Factors associated with a history of acute traumatic cycling injuries in 60941 cycling race entrants in South Africa: SAFER study XLII

Authors:

Bertus Jansen van Rensburg[1,2], Martin Schwellnus[2,3], Darren Green[4], Audrey Jansen van Rensburg[1], Esme Jordaan[5,6], Sonja Swanevelder[5], Nicola Sewry,[2,3]

Affiliations:

1. Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
2. Sport, Exercise Medicine, and Lifestyle Institute (SEMLI), Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
3. IOC Research Centre of South Africa, Pretoria, South Africa
4. MediClinic, Stellenbosch, South Africa
5. Biostatistics Research Unit, South African Medical Research Council (SAMRC)
6. Statistics and Population Studies, University of the Western Cape, Cape Town, South Africa

Address for correspondence:

Dr Nicola Sewry, Senior Lecturer: Sport, Exercise Medicine, and Lifestyle Institute (SEMLI), Faculty of Health Sciences, University of Pretoria, South Africa, Sports Campus, Burnett Street, Hatfield, Pretoria 0020, South Africa.

Telephone: -27-12-420 6133

Fax number: -27-12-362 3369

Email: nicolasewry@hotmail.com

Word Count:

Abstract: 250

Text body: 3532

Contributors:

Contributors BJvR and NS were responsible for the writing of the first draft. All authors (BJvR, MS, DG, NS, AjvR, SS, and EJ) contributed to the editing of the manuscript. MS and NS were responsible for the overall study concept, as well as the design thereof. MS, NS, AjvR, ES, and SS were responsible for the planning of the overall study. MS, NS, and AjvR were responsible for the overall content of the study. DG assisted with the collection of the data. SS was solely responsible for the management and cleaning of all the data. BJvR, NS, and SS were responsible for the interpretation of the data. MS secured funding for the conduction of the study. NS was the guarantor of the study.

Acknowledgement

The authors would like to thank Dr. Jannelene Killops, and the medical staff from the Events Department at Mediclinic Southern Africa for respectively facilitating the implementation of the questionnaire, and for their contribution to the collection of data for this study. We also would like to thank all race entrants of the Cape Town Cycle Tour for completing the questionnaire, and the CTCT event for their collaboration.

Data sharing statement

No additional data are available.

Funding

IOC Research Centre of South Africa (partial funding). South African Medical Research Council (partial funding, statistical analysis). NS received an NRF Thuthuka grant (Ref Number: TTK2204051971)

Declaration of competing interest

Dr Darren Green is the medical director for the event.

on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in British Journal of Sports Medicine and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Abstract:

Background: Information on acute traumatic cycling injuries (ATCIs) in the 12-months prior to entry in a cycling race and the predisposing factors have not been well-researched.

Objective: Determine factors associated with a history of ATCIs sustained in the previous 12-months by race entrants of a 109km cycling race.

Methods: Descriptive, cross-sectional study on 60941 Cape Town Cycle Tour race entrants from 2016-2020. Data on a history of ATCIs sustained in the previous 12-months were obtained through an online pre-race medical screening questionnaire (mandatory in 2016, and voluntary in 2017-2020). Factors investigated were demographics, cycling/training history, and history of chronic disease, collapse, cramping, allergies, and regular chronic prescription medication usage. We calculated the prevalence ratio (PR) for reporting a history of an ATCI in the previous 12-months for each category (multiple regression model).

Results: Factors associated with an increased PR for a history of ATCIs gathered from race entrants (34% of the total entrants) were: increased years of participation in distance cycling events >2 hours (PR=1.05 per 5 years of distance cycling, $p<0.0001$), increased weekly average training/racing distance of a cyclist in the past 12-months (PR=1.11 per 50km increase in weekly cycling). Other factors were: increased number of chronic diseases reported (PR=1.53, per 2 additional chronic diseases reported, $p<0.0001$), history of collapse (PR=1.75, $p=0.0005$), history of cramping (PR=1.65, $p<0.0001$) and history of allergies (PR=1.49, $p<0.0001$).

Conclusions: Subgroups of recreational cyclists at higher risk for ATCIs were identified. This information could assist in developing and implementing future strategies to mitigate ATCIs.

Keywords: Acute injuries, risk factors, cycling

Key messages:

What is already known on this topic: Currently, the literature available relates to acute medical encounters during a cycling event or information regarding gradual onset injuries (12-month history).

What this study adds: Increased weekly training distance and a greater number of years of cycling-event participation of > 2 hours, as well as a history of underlying chronic disease, a history of collapse, cramping, and allergies significantly increase the prevalence of acute traumatic cycling injuries (ATCIs) in the past 12-months.

How this study might affect research, practice or policy: There is a lack of information regarding the factors related to the sustaining of acute traumatic cycling injuries (ATCIs) during periods leading up to events, and therefore assists in the identification of contributing factors for sustaining ATCIs. This study identifies subgroups of recreational cyclists who may be at higher risk for ATCIs. This information may lead to the development and implementation of future strategies to mitigate the risk of ATCIs in cyclists.

INTRODUCTION

Cycling is a popular form of exercise and participation has grown exponentially over the last decade.[1-3] Participation in mass community-based cycling events and other endurance sports events has increased over the years.[4] Cycling has numerous health benefits, however, it is also well known for its high incidence of adverse events (injuries) sustained during training and competitions.[5-6] These injuries can be categorized into acute (sudden onset) traumatic cycling injuries (ATCIs), and gradual onset cycling injuries (GOCIs). Acute traumatic cycling injuries (ATCIs) are defined as any injury sustained instantaneously, such as a fall or collision, leading to acute damage to tissues such as joints, bones, muscles, tendons, or ligaments.[7] Gradual onset cycling injuries on the other hand refer to injuries sustained over a period of time due to repetitive stress.[7]

The incidence and factors associated with ATCIs in recreational cyclists have only been investigated in a few studies, mainly during tours and not during a training period. In one study, the annual incidence of injury-related medical encounters sustained by cyclists during the Cape Town Cycle Tour (CTCT, 2012-2014) was reported as 3.2 per 1000 race starters. The incidence of acute traumatic injury-related encounters varied from 3.7-5.0 per 1000 race starters during this period, and 4 distinct factors were identified that could potentially increase the risk of encounters in cyclists.[8] These factors were sex (females at a higher risk than males), older age (average of 44.88 years), faster cycling speed (average of 23.79 km/h), and higher wind speed (average of 5.76 units).[8] A second study described the incidence of adverse medical encounters (medical attention and did-not-finish the event) in race starters of the 94.7 Cycle race as 11.9 per 1000 race starters, and the serious acute injury-related encounters (requiring hospitalization) as 1.3 per 1000 race.[9] Females had a higher incidence of ATCIs, predominantly affecting the central nervous system and eyes. Furthermore, males 10-15 years, females 23-29 years, and race starters older than 50 years had a higher-than-expected risk for ATCIs.[9] A single study investigated risk factors associated with ATCIs during training in commuting students in China.[10] This study reported that those who cycled at a moderate speed (between 10 and 20km/h) had a lower injury prevalence (23.6%) compared to those who cycled at either a higher [≥20km/h; 79.4%] or a lower speed [≤10km/h; 55.4%]. Other factors associated with an increased prevalence of ATCIs were: cycling while feeling fatigued/sleepy (40.3%), when in a melancholic mood (37.1%), and after consuming caffeinated drinks (31.7%).[10] Challenging environmental conditions such as high winds, and rain can also potentially contribute to a higher risk for sustaining ATCIs.[11]

Identifying sub-groups at higher risk for ATCIs is important to develop and implement future prevention strategies to mitigate the risk of ATCIs and make recreational cycling safer. Therefore, this study aimed to investigate

selected factors associated with a history of ATCIs (in the previous 12-months) in race entrants of the CTCT over 5 years (2016-2020).

Methods:

Study design:

This descriptive, cross-sectional study forms part of an ongoing SAFER (Strategies to reduce Adverse medical events for the ExerciseR) study series.[12]

Ethics statement

The Research Ethics Committee of the University of Pretoria approved this study (REC 376/2023, 431/2015).

Setting:

The CTCT race is a 109km mass community-based, road cycle event with ±1200m elevation gain, held annually in the late summer in Cape Town, South Africa. It is known as the largest timed cycle race worldwide and attracts elite and recreational cyclists from across the globe. Each year, around 35000 cyclists enter this cycling event. The entrant population consists of a variety of cyclists of different ages (predominantly older than 40; 64.1%), sex (predominantly males; 79%), and overall skill sets. The race requires no minimum experience, and is open to cyclists from 13 years of age with no upper age limit.[11]

Race entrants and demographics

Cycling race entrants of the CTCT during 2016-2020 who gave informed consent for using their data for research purposes were included.

Definitions

According to the 2020 International Olympic Committee consensus injuries are the result of either: 1) a near-instantaneous exchange of a large quantity of kinetic energy (ATCI or medical encounter), 2) a gradual accumulation of kinetic energy over a specific period (Low-grade GOI), or 3) a combination of these aetiologies.[7]

Data collection

We requested all race entrants to complete an online, pre-race medical screening questionnaire at the time of registration. Completing this questionnaire was compulsory in 2016, but optional during 2017-2020. Furthermore, no medical clearance was required for participation. The pre-race medical screening questionnaire was designed per the guidelines for cardiovascular evaluation of middle-aged/senior individuals who engage in leisure-time sports activities (Position stand from the European Association of Cardiovascular Prevention and Rehabilitation).[13] It consists of a series of questions developed to provide detailed clinical information to assist medical staff in improving medical care on race day and has been described extensively elsewhere.[14] The pre-race medical screening questionnaire, originally designed for runners, was adapted for cyclists by including questions specifically relating to common medical complications encountered during cycling. Following the pre-race medical screening, individuals identified as high risk were sent an educational intervention to mitigate the risk of a medical encounter during the event. Within the pre-race medical screening questionnaire (developed before the recent IOC Consensus Statement) cyclists were specifically asked the following questions related to ATCIs when completing the online questionnaire: *"Do you or did you suffer from any symptoms of an* ***ACUTE ("CRASH")*** *cycling injury (muscles, tendons, bones, ligaments or joints****) IN THE PAST 12-MONTHS OR CURRENTLY*** *(NB: Only if an injury is/was severe enough to interfere with cycling, or required treatment e.g. used medication, or required you to seek medical advice from a health professional).* The questionnaire also included questions regarding 1) cycling training/racing history, 2) medical history which included a history of acute injuries in the past 12-months, 3) chronic disease history (a history of any cardiovascular disease (CVD), or factors for CVD, any symptoms of CVD, respiratory disease, metabolic or hormonal disease, GIT (gastro-intestinal) disease, nervous system/psychiatric disease, renal or bladder disease, haematological/immune system disease, history of cancer), 4) history of collapse, 5) history of cramping, 6) history of allergies, and 7) regular chronic prescription medication usage. The 10 chronic diseases used to compile the Composite Chronic Disease Score (CCDS) are listed in Supplementary Table 1.

Selected Factors:

In this study, selected factors associated with a history of ATCIs in cyclists (up to 12-months prior to the date of race entry) were explored in the following domains:

1) Demographic variables: age groups (≤30, 31-≤40, 41-≤50, and >50), sex (male and female).

2) Cycling and training/racing history variables: a) years of participation in distance cycling events of >2 hrs, b) average weekly training/racing distance in the past 12-months, and c) average training speed in the past 12-months.
3) History of chronic disease: a) any risk factors for CVD, b) history of CVD, c) symptoms of CVD, d) history of endocrine disease, e) history of respiratory disease, f) history of GIT disease, g) history of nervous system or psychiatric disease, h) history of kidney and bladder disease, i) history of haematological or immune system disease, j) history of cancer. A composite chronic disease score was calculated as a score of 0-10 based on the individual's response to the 10 chronic disease variables listed above.
4) History of collapse, history of cramping, history of allergies, and regular chronic prescription medication usage.

Patient and Public Involvement (PPI)

We did not directly include PPI in this study, but the race medical director, who was directly involved with data collection and interpretation, was consulted.

Statistical analysis of data

In 2016, completing the online medical questionnaire was compulsory for all CTCT entrants, but voluntary during 2017-2020. Therefore, all the data collected through the medical screening questionnaire was weighted for 2017-2020, to align the sex and age profiles to those of 2016. We reported on the weighted frequencies and percentages for all data aiming to represent the respective years of CTCT entry accurately. All analyses were conducted using SAS statistical software (version 9.4, Cary NC). This binary-scaled dependent variable in the model was the response to a question related to any acute traumatic cycling injury (ATCI), currently or in the previous 12-months. Cyclists could report up to a maximum of two acute injuries. Since convergence problems arose in some modelling situations, PROC GENMOD with a Poisson distribution and a log link option was used for all statistical models, and p-values for Type 3 GEE (generalized estimating equations) analyses and 95% confidence intervals were reported. The control group constituted those cyclists who reported no ATCI for that year. PRs for ATCI in the previous 12-months were calculated as the measure of association. The statistical significance level was 5% unless specified otherwise. Univariate unadjusted (PRs) (and 95%CIs) were reported for age groups and sex, cycling, and training/racing history variables, and history of chronic disease. The Composite Chronic Disease Score was

calculated, and a history of collapse, a history of ever cramping, a history of allergies, and regular chronic prescription medication usage were entered into the model as categorical variables. The training and racing variables, the Composite Chronic Disease Score, allergies and histories of collapse and cramping were entered into the multiple model as numeric variables and the prevalence of ATCIs (% and 95%CIs) were reported at the 1st quartile, median and 3rd quartile for these variables. The final multiple regression model contained only the significant factors ($p<0.01$) for ATCIs in cyclists, adjusted for age group and sex.

Results:

Demographics of study race entrants

The cohort included 60941 consenting race entrants (approximately 34% of all race entrants) and 2754 cyclists reported 2868 ATCIs. The demographic characteristics of all CTCT consenting race entrants by year of entry (2016-2020) (weighted) are reported in Table 1.

Table 1: Demographic characteristics of all CTCT (South Africa) consenting race entrants by year of entry (2016-2020) (weighted)

		Consenting race entrants per year of registration (n= 60941)											
		2016		**2017**		**2018**		**2019**		**2020**		**(2016-2020)**	
Total race entrants		n*	%**	n*	%**	n*	%**	n*	%**	n*	%**	n*	%**
		21386		8304		9272		8453		13526		60941	
Sex	**Males**	16957	79.3	6463	77.8	7227	78.0	6661	78.8	10818	80.0	48126	79.0
	Females	4429	20.7	1840	22.2	2045	22.1	1792	21.2	2708	20.0	12814	21.0
Age groups (years)	**≤30**	3284	15.4	1286	15.5	1439	15.5	1303	15.4	2075	15.3	9387	15.4
	31-≤40	4377	20.5	1716	20.7	1909	20.6	1746	20.7	2769	20.5	12517	20.5
	41-≤50	6257	29.3	2431	29.3	2719	29.3	2466	29.2	3976	29.4	17848	29.3
	>50	7468	34.9	2870	34.6	3206	34.6	2939	34.8	4706	34.8	21188	34.8

CTCT: Cape Town Cycle Tour

ATCIs: Acute Traumatic Cycling Injuries

*: Weighted frequencies and percentages

**: % out of total

The total consenting race entrants for the CTCT (2016-2020) was 60941 [males n*=48126, 79.0%; females n*=12814, 21.0%].

History of ATCIs

Over the 5 years, 2754 cyclists reported ATCIs, 4.52% [95%CI (4.35-4.69)]. The %ATCIs (95%CI) reported were similar by year (2016: 4.76% [95%CI (4.47-5.06)]; 2017: 5.92% [95%CI (5.42-6.47)]; 2018: 3.68% [95%CI (3.31-4.09)]; 2019: 4.25% [95%CI (3.83-4.71)] and 2020: 4.02% [95%CI (3.70-4.37)].

Factors associated with a history of acute traumatic cycling injuries (ATCIs) (Univariate analysis)

Demographic factors associated with a history of ATCIs in race entrants for the CTCT (South Africa) are summarised in Table 2.

Table 2: The number (n), frequency (%; 95%CI), and unadjusted Prevalence Ratio (PR) of all cycling entrants of the CTCT (South Africa) with and without a history of acute traumatic cycling injuries (ATCIs) by sex and age group. (Univariate analysis) (n=60941) (weighted)

Demographic variables		**Control group (No history of ATCIs) (2016-2020) (n=58187)**	**Cycling race entrants with a history of ATCIs (2016-2020) (n=2754)**		**PR**	**p-value**
		N	**N**	**% (95% CI) Prevalence**	**(95% CI)**	
Sex	Male	45922	2204	4.58 (4.39-4.78)	1.07 (0.97-1.17)	0.1638
	Female	12265	550	4.29 (3.94-4.66)	—	
Age group (years)	≤30	9060	327	3.49 (3.13-3.88)	—	<0.0001
	31-≤40	12078	439	3.51 (3.20-3.85)	1.01 (0.87-1.16)	
	41-≤50	17076	772	4.32 (4.03-4.64)	1.24 (1.09-1.41)	
	>50	19973	1216	5.74 (5.42-6.07)	1.65 (1.46-1.86)	

ATCIs: Acute Traumatic Cycling Injuries

CTCT: Cape Town Cycle Tour

PR: Prevalence Ratio

Age group: >50 vs 41-≤50 PR=1.33 (95%CI: 1.21-1.45) p<0.0001

Older age (> 50 years; PR=1.65 [1.46-1.86]; p<0.0001) was associated with a higher risk of a history of ATCIs (there was no age/sex interaction, p=0.5216).

Training-related variables, as factors associated with a history of ATCIs are presented in Table 3.

Table 3: The prevalence (%; 95%CI) and unadjusted Prevalence Ratio (PR; 95%CI) of cycling entrants of the CTCT (South Africa) with a history of acute traumatic cycling injuries (ATCIs) by cycling training/ racing history (2016-2020) (Univariate analysis) (n=60871) (weighted)

Training related variables	**Points on the continuous variable**	**Predicted intervals for acute traumatic cycling injuries (ATCIs) at specific points in the continuous variable Prevalence % (95%CI)**	**PR (95%CI)**	**p-value**
Years of participation in distance cycling events >2 hours (years)	3 yrs	3.91 (3.72-4.11)	**For every 5yr increase:** 1.12 (1.10-1.14)	<0.0001
	6 yrs	4.18 (4.01-4.37)		
	15 yrs	5.11 (4.90-5.32)		
Average weekly training/racing distance in the past 12-months (km/wk)	40 km/wk	4.06 (3.88-4.26)	**For every 50km increase:** 1.11 (1.09-1.13)	<0.0001
	70 km/wk	4.32 (4.15-4.50)		
	120 km/wk	4.80 (4.62-4.99)		
Average training speed in the past 12-months (km/h)	20 km/h	4.42 (4.23-4.62)	**For every 3 km/h increase:** 1.04 (1.02-1.06)	0.0003
	23 km/h	4.60 (4.42-4.77)		
	26 km/h	4.78 (4.58-4.99)		

ATCIs: Acute Traumatic Cycling Injuries

CTCT: Cape Town Cycle Tour

PR: Prevalence Ratio

Points on the continuous scale were chosen as First quartile, Median, and Third quartile.

(Missing n=3186)

An increase in the years participating in distance cycling events >2 hours, was associated with an increased risk for a history of ATCIs, as was the average weekly training/racing distance, and the average training speed.

A history of chronic disease, collapse, cramping, and allergies as factors associated with a history of ATCIs (Univariate analysis) is summarised in Table 4.

Table 4: The frequency (n; %95%CI) and unadjusted Prevalence Ratio (PR; 95%CI) of cycling entrants of the CTCT (South Africa) with a history of acute traumatic cycling injuries (ATCIs) by a history of the main categories of chronic disease, history of collapse, history of cramping, history of allergies, and regular chronic prescription medication use (Univariate analysis) (2016-2020) (n=60941) (weighted)

Variables		**Control group (No history of ATCIs) (2016-2020) (n=58187)**	**Cycle race entrants with a history of acute traumatic cycling injuries (ATCIs) (2016-2020) (n=2754)**		**PR (95%CI)**	**p-value**
		N	**N**	**Prevalence % (95%CI)**		
Chronic disease composite score (0-10)	**0**	—	—	3.71 (3.54-3.88)	**For every 2-unit increase** 1.95 (1.81-2.11)	<0.0001
	2	—	—	7.23 (6.80-7.69)		
	4	—	—	14.10 (12.36-16.09)		
Any risk factor for CVD	**Yes**	11275	729	6.07 (5.64-6.53)	1.47 (1.35-1.60)	<0.0001
	No	46912	2025	4.14 (3.96.0-4.32)		
Any history of CVD	**Yes**	2077	158	7.05 (6.03-8.25)	1.60 (1.36-1.87)	<0.0001
	No	56110	2596	4.42 (4.26-4.60)		
Any symptoms of CVD	**Yes**	614	49	7.34 (5.54-9.72)	1.64 (1.23-2.17)	0.0016
	No	57573	2705	4.49 (4.32-4.66)		
Any endocrine disease	**Yes**	1933	130	6.29 (5.29-7.47)	1.41 (1.18-1.68)	0.0003
	No	56254	2624	4.46 (4.29-4.63)		
Any respiratory disease	**Yes**	5897	475	7.46 (6.82-8.16)	1.79 (1.62-1.97)	<0.0001

	No	52290	2279	4.18 (4.01-4.35)		
Any GIT disease	**Yes**	2998	259	7.96 (7.05-8.99)	1.84 (1.62-2.09)	<0.0001
	No	55189	2495	4.32 (4.16-4.50)		
Any nervous system/ psychiatric disease	**Yes**	2016	195	8.83 (7.67-10.16)	2.03 (1.75-2.34)	<0.0001
	No	56171	2559	4.36 (4.19-4.53)		
Any kidney/bladder disease	**Yes**	1629	154	8.66 (7.39-10.13)	1.97 (1.67-2.32)	<0.0001
	No	56558	2600	4.39 (4.23-4.57)		
Any haematological/immune disease	**Yes**	757	47	5.82 (4.37-7.75)	1.29 (0.97-1.73)	0.0942
	No	57430	2707	4.50 (4.34-4.67)		
Any cancer	**Yes**	1884	133	6.58 (5.55-7.80)	1.48 (1.24-1.76)	<0.0001
	No	56303	2621	4.45 (4.28-4.62)		
History of collapse	**Yes**	411	48	10.46 (7.88-13.87)	2.34 (1.76-3.11)	<0.0001
	No	57776	2706	4.47 (4.31-4.65)		
History of cramping	**Yes**	16496	1220	6.88 (6.51-7.28)	1.94 (1.80-2.09)	<0.0001
	No	41691	1534	3.55 (3.38-3.73)		
History of allergies	**Yes**	7805	606	7.21 (6.66-7.80)	1.76 (1.61-1.93)	<0.0001
	No	50382	2148	4.09 (3.92-4.27)		
Regular chronic prescription medication use	**Yes**	8913	566	5.97 (5.50-6.48)	1.40 (1.28-1.54)	<0.0001
	No	49274	2188	4.25 (4.08-4.43)		

ATCIs: Acute Traumatic Cycling Injuries

CTCT: Cape Town Cycle Tour

PR: Prevalence Ratio

CVD: Cardiovascular disease

For every 2 additional chronic diseases reported, the PR for a history of ATCI increased 1.95 times (for the multiple model only the composite score was used). A history of collapse, a history of cramping, and a history of allergies also had a high PR for a history of ATCIs.

Factors Associated with a History of ATCIs (Multiple regression model)

Factors associated with a history of ACTIs in the past 12-months in race entrants of the CTCT are shown in Table 5 (adjusted for sex and age group) (multiple regression model).

Table 5: The adjusted Prevalence Ratio (PR; %95%CI) of cycling entrants of the CTCT (South Africa) with a history of acute traumatic cycling injuries (ATCIs) by the main categories of factors cycling training/racing history, the Composite Chronic Disease Score, history of collapse, history of cramping, history of allergies) (adjusted for sex and age group) (multiple regression model) (2016-2020) (n=60941) (weighted)

Variable		Prevalence of cycle race entrants with a history of acute traumatic cycling injuries (ATCIs) % (95%CI)	PR (95%CI)	p-value
Years of participation in distance cycling events > 2 hours (years)	3 yrs	4.98 (4.24-5.87)	**For every 5yr increase** 1.05 (1.02-1.07)	<0.0001
	6 yrs	5.13 (4.36-6.02)		
	15 yrs	5.58 (4.74-6.57)		
Average weekly training/racing distance in the past 12-months (km/wk)	40 km	5.26 (4.47-6.19)	**For every 50km/wk increase** 1.11 (1.09-1.13)	<0.0001
	70 km	5.60 (4.77-6.58)		
	120 km	6.21 (5.28-7.29)		
Composite Chronic disease score (CCDS) (0-10)	0	4.85 (4.11-5.72)	**For every 2unit increase** 1.53 (1.41-1.67)	<0.0001
	2	7.42 (6.30-8.75)		
	4	11.37 (9.27-13.94)		
A history of collapse	Yes	9.51 (7.12-12.70)	1.75 (1.31-2.34)	0.0005
	No	5.44 (5.13-5.76)		
A history of cramping	Yes	9.24 (7.90-10.82)	1.65 (1.53-1.79)	<0.0001
	No	5.59 (4.79-6.53)		
A history of allergies	Yes	8.77 (7.44-10.35)	1.49 (1.36-1.64)	<0.0001
	No	5.89 (5.07-6.84)		

ATCIs: Acute traumatic cycling injuries

CTCT: Cape Town Cycle Tour

PR: Prevalence Ratio

Missing data for training data n=3186

Increased years of participation in distance cycling events >2 hours and increased average weekly training/racing distance in the past 12-months were associated with an increased PR for a history of ATCIs. A greater number of chronic diseases reported by a cyclist, and histories of collapse, cramping, and allergies were significantly associated with an increased PR for a history of ATCIs.

Discussion

This study aimed to identify factors associated with a history of ATCIs in recreational cyclists. The main findings of this study were that the following factors were associated with a higher PR for a history of ATCIs

Demographic factors:

We show that sex was not associated with an increased risk for a history of ATCIs. A few studies explored the relationship between sex and ATCI risk in cyclists and found that females are at higher risk of ATCIs during races. One study reported that female mountain bike racers in California had a 1.94 times higher odds ratio of sustaining severe cycling injuries during a race and a 4.17 higher odds of sustaining a fracture.[15] In another study, women had a higher risk of sustaining adverse medical events (injuries and illnesses) and serious adverse events during a 90km race.[9] During a 109km race in Cape Town females had a 2.2 times increased risk of injuries compared to men, and a 3.1 times higher chance to sustain a serious/life-threatening injury/death compared to men.[8] These studies were all conducted during a race and not during a training period prior to the race. Comparing factors during a race rather than during training is not strictly correct and this could possibly explain the difference between our findings and the findings of these studies conducted during races.

The relationship between age and ATCI risk in cyclists is reported in a few studies. In two studies, older age was an independent risk factor associated with ATCIs during a 109km[8] and a 90km race.[9] In our study, in the univariate analysis, we report that cyclists older than 50 years of age had an increased PR for ATCIs (PR=1.65 vs <30 years). Again, the data cannot be compared because our study reports ATCIs sustained during the 12-month period prior to a race, rather than during a race. However, it appears that older age (>50yrs) may be associated with an increased risk of ATCI during training and racing. The precise reasons for this observation are speculative and need further investigation.

Training-related variables as factors:

In our study, an increased number of years of cycling event participation, and an increase in the average weekly training/racing distance in the past 12-months were factors associated with a history of ATCIs. In the Swiss Epic Mountain Bike Event it was reported that the acute injury prevalence between elites and amateurs was similar.[16-17] A study reported that commuting-students who cycled at a moderate speed (between 10 and 20km/h) had a lower injury prevalence (23.6%) compared to those who cycled at either a higher [≥20km/h; prevalence= 79.4%] or a lower speed [≤10km/h; prevalence= 55.4%]. Other factors identified in this study were fatigue/sleepiness, riding in a melancholic mood, and riding post-consumption of caffeinated drinks.[10] In a 109km race, cycling speed was an independent risk factor, with 1.7 times increased risk for every 1km/h increase in speed.[8] We should note that even though recreational cycling and mountain biking differ, cyclists with more experience are possibly more likely to attempt skills that are associated with a higher degree of danger, accumulate more distance on their bikes, and cycle at faster speeds. They have a lengthy exposure to the cycling environment and its adverse effects, which probably increases their risk of sustaining ATCIs during their cycling career.[18]

History of chronic disease, collapse, cramping, allergies as factors associated with ATCIs:

To our knowledge, this is the first study reporting that a history of underlying chronic disease (PR=1.53 for every 2 additional chronic diseases reported) is associated with an increased risk of a history of ATCIs in recreational cyclists. Previous studies in cyclists reported a higher risk of gradual onset injuries in cyclists with a history of chronic disease.[19-20] The potential mechanisms to explain a causal relationship between chronic disease and the risk for ATCIs are not clear. Some postulated mechanisms linking gradual onset cycling injuries to chronic diseases have been reported in the literature.[19,21-23] The authors postulate that the potential mechanisms may be related to either the disease process itself, or the medication used to treat these diseases. Chronic diseases can be associated with tendon, ligament, and bone stress injuries. We postulate that pain, fatigue, and weakness in these tissues may increase the risk of falling, but this needs to be investigated in future studies.[24]

The use of medication by athletes for acute and chronic conditions is linked with a higher risk for sport-related injuries. In our study, the use of prescribed medication was significantly associated with a history of ACTIs in cyclists (PR=1.40, in the univariate analysis). One of these mentioned studies reported that NSAIDs (non-steroidal anti-inflammatory drugs) are the most commonly used modality worldwide for exercise-induced muscle injury during the last 2 decades.[25] In a study on triathletes, NSAIDS were common, and most athletes were unaware of

the adverse effects of NSAIDs, which could be detrimental to their sporting careers.[26] The use of corticosteroids as an anti-inflammatory medication could lead to tendon injuries, which have detrimental consequences and may increase a cyclist's risk for ATCIs.[27-28] Other treatment-related causes contributing to tendon injuries are fluoroquinolones, with pathological lesions in tendons that can occur within hours of commencing treatment and last months after discontinuation.[29-31] The use of fluoroquinolones with excessive tendon loading during physical exercise, has been identified as the main pathological stimulus for tendon degeneration and thus rupture.[32] Furthermore, statins are associated with skeletal myopathy, which could contribute to a higher risk of ATCIs.[33-34]

A history of collapse in cycling is not well researched. However, research has extensively examined collapse in marathon runners, identifying exercise-associated postural hypotension (EAH) as the predominant cause. Other possible causes of collapse are exertional heat illness (EHI), fluid and electrolyte disturbances, and although rare, sudden cardiac arrest or sudden cardiac death. A study reported that during a 109km cycling event, EHI was the fatal cause of 5 out of 28753 race starters.[35] Our finding linking a history of collapse as a factor associated with a history of ATCIs requires further investigation, specifically to determine the cause of collapse, and subsequent injuries, in cyclists.

A history reported by a cyclist concerning cramping and how it consequently leads to an increase in the risk for ATCIs has not been thoroughly studied. In our study, we found that a history of exercise-associated muscle cramps (EAMC) is significantly associated with a history of ATCIs (PR=1.65, $p<0.0001$). We postulate that the EAMC could lead to a cyclist falling from their bicycle by possibly distracting them from the task at hand and lead to potential injury (dislocation, fracture, or superficial dermatological wounds).[36]

Allergies and using first-generation antihistamines to treat these conditions can affect the central nervous system by causing drowsiness, fatigue, and reduced cognitive, psychomotor, and perceptive performance.[37] Another study looking at the effect of histamine release during exercise and the protection of muscle from exercise-induced damage reported that a single dose of an over-the-counter antihistamine could lead to muscle damage (increase in creatine kinase observed) in athletes.[38] One study reports that untreated allergy symptoms and the usage of first-generation antihistamines can distract patients from driving and be related to traffic crashes. Therefore, it can be postulated that using medications that affect concentration, coordination, and perceptive skills may increase the risk of ATCIs.[39]

Strengths and Limitations:

The strengths of our study are the large number of consenting race entrants and the long study period (2016-2020). We were also able to conduct multiple regression analyses on 5 years of data collected and therefore, have a strong statistical method for determining factors that may be associated with a history of ATCIs in recreational cyclists. Limitations to our study include the reliance on self-reported data, the relatively low response rate (the completion of the questionnaire was only compulsory in 2016), the potential for recall bias, and the inability to determine the cause and effect related to the injuries. Another limitation encountered due to anonymized data is that data of race entrants who did not consent was missing. The data was de-identified; therefore, we did not have information on repeated race entrants and could not adjust for the clustering effect. We acknowledge that our cross-sectional study design is limited and does not allow us to establish causality. We suggest that future research studies follow a prospective cohort design to identify risk factors for acute traumatic cycling injuries. It is difficult to compare our research with other studies since the definitions, type of sport (mountain biking, stationary biking, recreational biking), population size, setting (during races or training), and timelines over which the studies were conducted differ vastly, however similar demographic distributions for sex were found in a study on the 94.7 cycle race.[9] We recognize that the risks associated with sustaining ATCIs are multifaceted and include other extrinsic factors, such as adverse weather conditions. We also recognize that many bicycle-related injuries are predominantly caused by crashes with either other cyclists or motor vehicles.

Conclusions

We show that factors associated with a history of ATCIs in recreational cyclists who entered a mass community-based cycle event (>100km) included increased years of distance cycling, increased weekly training/racing sessions and distance, and a history of chronic diseases, collapse, cramping and allergies. The findings of our study contribute to the body of knowledge of factors for ATCIs, and we specifically identify subgroups of cyclists at higher risk of ATCIs. Our study can be utilized in future research endeavours to develop and implement strategies and mitigate ATCIs in cyclists.

References

1. Rérat P, Haldimann L, Widmer H. Cycling in the era of Covid-19: The effects of the pandemic and pop-up cycle lanes on cycling practices. Trans Resp Interdiscp Perspect. 2022; 15 doi.org/10.1016/j.trip.2022.100677

2. Buehler R, Pucher J. Covid-19 impacts on cycling, 2019–2020. Transp. Rev. 2021; 41(4):393-400 doi.org/10.1080/01441647.2021.1914900

3. World Health Organization: physical activity [online]. 2022. https://www.who.int/news-room/fact-sheets/detail/physical-activity (accessed 2023 Mar 14).

4. Murphy N, Lane A, Bauman A. Leveraging mass participation events for sustainable health legacy. J. Leis. Res. 2015; 34(6):758-66. doi: 10.3389/fspor.2023.1192401

5. Decalzi JF, Narvy SJ, Vangsness Jr CT. Overview of cycling injuries: results of a cycling club survey. Orthop. Res. Online J. 2013; 36(4):287-9. doi: 10.3928/01477447-20130327-07

6. Palmer D, Florida-James G, Ball C. Enduro World Series (EWS) mountain biking injuries: A 2-year prospective study of 2010 riders. Int J Sports Med. 2021; 42(11):1012-8. doi: 10.1055/a-1320-1116

7. Bahr RMDP, Clarsen BPTP, Derman WMDP, et al. International Olympic Committee (IOC) consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sports 2020 (including the STROBE extension for Sports Injury and Illness Surveillance (STROBE-SIIS)). Orthop. J. Sports Med. 2020; 8(2) doi: 10.1177/2325967120902908

8.Killops J, Sewry NA, Schwellnus M, et al. Women, older age, faster cycling speed and increased wind speeds are independent risk factors for acute injury-related medical encounters during a 109 km mass community-based participation cycling event: a 3-year study in 102251 race starters-SAFER XII. Injury prevention : Inj Prev. 2021; 27(4):338-43. doi:10.1136/injuryprev-2020-043874

9. Breedt M, Janse van Rensburg DC, Schwellnus M, et al. The injury and illness profile of male and female participants in a 94.7 km cycle race: A cross-sectional study. Clin J Sport Med. 2019 Jul;29(4):306-311. doi: 10.1097/JSM.0000000000000517. PMID: 31241533.

10. Lin ZB, Ji YH, et al. Risk factors of bicycle traffic injury among middle school students in Chaoshan rural areas of China. Int J Equity Health. 2017 Jan 26;16(1):28. doi: 10.1186/s12939-016-0512-8. PMID: 28122573; PMCID: PMC5267448.

11. Cape Town Cycle Tour: Cape Town Cycle Tour History - Cape Town Cycle Tour [online]. 2023. https://www.capetowncycletour.com/cape-town-cycle-tour-history/. (accessed 2023 Apr 15).

12. Schwellnus M, Derman W. The quest to reduce the risk of adverse medical events in exercising individuals: introducing the SAFER (Strategies to reduce Adverse medical events For the ExerciseR) studies. Br J Sports Med. 2014 Jun;48(11):869-70. doi: 10.1136/bjsports-2014-093606. PMID: 24815926.

13. Borjesson M, Urhausen A, et al. Cardiovascular evaluation of middle-aged/ senior individuals engaged in leisure-time sport activities: position stand from the sections of exercise physiology and sports cardiology of the European Association of Cardiovascular Prevention and Rehabilitation. Eur J Cardiovasc Prev Rehabil. 2011 Jun;18(3):446-58. doi: 10.1097/HJR.0b013e32833bo969. PMID: 21450560.

14. Schwellnus M, Swanevelder S, et al. Prerace medical screening and education reduce medical encounters in distance road races: SAFER VIII study in 153 208 race starters. Br J Sports Med. 2019 May;53(10):634-639. doi: 10.1136/bjsports-2018-099275. Epub 2018 Nov 9. PMID: 30413425.

15. Kronisch RL, Pfeiffer RP, et al. Gender differences in acute mountain bike racing injuries. Clin J Sport Med. 2002 May;12(3):158-64. doi: 10.1097/00042752-200205000-00003. PMID: 12011723.

16. Becker J, Runer A, et al. A prospective study of downhill mountain biking injuries. Br J Sports Med. 2013 May;47(7):458-62. doi: 10.1136/bjsports-2012-091755. Epub 2013 Jan 17. PMID: 23329619.

17. Burr JF, Drury CT, et al. Physiological demands of downhill mountain biking. J Sports Sci. 2012 Dec;30(16):1777-85. doi: 10.1080/02640414.2012.718091. Epub 2012 Oct 2. PMID: 23025296.

18. Impellizzeri FM, Marcora SM, et al. Correlations between physiological variables and performance in high level cross country off road cyclists. Br J Sports Med. 2005 Oct;39(10):747-51. doi: 10.1136/bjsm.2004.017236. PMID: 16183772; PMCID: PMC1725050.

19. Abate M, Schiavone C, et al. Occurrence of tendon pathologies in metabolic disorders. Rheumatol. 2013 Apr;52(4):599-608. doi: 10.1093/rheumatology/kes395. Epub 2013 Jan 12. PMID: 23315787.

20. Wilber CA, Holland GJ, et al. An epidemiological analysis of overuse injuries among recreational cyclists. Int J Sports Med. 1995 Apr;16(3):201-6. doi: 10.1055/s-2007-972992. PMID: 7649713.

21. Abboud JA, Kim JS. The effect of hypercholesterolemia on rotator cuff disease. Clin Orthop Relat Res. 2010 Jun;468(6):1493-7. doi: 10.1007/s11999-009-1151-9. PMID: 19885710; PMCID: PMC2865626.

22. Graat-Verboom L, Spruit MA, et al. Correlates of osteoporosis in chronic obstructive pulmonary disease: An underestimated systemic component. Respir Med. 2009 Aug;103(8):1143-51. doi: 10.1016/j.rmed.2009.02.014. PMID: 19304474.

23. Mammen AL. Statin-associated autoimmune myopathy. N Engl J Med. 2016 Feb 18;374(7):664-9. doi: 10.1056/NEJMra1515161. PMID: 26886523.

24. Horlings CG, van Engelen BG, et al. A weak balance: the contribution of muscle weakness to postural instability and falls. Nat Clin Pract Neurol. 2008 Sep;4(9):504-15. doi: 10.1038/ncpneuro0886. PMID: 18711425.

25. Baldwin Lanier A. Use of nonsteroidal anti-inflammatory drugs following exercise-induced muscle injury. Sports Med. 2003;33(3):177-85. doi: 10.2165/00007256-200333030-00002. PMID: 12656639.

26. Gorski T, Cadore EL, et al. Use of NSAIDs in triathletes: prevalence, level of awareness and reasons for use. Br J Sports Med. 2011 Feb;45(2):85-90. doi: 10.1136/bjsm.2009.062166. Epub 2009 Aug 6. PMID: 19666628.

27. Ricard G, Garant MP, Carrier N, Leblanc N, Boulanger JM. Statins may increase intracerebral hemorrhage volume. Can J Neurol Sci. 2010 Nov;37(6):791-6. doi: 10.1017/s0317167100051453. PMID: 21059540.

28. Diehl N, Johnson MM. Prevalence of osteopenia and osteoporosis in patients with noncystic fibrosis bronchiectasis. South Med J. 2016 Dec;109(12):779-783. doi: 10.14423/SMJ.0000000000000565. PMID: 27911973.

29. Hall MM, Finnoff JT, et al. Musculoskeletal complications of fluoroquinolones: guidelines and precautions for usage in the athletic population. PM R. 2011 Feb;3(2):132-42. doi: 10.1016/j.pmrj.2010.10.003. PMID: 21333952.

30. Briones-Figueroa A, Sifuentes-Giraldo WA, et al. Achilles tendon rupture associated with the use of fluoroquinolones in patients over 60 years of age: experience from a single tertiary centre. Reumatol Clin (Engl Ed). 2021 Mar;17(3):141-143. English, Spanish. doi: 10.1016/j.reuma.2019.08.004. Epub 2019 Oct 28. PMID: 31672507.

31. Fleming VH, Xu J, et al. Risk of tendon injury in patients treated with fluoroquinolone (FQ) versus non-fluoroquinolone antibiotics for community-acquired pneumonia. Ann Pharmacother. 2023 Nov 9:10600280231210275. doi: 10.1177/10600280231210275. Epub ahead of print. PMID: 37946374.

32. Magra M, Maffulli N. Matrix metalloproteases: a role in overuse tendinopathies. Br J Sports Med. 2005 Nov;39(11):789-91. doi: 10.1136/bjsm.2005.017855. PMID: 16244185; PMCID: PMC1725078.

33. Bouitbir J, Sanvee GM, et al. Mechanisms of statin-associated skeletal muscle-associated symptoms. Pharmacol Res. 2020 Apr;154:104201. doi: 10.1016/j.phrs.2019.03.010. Epub 2019 Mar 12. PMID: 30877064.

34. Nikolic D, Banach M, et al. An overview of statin-induced myopathy and perspectives for the future. Expert Opin Drug Saf. 2020 May;19(5):601-615. doi: 10.1080/14740338.2020.1747431. Epub 2020 Apr 13. PMID: 32233708.

35. López de Lara D, Ruiz-Sánchez JG, et al. Exercise-induced hyponatremia: An assessment of the international hydration recommendations followed during the Gran Trail De Peñalara and Vitoria-Gasteiz Ironman

competitions. Front Nutr. 2022 Feb 21;8:781229. doi: 10.3389/fnut.2021.781229. PMID: 35265650; PMCID: PMC8898836.

36. Rae DE, Knobel GJ, et al. Heatstroke during endurance exercise: is there evidence for excessive endothermy? Med Sci Sports Exerc. 2008 Jul;40(7):1193-204. doi: 10.1249/MSS.0b013e31816a7155. PMID: 18580397.

37. Popescu FD. H1 antihistamines and driving. J Med Life. 2008 Jul-Sep;1(3):262-8. PMID: 20108503; PMCID: PMC5654300.

38. Ely MR, Romero SA, et al. A single dose of histamine-receptor antagonists before downhill running alters markers of muscle damage and delayed-onset muscle soreness. J Appl Physiol (1985). 2017 Mar 1;122(3):631-641. doi: 10.1152/japplphysiol.00518.2016. Epub 2016 Aug 4. PMID: 27493198; PMCID: PMC5401952.

39. Scholler V, Groslambert A, et al. General neural process in cycling exercise. J Sci Sport Exer. 2022; 5(1):1-15. doi:10.1007/s42978-022-00170-4