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RESEARCH ARTICLE

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A Community Cycling Survey: Initial Results of an Online Questionnaire on Cyclist Characteristics

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Abstract

Cycling is an increasingly popular exercise, mode of transportation, and sport with a growing body of literature on all three of these aspects. Research on injury incidence and prevalence has been highly focused on localities or population subsets. The aims of this study were to describe the characteristics of a large group of cyclists, and determine the existence of any relationship between gender and study variable (riding habits, racing, crash history, etc). This was an online-survey design study. This study added to the literature by using an online, self-reporting questionnaire regarding riding habits, crash history, and traumatic and overuse injury history. 785 people completed the survey. The majority were road cyclists, and nearly half (50.9%) of respondents were active racers. 51.7% of respondents reported a crash in the 2 years prior to taking the survey, and 23.5% reported chronic discomfort when riding. Of those with traumatic or overuse injury, 84.5% and 63.1%, were satisfied with the medical care for that injury, respectively. Researchers and clinicians need to work together to investigate factors that impact riding habits, crash and injury incidence, and outcomes of medical care. Cyclists have complex medical needs that are not always adequately addressed by medical providers, particularly in the spectrum of overuse injury. We identify several gaps in cycling research and lay the groundwork for future questions that will contribute to the literature in the areas of medicine and cycling.

Keywords: Cycling, Habits, Online, Survey, Injury.

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Introduction

Cycling is an increasingly popular mode of transportation, exercise, and sport. In the United States, nearly 750,000 people regularly commuted by bicycle (League of American Bicyclists, 2011), 40,000 hold racing licenses with USA Cycling (2017), and the Breakaway Research Group Benchmarking Study Report (2015) found that in the year prior to analysis, 34% of Americans rode a bicycle at least once in the previous year - 103 million people. The large (and growing) number of American cyclists reflects a wider trend of individuals using bicycles for everyday travel (Pucher & Buehler, 2007). Research shows that cycling has health (De Hartog et al, 2010; Oja et al, 2011), economic (Deenihan & Caulfield, 2014; Pucher & Dijkstra, 2003; Macmillan et al, 2014), and environmental benefits (Lindsay et al, 2010; Blondel et al, 2011). In addition, cycling's low-impact nature makes it a natural choice for rehabilitation settings and comes highly recommended after major orthopedic surgery of the hip and knee (Swanson et al, 2009). Given past growth trends, Smale's (2016) assertion that cycling is poised to continue growing in popularity is probably not far from the mark.

If current trends hold, an increased number of cyclists will bring an increased number of cycling-related injuries. A protocol has been defined to collect data on cycling exposure, habits, and crashes or injuries in order to better understand injury among cyclists (Poulos et al, 2012). The resulting publication offers a unique insight into rates of injury in a large adult cycling population (Poulos et al, 2015). It is reported that in nearly 26,000 days of cycling there were roughly 100 falls and 100 collisions, for an overall crash rate of 0.29 per 1000km ridden (Poulos et al, 2015). Emergency room data shows that cyclists who were younger than 6 years old or or older than 39 years old, travelling over 15mph, or in a collision with a motor vehicle had odds ratios of injury of 1.2-4.6 compared to subjects who did not meet the outlined criteria (Rivara et al, 2015). Projecting Poulos' (2012; 2015) and Rivara's (2015) rates onto an increasing number of cyclists shows clearly that the absolute number of crashes lends itself to a potential area of research. In addition to studying injury treatment after the fact, it is essential to implement preventative strategies to reduce risk or rate of injury. Crash and injury rates are higher among females, less experienced cyclists and those who rode for transport as opposed to sport (Poulos et al, 2015). The effect for females is of interest, as injuries have been shown to occur, and - in the case of head injuries - be reported and treated at a higher rate (Rice et al, 2016). While the effect has been shown in previous research, the reasons these groups have higher incidence and prevalence of injury remains unknown and warrants investigation, particularly in the context of the recent growth of cycling participation.

Cycling injuries can be separated into into two categories -- traumatic and overuse (Mellion, 1991; Cohen, 1993). Traumatic cycling injuries result from a myriad of factors: poor infrastructure or road conditions, operator error, mechanical failure, or interaction with a motor vehicle (Reynolds et al, 2009). After motorcycle crashes, fatal injury rates are highest in the United States for pedestrians and cyclists (21 and 13.7 per 100M person-trips, respectively) (Beck et al, 2007). Mellion (1991) and more recently, Sanford (2015), both indicate that higher speeds and motor vehicle collisions are a growing factor in traumatic cycling injuries. Rider appearance (perceived gender, location on roadway, helmet use, etc) has been shown to influence motorist behavior when overtaking a cyclist (Walker, 2007). Single- or multiple-bicycle crashes are also common in bicycle racing, where cyclists travel at high speeds and a small error can cause a pileup (Sanford et al, 2015). As Smale (2016) observed, Sanford (2015) notes that older individuals are driving not only the growth of cycling but also the increase in injury rate and hospitalization after traumatic injury. Traumatic injuries often result in a growing number of head and torso injuries (Perrin, 2012; Sanford et al, 2015). Helmet use has also been investigated for its role in preventing or attenuating injury after impact (Attewell et al, 2001; Elvik, 2011; Thompson et al, 2000). While helmet laws have not shown a consistent effect in reducing head injuries (de Jong, 2012), some posit that increased risk-taking behavior when wearing a helmet may account for the non-difference in injury incidence between conditions (helmeted or non-) (Gamble & Walker, 2016; Robinson, 2006).

Overuse injuries, that is, injuries involving only the rider and their interface with the bicycle, are a large part of overall cycling injuries. Hours on the bicycle repeating the pedaling motion thousands of times, or an asymmetry putting uneven pressure on the body for hours at a time, mean that small problems may be magnified many times over by their repeated occurrence. While rates may vary among subgroups of the cycling population, studies suggest 85% of cyclists may experience overuse injury during the course of a calendar year (Dettori & Norvell, 2006; Wilber et al, 1995). The repetitive motion of pedaling, particularly in the setting of faulty biomechanics, joint imbalances, degenerative changes, or suboptimal bike fit, can cause chronic joint and tissue stresses and dysfunction. Typical overuse injuries, especially in those who ride high volumes or race, include neck or back pain, knee pain, or numbness of the hands or groin (van der Walt et al, 2014; Clarsen et al, 2010; Usabiaga et al, 1997). Among professionals, overuse injuries of the knee result in the highest time-loss from cycling (Clarsen et al, 2010). Extended high pressures on the hands (Akuthota et al, 2005) and perineum (Hibner et al, 2010) may also cause neuropathy and are not well-studied in the literature. Position of the rider on the bicycle is an important consideration and many overuse injuries, while common, are often preventable (Wanich et al, 2007). A plethora of research has established that a poorly fitted bicycle can lead to reduced performance or increased risk of injury (Asplund & St. Pierre, 2004; Bini et al, 2011; Silberman et al, 2005; Silberman, 2013).

The medical care following injury in cyclists has not received much attention in the literature. Some small studies have taken place examining the costs of minor bicycle accidents, defined as those "not involving death or heavily injured persons" with hospital visits of <24hrs (Aertsens et al, 2010; de Geus et al, 2012). The calculated cost of an average minor accident was 841 euro ($1141, 2010 dollars), and insurance companies were involved in 30% of incidents (Aertsens, 2010; de Geus, 2012). In an examination of the total cost of bicycle injuries in Norway, it was found that cycling injury was underreported due to official statistics using official police data, and many crashes involving only a single user (Veisten, 2007). Accounting for that, an estimate of healthcare related costs for bicycle injuries and fatalities in Norway was $29.3m (2004 dollars) (Veisten, 2007). Some would argue that cost-of-injury studies are only useful for political or publicity circumstances and detract resources from real, effective programs that would contribute to lowering either the prevalence or cost of injury (Currie et al, 2006). To their credit, Currie et al did suggest the health economics' contributions should be focused on cost:benefit analysis of injury prevention strategies (2006). It is the authors' opinion that the current research on cycling medicine in the United States does not justify true "cost-of-injury" studies. This study aims to establish demographics and characteristics of an American cycling population, in order to inform future research on incidence, prevalence, and mode of injury, and the current state of medical care following injury.

While the literature does address the incidence and prevalence of injury in subgroups of cyclists, there is a gap that exists when examining the location-specific habits, crash history, and medical care of cyclists. These are important to note because of the differences in infrastructure and attitudes towards cycling in different countries (Buehler, 2011; Furth, 2012; Heinen et al, 2011; Heinen & Bohte, 2014). To rectify this, this study aimed to provide a succinct overview of the results of an online self-report survey for cyclists in the United States, investigating demographics, riding habits, and crash and injury history. Filling out the gaps in knowledge will allow more focused future research which develops and answers meaningful questions about cycling medicine, riding habits, and injury prevention strategies unique to certain subpopulations of cyclists.

Methods

An online cross-sectional survey for cyclists aged 18 and older was used to collect data for this study. The study was designed to meet the ethical criteria set forth by Harriss and Atkinson (2011), but deemed exempt from review by an institutional review board because of anonymity and lack of personal health information in the data obtained. Study data were collected and managed using REDCap electronic data capture tools hosted at Partners Healthcare. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources (Harris et al, 2009). The survey was distributed through emails to local cycling organizations, as well as posting on social media including Facebook and Twitter. The study remained online for approximately 15 months (24 Jan 2015 - 3 May 2016).

There were a total of 66 items on the questionnaire. Items were nested in three levels, so that participants only saw secondary- and tertiary-level questions if they answered the primary question appropriately. Answers were categorical, with a minimum of two options for yes/no questions. The survey was organized into sections including: demographic information (age, gender, state of residence); medical conditions (presence of any of 20 specific medical and psychiatric diagnoses selected by the authors to be relevant to cycling and exercise); cycling information (discipline, mileage, helmet use, racing); crashes (characteristics of the crash, related injury including concussion symptoms, medical treatment following the crash, and residual symptoms); nontraumatic injury (areas of discomfort, medical evaluation and treatment); and comments and contact information. Questions on crash-related injuries were limited to incidents within the past 2 years. The aims of this paper were to examine demographics, riding habits, and crash and injury history. Other questions were asked for future research. The survey took from 2-10 minutes to complete depending on the number of positive responses.

Statistical analysis

Statistical analysis was performed using SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY). Means and standard errors were computed for participant demographics. Independent-sample t-tests were used to determine if there were significant gender group age differences, and simple Chi-square contingency tables were run to determine if there were significant male/female group proportion differences in demographics, riding and racing habits, or traumatic or overuse injury in the prior 2-year period.

Results

Eight-hundred, ninety-two individuals responded to the survey. Only completed surveys (N=785) were used for analysis. Participants were majority male (N=557; 70.9%). Two identified as “genderqueer/non-binary”, one as “transgender female”, and the remainder as female (N=225). Ages ranged from 18-84 years. An independent-samples t-test was used to ascertain differences in participant age. Male respondents (46.07 ± 14 years), were significantly older than their female counterparts (39.4 ± 12.3 years), t=6.72, df=828, p<0.01. Most subjects were from Massachusetts (N=472; 60%). The next largest groups came from Connecticut (N=79; 10%), Illinois (N=72; 9.1%), California and New York (each N=29; 3.7%), and Pennsylvania (N=23; 2.9%). Thirty-two states were represented, and no state besides those mentioned had more than 10 participants. There were 4 international respondents and 1 participant who declined to answer the question. Subject demographics are described in Table 1.

Demographics	N	%	M	SE
Gender				
Male	557	70.9		
Female	225	28.6		
Non-Binary	2	0.2		
Transgender F	1	0.1		
Age				
Male			46.07	14
Female			39.4	12.3
Location				
MASS	472	60		
CONN	79	10		
ILL	72	9.1		
CAL	29	3.7		
NY	29	3.7		
PA	23	2.9		
INT	4	0.4		
OTH	77	10		

Table 1: Subject demographics and locations

Riding and Racing Habits

The majority of respondents who completed the survey identified themselves as road riders (N=705; 89.8%). Commuting (N=369; 47%), leisure (N=276; 35.2%), and mountain (N=202; 25.7%) also had high participation rates. Chi-square testing revealed that a significantly greater proportion of males than females participated in road cycling (93% v 83.2%; X3=18.47, p<0.01) and bicycle motocross (BMX) (.8% to 0%; X3=78.62, p<0.01). Conversely, more females than males participated in triathlon (16.8% v 7.9%; X3=14.41, p=0.002), commuting (56.8% v 42.2%; X3=17.96, p<0.01), and leisure (45.6% v 30.1%; X3=19.886, p<0.01) cycling.

Only 5 (0.6%) respondents reported less than one year of regular riding. There was a general increase in number of respondents as experience increased: 147 (18.7%) claimed 1-5 years; 181 (23%) with 5-10 years; 179 (22.8%) with 10-20 years; and 272 (34.6%) respondents had been regularly cycling for over 20 years. Interestingly, there was an apparent interaction effect between experience and gender. While 77.6% of respondents with more than 20 years of cycling experience were male, the number dropped to 53.1% for those with 1-5 years of experience – possibly indicative of a recent demographic shift among newer cyclists. Chi-square testing for Gender*Experience (X12=39.83, $p<0.01$) indicated that this effect was significant.

The interaction trend seen in experience levels was mirrored in weekly mileage. While males constituted the bulk (82.1%) of riders reporting over 150mi/week during warm weather months (April-September), the number dropped with mileage. Females were 46.7% of those reporting 25-50mi/week, and 63.6% of those who rode less than 25 mi/week. Chi-square testing for Gender*Warm Weather Riding was significant (X18=66.74, $p<0.01$): During the cold weather months (October-March), males rode more across the board, from 58.9% of those who rode under 25 mi/week to 87.5% of those who rode more than 150 mi/week. Chi-square testing indicated that there were significantly fewer women who rode during the winter than men. Additionally, males were the more social riders: While chi-square testing indicated no significant difference between number of males and females who rode alone, males were more likely to ride with a friend (60.3% v 39.3%; X3=8.81, p=0.032) and in a group (73.3% v 26.7%; X3=9.94, p=0.019). 98% of riders reported wearing an approved helmet on the majority of their rides: 73% or respondents claimed that their helmets were less than 3 years old (i.e., still under warranty).

Interestingly, almost exactly half of our study participants (50.9% of respondents) were active bicycle racers (including road, track, cyclocross, mountain, triathlon). There was no significant difference in racing participation between genders. Males were more likely to participate in road racing (44.3% v 34.4%; X(3)=9.651, p=0.022), track racing (64.6% v 31.2%, X(3)=22.114, $p<0.01$). There were no other significant differences in racing participation in the mountain, cyclocross, triathlon, para-cycling, or BMX disciplines between gender groups. There was no significant effect of gender on racing experience. Most males (52.6%) and females (65.8%) had 6 or fewer years of racing experience.

Crash History

Participants were asked if they had been involved in a crash in the 2 years prior to responding to the survey. If they had been involved in multiple incidents, they were requested to recall and answer questions with respect to their self-reported "most serious" crash. There was no significant effect of gender on crash incidence in the 2 years previous to survey participation, circumstance of crash, cause of crash, or motor vehicle involvement in the crash. 51.7% (n=406) reported a cycling crash within the time period examined in the survey; 53.1% of males and 48.8% of females. The majority of crashes happened during training rides (48.2% of male crashes and 36.9% of female crashes). There were no significant differences between gender or cause but the overwhelming causes were vehicle-rider collisions (N=89; 22%), road surface changes (N=84; 20.7%), and rider-rider collision (N=78, 19.3%), and 23.6% of all crashes involved a motor vehicle.

Traumatic Injury History

There were significant gender effects for traumatic injury to the skin (X(3)=8.195, p=0.042), head (X(3)=18.105, $p<0.01$), and spine(X(3)=22.079, $p<0.01$). Males (18.3%) reported more skin-only injuries than females (11.2%). Females reported more head injuries (14% v 8.3%) and spine injuries (3.2% v 1.7%). 26.3% of respondents recorded an upper body injury post-crash. 18% reported a lower body injury. There were no significant gender effects for either of these.

Overuse Injury History

184 individuals (23.5%) reported chronic (>3 months) discomfort while riding. There was a significant gender effect (X(3)=12.51, p=0.006). 26.8% of females claimed chronic discomfort compared to 21.5% of males. Females (21.2%) reported more musculoskeletal and joint pain, sprain, and/or fracture than males (16.6%) (X(3)=15.812, p=0.001). There was a significant gender effect (X(3)=14.312, p=0.003) on neurological symptoms (concussion, migraine, numbness, tingling, weakness, etc.). Females (6.4%) reported more symptoms than men (3.2%). Males (6.2%) reported more low back pain than females (5.2%) (X(3)=31.11, $p<0.01$). Females reported more hip, groin, and/or buttock pain than males (9.2% v 5.3%) (X(3)=18.465, $p<0.01$). Females (4.0%) experienced more chronic pain of the foot and ankle when riding than males (1.9%) (X(3)=39.351, $p<0.01$), as well as pain located on or in the head (1.6% v 0%) (X(3)=83.971, $p<0.01$).

Discussion

To the authors' knowledge this is the first large study to examine rates of participation in various cycling disciplines depending on gender. While this may not strike one as 'groundbreaking', it provides retrospective justification for the innumerable cycling studies which preclude one gender or another. To identify large differences in discipline participation by gender offers guidance for future researchers who are seeking to develop research questions and hypotheses which will have the most impact on their target population. To have empirical evidence that suggests males are more likely road and BMX cyclists, and females, triathletes, commuters, or recreational cyclists, sheds light on the direction future researchers should take when undertaking studies of those cycling disciplines. One of the biggest strengths identified was the nearly even split between racing cyclists and non-racing cyclists. Much of the existing literature has used a high-level competitive subject pool. Addressing the needs of non-racing cyclists will lead to more generalizable studies with a larger impact on the general population. Additionally, over 50% of our respondents who were racers had less than 6 years of racing experience, suggesting a recent "growth spurt" in the sport of cycling. This may help investigators in developing and targeting recruitment efforts for studies which require all types of cyclists as subjects.

Nearly half of respondents were bicycle racers of some type. Half of the total respondents also reported a crash in the two years prior to taking the survey. Logically, it holds that there must be some overlap between these two groups, and future research should attempt to quantify the relationship or odds ratio between racing participation and crash risk. Crashes during training rides were attributable to a variety of causes, but motor vehicle collisions and road surface changes were the two top culprits. These may be affected by public policy and cyclist-friendly infrastructure development. Research on these two themes has received much attention in countries such as the Netherlands and Belgium, but far less in the United States, even as cycling is growing rapidly. The reasons for this discrepancy may lay in historic and cultural differences which have influenced attitudes and policy in regards to cycling. That topic lays outside the scope of this publication, but future research, especially in the United States, should examine the impact of dedicated up-to-date infrastructure on incidence and prevalence of cycling crashes in cities at the forefront of cycling-friendly urban planning. Establishing if the availability of cycling-specific infrastructure has an effect on ease and safety of cycling may go a long way towards lowering barriers to cycling to commute or for exercise.

Satisfaction with medical care is a complex topic, and the limited questions included in the survey were not addressed in this manuscript. Initial analysis of the data showed nearly 85% of respondents who had crashed were satisfied with the medical care they received afterwards. Cyclists who complained of overuse injury tended to be less satisfied with their post-injury care (63.1%). Satisfaction may be influenced by the patient-doctor relationship, communication, compliance with treatment, outcomes, and cost, none of which have been studied in this population or were addressed in this manuscript. A deeper understanding of the causes and treatment of crash and overuse injury would help to reduce the time spent injured. Future research should address factors contributing to injury including the influence of an individual's medical history. Researchers should also examine the impact that specific types of providers seen, the medical treatment received for both crash-related and overuse injury, and/or outcomes of various types of treatment have on patient satisfaction with medical care.

The major limitation of the current study lies in the methodology. Wright (2005) notes that online surveys have the ability to reach unique populations that may not exist in physical groups, as well as the benefits of reduced time and monetary costs associated with implementation. Online surveys also tend to have better response rates than traditional mailed surveys (Mehta & Suvadas, 1995; Stanton, 1998; Thompson et al, 2003), but can be prone to self-sampling (Stanton, 1998; Thompson et al, 2003). While online surveys have the potential to reach a worldwide audience, the majority of respondents in this study were confined to a single geographic area. This does limit the generalizability of our results, but the impact of future geographically-targeted research cannot be overlooked. It may provide unique insight into attitudes and cycling-specific infrastructure at a given location, which in turn would provide insight to needs which can be addressed at that level.

There is also the concern that certain populations may show lower response rates compared to the overall group of respondents (Lefever et al, 2006). Three respondents chose from the 3 non-binary gender options given (Transgender male, transgender female, genderqueer/non-binary). It is estimated that 0.58% of the United States population identifies as transgender (Flores et al, 2016). The 3 respondents worked out to 0.38% of total responses, comparable to the projected national proportion. However, the absolute number of responses is too low to draw any conclusions regarding trends or issues in the national population. Lastly, surveys of any kind are at risk of bias both selection and recall. Online surveys are especially prone to selection bias: First from the accessibility to the study, and secondly from respondent self-selection. There is no simple solution to the prior, but controlling for the latter may be done by ensuring a wide net is cast, in order to recruit a population-representative sample. Factors contributing to recall bias have not been well-studied (Coughlin, 1990), but it is important to note that recall may be biased or simply inaccurate, with no bias on the part of the respondent. Increasing the potential subject pool by networking with national cycling organizations and health care networks will allow researchers to separate specific sub-groups for more in-depth research. Besides increasing sample sizes, involving a team of multidisciplinary experts to address the issues of crash or injury rate, medical care, and cyclist satisfaction should be a high priority of research groups moving forward.

Conclusions

This paper contributes to the literature by reporting riding history, crash history, and medical care satisfaction among a large group of cyclists, examining gender differences where appropriate. Future research should focus on increasing the sample size, examining gender differences, and investigating the characteristics and needs of recreational cyclists. In conclusion, researchers and clinicians should work together to identify factors which influence cyclists' riding habits, crash rate, and satisfaction with medical care, both in localities with and without dedicated cycling infrastructure.

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Conflict of interest
Greg Robidoux is the owner of Serotta International Cycling Institute and the Co-Chair of Medicine of Cycling and Bike Fit Symposium – Interbike.

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