 (4.3)	5 (8.1
Elbow	7 (6.5)	3 (6.5)	4 (6.5)
Lower legs	5 (4.6)	1 (2.2)	4 (6.5)
Pelvis/SIJ	4 (3.7)	3 (6.5)	1 (1.6)
Thigh	4 (3.7)	-	4 (6.5)
Ankle	3 (2.8)	2 (4.3)	1 (1.6)
Wrist	3 (2.8)	2 (4.3)	1 (1.6)
Neck	3 (2.8)	1 (2.2)	2 (3.2)

Table 4: Self-reported medical attention injuries by type of a sample of competitive and non-competitive cyclists

Type of injury †	Injuries in all (n = 108)	Injuries in competitive cyclists (n = 48)	Injuries in non- competitive cyclists (n = 62)
Fracture (traumatic)	43 (39.8)	20 (43.5)	23 (37.1)
Contusion / Hematoma	19 (17.6)	8 (17.4)	11 (17.7)
Other / missing	18 (16.7)	8 (17.4)	10 (12.7)
Tendinopathy	5 (4.6)	3 (6.5)	2 (3.2)
Cartilage injury	5 (4.6)	3 (6.5)	2 (3.2)
Muscle injury (strain)	3 (2.8)	-	3 (4.8)
Disc prolapse	3 (2.8)	-	3 (4.8)
Nerve injury	3 (2.8)	2 (4.3)	1 (1.6)
Ligament injury (sprain)	3 (2.8)	1 (2.2)	2 (3.2)
Dislocation / subluxation	2 (1.9)	-	2 (3.2)
Concussion	2 (1.9)	1 (2.2)	1 (1.6)
Laceration	1 (0.9)	-	1 (1.6)
MTSS	1 (0.9)	-	1 (1.6)
Forearm	3 (2.8)	2 (4.3)	1 (1.6)
Hand	3 (2.8)	2 (4.3)	1 (1.6)
Foot / toe	2 (1.9)	-	2 (3.2)
Sternum	2 (1.9)	1 (2.2)	1 (1.6)
Thumb	1 (0.9)	1 (2.2)	-

† n (%)

knee pain, which appears to be higher than that reported among the general population, a finding which is supported by existing evidence [9,14,26]. However, it is difficult to draw comparisons between the results of this study and that of previous studies because of heterogeneity among participants characteristics, and variations with the methods used to record pain. In addition, there are few studies examining knee pain in cyclists. Althunyan et al. [14], estimated yearly knee pain prevalence at 25.8% in a group of competitive and non-competitive cyclists and, similarly, reported no statistically significant association between cycling status and knee pain. Clarsen and Bahr [9], reported yearly knee pain prevalence to be 23% in a group of professional cyclists, a similar value to the monthly prevalence of knee pain in competitive cyclists in this study (18.3%). Meanwhile, Weiss [11], monitored non-competitive cyclists during an eight-day cycling ride and estimated knee pain prevalence at 20%, close to the weekly prevalence of knee pain amongst non-competitive cyclists in this study (22.7%).

This study found that being over age 40 and over was associated with knee pain, an association that has been widely reported across both the cycling and general population [27]. However, was no longer associated when adjusted for female gender. The increased risk of knee pain in those over 40 years of age can be attributed to the degenerative changes that occur around the knee because of the natural aging process [28]. Other than age, this study found no factors to be associated with knee pain. The latest systematic review investigating risk factors associated with knee pain in cyclists had similar findings, with the authors concluding there to be no strong evidence to associate any bike, body, or load parameter and knee pain [29]. However, they did report that there is moderate evidence that an increase in cycling load (kilometres or hours cycled per week) and having a bike-fit, may be associated with overuse injuries causing knee pain. This contrasts the findings of the present study as no association was found between the number of kilometres cycled per week and knee pain. Similarly, having a bike-fit was found to

Table 5: Constitutional / biomechanical factors contributing to lifetime knee pain prevalence of a sample of competitive and non-competitive cyclists (n = 115). Odds Ratio (OR) (95% Confidence Interval, CI)

Factors		Crude	Adjusted for age	Adjusted for age and gender
Age (years)				
-	18-40	1	-	1
-	<40	**3.01 (1.22, 7.74)***	-	1.57 (.67, 3.66)
BMI		1.00 (.889, 1.13)	.96 (.84, 1.10)	.96 (.85, 1.10)
Gender				
-	Male	1	1	-
-	Female	1.39 (.62, 3.13)	1.57 (.67, 3.67)	-
History of knee injury				
-	No	1	1	1
-	Yes	2.24 (.53, 9.43)	2.68 (.60, 12.10)	2.46 (.53, 11.41)
Kilometers cycled per week		1.00 (.99, 1.01)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Hours cycled per week		1.02 (.946, 1.10)	1.01 (.93, 1.10)	1.01 (.93, 1.01)
Cycling status				
-	Competitive	1	1	1
-	Non-competitive	.79 (.36, 1.74)	.84 (.38, 1.90)	.85 (.38, 1.92)
Coach				
-	No	1	1	1
-	Yes	1.85 (.85, 4.01)	1.69 (.77, 3.72)	1.71 (.77, 3.80)
Bike-fit				
-	No	1	1	1
-	Yes	.83 (.40, 1.74)	.89 (.42, 1.89)	.91 (.43, 1.95)
Crank length				
-	167.5	1	1	1
-	170	.43 (.105, 1.803)	.42 (.10, 1.82)	.44 (.10, 1.96)
-	172.5	.90 (.220, 3.70)	.93 (.22, 3.95)	.97 (.22, 4.27)
-	175	.67 (.102, 4.35)	.80 (.12, 5.61)	.86 (,12, 6.14)
-	Does not know	.49 (.102, 2.31)	.53 (.11, 2.65)	.55 (.11, 2.80)
Pedal type				
-	Clipless	1	1	1
-	Look	1.46 (.18, 11.74)	1.07 (.12, 9.50)	1.07 (.12, 9.98)
-	Shimano	.95 (.12, 7.6)	.67 (.08, 5.75)	.63 (.07, 5.74)
-	Shimano SPD	.62 (.08, 4.95)	.46 (.05, 4.04)	.44 (0.5, 4.07)
-	Speedplay	.75 (.06, 8.82)	0.67 (0.5, 8.76)	.66 (.05, 8.91)
-	Time †	-	-	-
Knee alignment				
-	Normal	1	1	1
-	Bow legged	1.04 (.14, 7.66)	1.43 (.18, 11.66)	1.14 (.13, 10.15)
-	Knock-knee	.78 (.17, 3.660)	.82 (1.17, 4.01)	.70 (.14, 3.57)
Occupational knee loading				
-	Never	1	1	1
-	Seldom	1.14 (.47, 2.78)	1.28 (.51, 3.22)	1.26 (.50, 3.19)
-	Sometimes	.44 (.13, 1.49)	.43 (.13, 1.47)	.40 (.12, 1.40)
-	Often	.40 (.11, 1.45)	.43 (.11, 1.62)	.39 (.10, 1.51)
-	Always	.89 (.12, 6.81)	1.28 (.15, 10.98)	1.13 (.14, 9.26)
History of surgery				
-	No	1	1	1
-	Yes	.95 (.37, 2.45)	82 (.31, 2.18)	.84 (.32, 2.23)
Comorbidity				
-	No	1	1	1
-	Yes	1.03 (.50, 2.15)	1.00 (.47, 2.12)	1.04(.49, 2.10)

*p = < 0.05
† Only one value available for this variable, therefore OR not reported

have no association with knee pain. Bini and Bini [13], analysed biomechanical factors that may increase a cyclist's risk of knee pain, including saddle height, the angle at an individual's knee at the bottom of their pedal stroke, and activation levels of lower limb muscles. This study found no association between factors which could influence an individual's biomechanics on a bike and knee pain, including crank length and pedal type. Due to the nature of this study, it was not possible to measure biomechanical factors such as angle at the knee during phases of the pedal stroke which may be associated with knee pain. Furthermore, both this study and previous studies are limited because they compare cyclists with and without knee pain in retrospect. Future research could look to assess biomechanical factors at baseline and monitor their association with knee pain over a given period.

The present study found lower back was reported as the most common site of injury, followed by the shoulder. A retrospective study that examined the medical records of 523 members of the Great Britain Cycling Team, similarly, reported the lower back to be the most common site of injury, highlighting the need for both preventative and rehabilitation strategies which help cyclists with lower back injuries [8]. Secondly, fracture

Table 6: Constitutional / biomechanical factors contributing to monthly knee pain prevalence of a sample of competitive and non-competitive cyclists (n = 115) Odds Ratio (OR) (95% Confidence Interval, CI)

Factors †	Crude	Adjusted for age	Adjusted for age and gender
Age (years)			
- 18-40	1	-	1
- <40	1.52 (.50, 4.63)	-	1.49 (.49, 4.56)
BMI	.97 (.84, 1.12)	.94 (.80, 1.11)	.94 (.79, 1.10)
Gender			
- Male	1	1	-
- Female	.72 (.25, 2.07)	.74 (.26, 1.12)	-
History of knee injury			
- No	1	1	1
- Yes	2.22 (.46, 10.68)	2.60 (.46, 10.99)	2.60 (.51, 13.26)
Kilometres cycled per week	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Hours cycled per week	1.02 (.92, 1.12)	1.01 (.92, 1.12)	1.01 (.92, 1.12)
Cycling status			
- Competitive	1	1	1
- Non-Competitive	1.46 (.54, 3.98)	1.50 (.55, 4.10)	1.47 (.54, 4.04)
Coach			
- No	1	1	1
- Yes	.47 (.16, 1.41)	.45 (1.50, 1.36)	.45 (.15, 1.36)
Bike-fit			
- No	1	1	1
- Yes	1.27 (.51, 3.19)	1.31 (.52, 3.31)	1.28 (.51, 3.25)
Occupational knee loading			
- never	1	1	1
- seldom	3.03 (.98, 9.32)	3.16 (1.02, 9.84)	3.30 (1.05, 10.37)
- sometimes	1.54 (.34, 7.08)	1.55 (.34, 7.13)	1.69 (.36, 7.90)
- often	3.09 (.60, 15.98)	3.15 (.60, 16.46)	3.65 (.67, 19.94)
- always	10.29 (.82, 129,55)	11.20 (.86, 145.30)	12.27 (.89, 168.90)
History of surgery			
- No	1	1	1
- Yes	.49 (.13, 1.87)	.45 (.12, 1.73)	.43 (.11, 1.66)
Comorbidity			
- No	1	1	1
- Yes	1.07 (.43, 2.67)	1.05 (.42, 2.63)	1.03 (.41, 2.59)

† Unable to test for bike-fit, crank length, pedal type, and angle at the knee at rest due to low count numbers

Table 7: Constitutional / biomechanical factors contributing to weekly knee pain prevalence of a sample of competitive and non-competitive cyclists (n = 115). Odds Ratio (OR) (95% Confidence Interval, CI)

Factors †	Crude	Adjusted for age	Adjusted for age and gender
Age (years)			
- 18-40	1	-	1
- <40	1.05 (.30, 3.64)	-	1.14 (.35, 3.67)
BMI	.91 (.76, 1.09)	.89 (.73, 1.09)	.89 (.73, 1.10)
Gender			
- Male	1	1	-
- Female	1.14 (.35, 3.65)	1.14 (.35, 3.67)	-
History of Knee Injury			
- No	1	1	1
- Yes	.79 (0.09, 7.04)	.79 (.09, 7.06)	.75 (.08, 6.94)
Kilometers cycled per week	1.00 (.99, 1.00)	1.00 (.99, 1.00)	1.00 (.99, 1.00)
Hours cycled per week	.93 (.811, 1.07)	.93 (.81, 1.06)	.93 (.81, 1.06)
Cycling status			
- Competitive	1	1	1
- Non-competitive	4.23 (.90, 19.6)	4.26 (.90, 20.11)	4.37 (.92, 20.81)
Coach			
- No	1	1	1
- Yes	.45 (.12, 1.73)	.45 (.12, 1.72)	.45 (.12, 1.73)
Bike-fit			
- No	1	1	1
- Yes	1.41 (.48, 4.14)	1.42 (.48, 4.18)	1.43 (.48, 4.26)
History of surgery			
- No	1	1	1
- Yes	.24 (.03, 1.91)	.23 (.03, 1.87)	.23 (.03, 1.88)
Comorbidity			
- No	1	1	1
- Yes	.89 (.30, 2.62)	.88 (.30, 2.62)	.89 (.30, 2.64)

† Unable to test for bike-fit, crank length, pedal type, and angle at the knee at rest, and occupational knee loading due to low count numbers

Table 8: Constitutional / biomechanical factors contributing to cycling related medical attention injury of a sample of competitive and non-competitive cyclists (n = 115) Odds Ratio (OR) (95% Confidence Interval, CI)

Factors	Crude	Adjusted for age	Adjusted for age and gender
Age (years)			
- 18-40	1	-	1
- <40	**.36 (.15, .86)***	-	1.11 (.48, 2.56)
BMI	.93 (.82, 1.05)	.96 (.84, 1.09)	.96 (.84, 1.09)
Gender			
- Male	1	1	-
- Female	1.20 (.54, 2.70)	1.11 (.48, 2.56)	-
Kilometers cycled per week	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Hours cycled per week	1.02 (.95, 1.10)	1.04 (.96, 1.12)	1.04 (.96, 1.12)
Cycling status			
- Competitive	1	1	1
- Non-competitive	**.39 (.17, .88)***	**.34 (.15, .79)***	**.34 (.15, .79)***
Coach			
- No	1	1	1
- Yes	1.25 (.58, 2.69)	1.44 (.65, 3.18)	1.44 (.65, 3.18)
Bike-fit			
- No	1	1	1
- Yes	1.66 (.79, 3.48)	1.59 (.74, 3.93)	1.60 (.75, 3.43)
History of surgery			
- No	1	1	1
- Yes	.699 (.27, 1.84)	.79 (.29, 2.11)	.79 (.29, 2.13)
Comorbidity			
- No	1	1	1
- Yes	1.03 (.50, 2.15)	1.07 (.50, 2.27)	1.08 (.51, 2.30)
$^*p = < 0.05$			

(traumatic) followed by contusion / hematoma, were the most frequently reported type of injury, suggesting that traumatic injuries are more common than overuse injuries in cyclists. De Bernardo et al. [30], conducted a study that followed high level competitive cyclists and likewise found fractures caused by trauma to be the most frequently reported type of injury. The high number of fractures relative to other types of injuries may have been influenced by this studies injury registration method. This is because endurance athletes are often reluctant to consult a medical practitioner when they have gradual onset injury, whereas traumatic fractures often require immediate medical consultation [31]. Implications of this mean that gradual onset overuse injuries are often under reported. Future research conducted in the UK could follow a cohort of cyclists over a set period and use alternative methods to register gradual onset injuries, such as that used in studies across Europe [9].

This study is not without limitations. Firstly, the cross-sectional design of the study means that participants may be subject to recall bias, particularly when asking participants to remember lifetime knee pain prevalence. To combat this, lifetime knee pain prevalence was defined as knee pain that lasted longer than one month to increase the likelihood of recall. Similarly, participants may have not been able to remember cycling related injuries. This was addressed by defining injury by a validated definition, whereby participants must have sought medical attention. Secondly, cyclists who have a history of knee pain may have been more likely to respond to advertisements to participate in the study. To address this potential recruitment bias clubs were contacted no matter their size, targeted member age group or gender, or whether the club was competitive or non-competitive. Furthermore, an effort was made to ensure that both the invitation email (appendix A and B) and recruitment poster (appendix E) clearly stated that cyclists who do not have a history of knee pain were able to participate in the study. Finally, variation in definitions of knee pain amongst similar studies, means that comparisons drawn between studies should be interpreted with caution. The main strength of this study is that validated methods were used to collect data for both knee pain and injury meaning that the study can be easily replicated across different populations.

CONCLUSION

The lifetime and period (monthly and weekly) prevalence of knee pain is high amongst the sample of cyclists in this study. Despite this, only factor found to be associated with knee pain of any measure was being over the age of 40. Similarly, no association was found between cycling status and knee pain prevalence of any measure. It appears that the lower back injuries and traumatic fractures injuries are also common amongst cyclists. Physiotherapists, who frequently work with cyclists, would benefit from having a strong understanding of strategies aimed at preventing and treating knee pain, lower back injuries and traumatic fracture injuries. Future longitudinal research is needed to identify if there are modifiable risk factors that may reduce the frequency of knee pain, lower back injuries, and traumatic fractures injuries in cyclists.

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