



Sensation seeking and crashes among young cyclists

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ABSTRACT

While young cyclists remain overrepresented in cycling crash figures, effective actions to mitigate their risks remain understudied and underapplied, especially in regions with low cycling tradition and weak or fragmented governance, as is the case in most Hispanic countries. One key emerging issue is the potential influence of personality traits such as sensation seeking (SS) on young cyclists' behavior and safety outcomes. This study aimed to assess the relationships among SS, cycling behavior, and safety-related outcomes among a sample of young cyclists. Data were collected from 945 cyclists aged 18–25 from five Hispanic countries, who responded to an electronic survey on personality traits and cycling-related topics. Significant associations were found between sensation seeking and risk-related cycling behaviors, as well as gender differences in SS, risky cycling behavior, and self-reported cycling crash rates, with males exhibiting higher values in all categories. Path analyses suggest that SS predicts self-reported crashes through the full mediation of both deliberate (traffic violations) and unintentional (errors) risky road behaviors, with the former having a greater explanatory effect on young cyclists' self-reported crash figures. The findings of this study highlight the need to address under-researched issues such as sensation seeking (SS) and risk-taking behavior through evidence-based interventions aimed at improving the safety of young cyclists. This is particularly relevant in countries with similar demographic characteristics and further nascent cycling cultures.

1. Introduction

While young cyclists remain overrepresented in cycling crash figures, only a few actions addressing potential solutions to the great number of safety issues they suffer have been developed. Among other relevant issues, this poses the challenge to promote sustainable transport means in both efficient and safe ways, given that young users represent nowadays one of the core focus of modal shifts and mobility-related environmental improvements in cities but, at the same time, a frequent concern in terms of behavioral risk and crash-related contributors (Alonso et al., 2023; Sarma et al., 2013; Useche et al., 2024; Zeuwts et al., 2017, 2021).

There are some relevant facts documented in this regard. For instance, it is known that, just like young drivers of other types of vehicles (especially motorized cars and motorcycles), early adults using non-traditional transportation means such as cycling (Useche et al.,

2019a,b; Zeuwts et al., 2017), e-scooting (Useche et al., 2022, 2024), and even walking (Delclòs-Alió et al., 2022; Useche et al., 2020), have been focused as a key at-risk segment of the road user population (Oviedo-Trespalcacios et al., 2021; Oviedo-Trespalcacios and Scott-Parker, 2018; Poulos et al., 2015).

Moreover, and although specific research studying personality matters among two-wheeled users (O'Hern et al., 2020), young cyclists have been targeted as a population of interest in terms of personality-related issues, given their greater proneness to be high scorers in traits such as neuroticism, extraversion and (especially) sensation seeking (Stephens et al., 2020; Zheng et al., 2019). From a conceptual standpoint, sensation seeking (SS) is defined as the need for varied, novel, and intense experiences, coupled with the willingness to take physical and social risks to achieve such experiences. Individuals with high sensation seeking are driven by the pursuit of excitement and stimulation (Roberti, 2004; Zuckerman, 1994).

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Among its typical correlates, sensation seeking has been closely linked to other risky behaviors, such as drugs and alcohol consumption, circulation under the influence of them, and aggressive behaviors (Jiménez-Granado et al., 2023; LaSpada et al., 2020; Lemarié et al., 2019; McCabe et al., 2015). In addition, to the extent that more evidence is developed, SS is getting growingly and systematically linked to greater rates of road risk assumption, lower risk perception rates, and a greater likelihood to get involved in traffic crashes (Navas et al., 2019; Wang et al., 2019, 2020).

While only a few studies have examined this issue so far, it is already assumed that cyclists with higher scores on sensation seeking (i.e., SS *high scorers*) are more likely to engage in high-speed cycling, frequently seeking the thrill of rapid travel despite potentially understanding the increased risk of crashes. As a relevant example, some previous empirical experiences have documented a high frequency of SS-related cycling behaviors, such as weaving through traffic, running red lights, or performing stunts (Useche, 2024; Zadka-Peer & Rosenbloom, 2024; Zheng et al., 2019).

1.1. Cycling and age-related issues in Hispanic countries

In the case of Hispanic countries, the situation seems even more critical. Although some of them are categorized as high-income countries, it is evident that policymaking on cycling safety in these regions often lags behind that of countries with a greater cycling tradition (Cervero et al., 2009; Tello et al., 2022). This results in less robust infrastructure and fewer safety measures specifically developed to improve cyclists' behavior, safety, and travel experience (Mora et al., 2024a,c; Zeuwts et al., 2021), as well as huge disparities in cycling infrastructure across districts (Tiznado-Aitken et al., 2022). Furthermore, in some countries within this large region, such as Colombia or Chile, risk and thrilling cycling is an everyday activity for young groups, and city authorities even promote it as leisure (The Guardian, 2019). Additionally, regarding young cyclists, there is a lack of targeted educational campaigns and interventions, despite the significant fact that the mean age of the Hispanic population in Latin America tends to be considerably lower than that of aging regions such as parts of Europe and Asia, where the average age of cyclists tends to be greater (Cordovil et al., 2022; Rodríguez-Rodríguez et al., 2019).

One significant policy gap is that, while utilitarian modalities of cycling such as cycling commuting are on the rise in most countries of Latin and North America, despite a growing participation of both young and female cyclists, there is a marked absence of comprehensive cycling safety laws and regulations, and many cycling-cultural flaws remain threatening the future of cycling attractiveness and safety (Ravensbergen et al., 2020; Useche et al., 2018, 2021).

In addition, and as for other relevant cycling crash prevention issues, in many Hispanic countries, laws mandating the use of helmets and visibility-enhancing devices, are either non-existent or poorly enforced (Rojas-Rueda, 2021). In other cases, these preventive measures are simply ignored by most cyclists. For example, a large observational analysis in the city of Santiago (Chile) showed that, despite being mandatory, only 28 % have a functioning front light (DATAVOZ, 2019). Also, previous studies have found that the poor use of such protective measures and devices among young urban cyclists sometimes causes resentment and social discomfort on the part of other road users, such as bus drivers, thus enhancing possible road conflicts and social prejudices (Mora et al., 2024a).

This regulatory shortfall not only endangers young cyclists but also fails to ensure the mid- and long-term safety of urban cycling, given that cycling is already perceived as a trendy activity among educated groups in the Latin American region (Avila-Palencia et al., 2023; Pardo et al., 2021) and is expected to continue growing in these countries over the next few years (Cordovil et al., 2022; Orozco et al., 2023; Vecchio et al., 2020).

In risk-related terms, recent studies have highlighted several key

issues contributing to the heightened risk –and rarely to positive riding behaviors– among young cyclists in Hispanic countries. These include inadequate cycling infrastructure, such as poorly maintained bike lanes and a lack of dedicated cycling paths, which forces cyclists to share the road with light and heavy motor vehicles (Mora et al., 2024b), increasing the likelihood of accidents (Torres-Barragan et al., 2020). Furthermore, cultural attitudes towards cycling can sometimes be dismissive, viewing it more as a leisure activity rather than a legitimate mode of transportation, which can influence policy priorities and resource allocation (Carvajal et al., 2020; Cordovil et al., 2022). Moreover, these cultural attitudes are often mirrored by norms and manuals surrounding cycling, which portrays this activity as less important than driving (Mora et al., 2024c), as well as cycling investment coming from national agencies, which remain almost non-existent in several developing and Low- and Middle-income countries of the globe (Iglesias et al., 2019). There is also a pressing need for data-driven approaches to identify high-risk areas and times for cycling crashes, enabling more targeted interventions (Rojas-Rueda, 2021).

1.2. Study aim and hypotheses

Bearing in mind the aforementioned empirical studies and their grounding considerations, the aim of this study was to assess the relationships among sensation seeking, cycling behavior, and safety-related outcomes among a sample of young Hispanic cyclists.

In this regard, and considering the information provided by previous studies and relevant evidence-based assumptions in the reviewed literature, three study hypotheses were developed as follows:

Hypothesis 1. *Significant associations will be found between sensation-seeking scores and both self-reported risky cycling behavior (errors and violations) and cycling crashes involving young cyclists.*

Hypothesis 2. *Gender differences exist in both sensation-seeking scores and self-reported cycling behavioral factors among cyclists, with males showing greater assumed risks in these regards.*

Hypothesis 3. *Sensation seeking has a predictive relationship to self-reported cycling safety outcomes of young cyclists, potentially mediated by risky and positive cycling behaviors.*

2. Methods

2.1. Sample

For this study, it was used a pooled sample composed of 945 Hispanic cyclists from five countries ranging [18–25], with an average of $\mu = 20.55$ ($x \sim 20.00$; $\sigma = 2.14$) years. Among them, 355 (37.6 %) were females, 586 (62 %) were males, and 4 (0.4%) identified themselves as non-binary.

The participating young cyclists resided in five different Hispanic countries; Chile (3 %), Colombia (44 %), Mexico (5 %), Dominican Republic (32 %), and Spain (16 %). Regarding their cycling habits, commuters reported a mean number of $\mu = 5.54$ ($x \sim 4.00$; $\sigma = 6.62$) cycling hours a week, and average bicycle journeys of $\mu = 46.58$ ($x \sim 35.00$; $\sigma = 38.29$) minutes. All of them were riders of conventional bikes.

2.2. Procedure

This cross-sectional study was based on self-reported data from cyclists in five Hispanic countries (four Latin American and one European), where cycling among young adult populations has significantly increased and where policy enforcement has been strengthened in most countries over the past decade.

Regarding participant recruitment procedures, we utilized pre-existing research email lists, shared among the study authors, to distribute electronic invitations to a broad sample. Each invitation

included a link to the study questionnaire and an introductory letter outlining the study objectives, its purely scientific nature, the inclusion and exclusion criteria, and the participation process, which involved completing an anonymous electronic survey.

For inclusion/exclusion criteria, individuals needed to meet the following conditions to participate in this research: (i) residing and cycling in the country, (ii) cycling more frequently than “a few times a month”, (iii) having at least five years of cycling experience, and (iv) having access to a smartphone, tablet, or computer with an internet connection, something technically necessary to complete the survey.

The response rate was estimated at approximately 46% and was consistent across all countries, with effective participation rates whose response rate ranged between 40 % and 50 % of valid responses in all cases. After accounting for the exclusion of incomplete responses (surveys completed at less than 80 %), six participants under the required age, and 14 cases flagged as duplicates due to repeated MAC addresses, the final dataset was compiled.

2.3. Questionnaire contents

In accordance with the study variables described above, the contents of the analyzed survey were structured and measured as follows:

A study presentation statement, where we disclosed the basic information to our potential partakers, an informed consent statement was provided outlining the study objectives, survey duration, data treatment, and voluntary participation before participants completed the questionnaire.

The first block of questions addressed sociodemographic information (e.g., age, gender, occupation, educational attainment of cyclists) and cycling patterns (e.g., cycling frequency, length of common cycling trips, hours riding per week). Finally, the number of self-reported cycling crashes suffered was assessed through a single item, addressing these incidents over a period of five years and regardless of their severity.

To assess both self-reported risky and positive cycling patterns, the Cycling Behavior Questionnaire (CBQ) was used. This is a validated Likert-type survey with 29 questions that evaluate different types of cycling behaviors (Useche et al., 2022). Its structure includes three main factors, allowing cyclists to self-report their common riding behaviors in three categories: intentional risky behaviors (traffic violations; 8 items; Cronbach's alpha $[\alpha] = 0.826$; McDonald's omega $[\omega] = 0.829$; Guttman's lambda $[\lambda] = [.723 - 828]$), unintentional risky behaviors (riding errors; 15 items; $\alpha = 0.930$; $\omega = 0.929$; $\lambda = [.868 - 932]$), and positive behaviors (6 items; $\alpha = 0.889$; $\omega = 0.887$; $\lambda = [.741 - 889]$). The full set of items composing the cross-culturally validated version of the CBQ is publicly available in Useche et al. (2022).

Traffic rule knowledge and risk perception were tested through the Risk Perception and Regulation Scale (RPRS), a 12-item Likert-type scale assessing two factors (Useche et al., 2022). The first factor, rule knowledge, is composed of 5 items ($\alpha = 0.805$; $\omega = 0.806$; $\lambda = [.644 - 809]$). The second, risk perception, consists of 7 items ($\alpha = 0.858$; $\omega = 0.856$; $\lambda = [.735 - 859]$). Sensation seeking was assessed using the Sensation Seeking in Cycling (SSC) scale, which allows the measuring of sensation-seeking factors in the specific setting of urban cycling (Useche, 2025). This scale, used in its unifactorial version, consists of 13 items ($\alpha = 0.805$; $\omega = 0.806$; $\lambda = [.644 - 809]$).

Finally, and with the aim of using this variable for statistical contrasts and inter-group comparisons, the study participants were asked to self-report their *riding crashes* (or incidents, regardless of their severity, as long not fatal) suffered along the previous five years.

2.4. Data analysis

After a careful data cleaning and curation process, the basic descriptives and coefficients of the study variables were calculated. Instrument scores (e.g., CBQ; RPRS) were scored in accordance with their validated criteria, and internal reliability coefficients were estimated. In

addition to Cronbach's alphas, whose sole use is criticized in methodological literature for its likelihood to produce biased results if not double-checked, McDonald's omegas and Guttman's lambda-2 coefficients were also used (see Dunn et al., 2014; Stensen & Lydersen, 2022).

The bivariate associations between sensation seeking and the other study variables were assessed through partial (non-parametric) correlations. These correlations are similar to typical Pearson (r) coefficients but add confidence intervals to the association coefficients, as well as statistical corrections to the significance levels, thus minimizing the risk of committing type 1 errors and assuming spurious associations. These correlations controlled for age and gender to ensure that the observed correlations between SS and the study variables were not influenced by these factors (see Karras et al., 2024).

Gender-based mean differences between male and female cyclists were assessed through robust comparative tests, specifically t-based Welch tests. From a technical perspective, Welch's robust tests are appropriate for comparing means in situations involving non-normal distributions, unequal sample sizes, and ordinal variables. As distribution-free methods, these tests offer greater flexibility for dealing with mixed or non-interval data often found in behavioral research (see West, 2021).

The hypothesized predictive paths linking sensation seeking with cycling behaviors and safety outcomes were tested through confirmatory SEM-based procedures, which controlled for cyclists' age and gender. The aim of this procedure was to assess a set of literature-based directional relationships between exogenous and endogenous variables using a confirmatory approach.

2.4.1. Bootstrapping procedures

As for statistical corrections, bootstrapping procedures were conducted to bias-correct both partial correlations and SEM analysis outcomes. We used Monte Carlo parametric tests with 2,000 bootstrap iterations, with confidence intervals set at 95 %. These bootstrapping procedures are useful to address potential biases and improve the reliability of the statistical results (Gilleland, 2020).

Specifically, bootstrapping the study data helps reduce the risk of Type I errors by creating multiple resamples of the data and recalculating the estimates for each resample, thereby providing more robust and less biased estimates of significance. This method corrects for issues such as non-normality (something considerably common in behavioral studies) and small sample sizes, which can lead to inaccurate or misleading results in traditional tests (Efron and Tibshirani, 1993; Gilleland, 2020).

Regarding the usefulness of these procedures, in our study applying bias-corrected confidence intervals helps to ensure that the reported p-values and confidence intervals were more reliable and robust against such potential biases, ultimately reducing the likelihood of committing Type I errors in path significance (Dunn et al., 2014; Efron and Tibshirani, 1991, 1993).

All statistical analyses were performed using IBM SPSS v.28, while structural equation modeling analyses utilized IBM SPSS AMOS v.28 software.

2.5. Ethics

In order to conduct this study, the research protocol was first reviewed and approved by the Research Ethics Committee of the Research Institute on Traffic and Road Safety (INTRAS), ensuring it adhered to the essential ethical principles of the Declaration of Helsinki for research involving human subjects (Institutional Review Board approval number (HE0001090423)).

3. Results

3.1. Partial correlations

The associations between sensation seeking and risk-related study factors were tested using partial correlations, whose test (r) coefficients, confidence intervals, and statistical corrections, are available in [Table 1](#). In the first correlation, i.e., between sensation seeking and perceived cycling performance, it was found that young cyclists with high sensation seeking scores tend to consider themselves better riders than their low-scoring counterparts.

Among other key correlates of sensation seeking scores, those related to risk perception and traffic rule knowledge stand out. Specifically, risk perception scores have shown a correlation coefficient near zero with sensation seeking scores, suggesting they occur independently, which makes sense in consideration of the basic assumptions of trait-based psychology of personality mentioned in the literature review. Meanwhile, traffic rule knowledge has a moderate but still non-significant association with sensation seeking, as the bootstrapped significance level remains above the cut-off threshold of $p < 0.050$, suggesting that sensation seeking scores are independent from the normative awareness of young cyclists.

Regarding the correlations between sensation seeking and self-reported cycling behaviors, positive and significant bivariate associations were found between this personality trait and both traffic violations and riding errors. Conversely, the association between sensation seeking and positive behaviors is significant but negative, and of a smaller magnitude. Finally, the extent to which young cyclists self-report cycling crashes is positively linked to their sensation seeking scores.

3.2. Gender comparisons

Secondly, to evaluate the differences in terms of the study variables among genders, a series of comparative tests was conducted. Given that non-binary participants ($n = 4$) were underrepresented, the comparisons solely refer to female vs. male young cyclists. The two groups were then compared in terms of sensation seeking scores, self-reported cycling behavior (i.e., traffic violations, riding errors, and positive behaviors), risk perception, rule knowledge, and traffic crashes as cyclists suffered in the last five years. The detailed results of these analyses are available in [Table 2](#).

Table 1

Partial bivariate correlations of sensation seeking (SS) with other study variables.

Variable ^a	Statistic ^b	Bootstrap ^c			Confidence Interval ^d	
		Std. Error	Bias	Sig.	Lower	Upper
Self-rated cycling performance	0.271	0.033	0.001	<0.010	0.210	0.329
Risk perception	-0.014	0.039	-0.002	0.660	-0.094	0.059
Rule knowledge	0.063	0.037	-0.001	0.053	-0.015	0.134
Traffic violations	0.508	0.027	0.000	<0.010	0.459	0.554
Riding errors	0.385	0.031	0.000	<0.010	0.330	0.438
Positive behaviors	-0.101	0.041	0.003	<0.050	-0.165	-0.038
Self-reported cycling crashes	0.245	0.037	0.001	<0.010	0.184	0.304

Notes: ^a Partial correlation controlling for cyclists' age and gender; ^b All bivariate correlations refer to direct Sensation Seeking (SS) scores; ^c Bootstrap results are based on 1,000 bootstrap samples; ^d Confidence Interval [C.I.] Level = 95 %.

Overall, significant differences between male and female young cyclists were found in five out of the seven variables contrasted. The first one corresponded to sensation seeking, to which significantly higher scores corresponded to male cyclists ($\mu_{\text{diff}} = 0.46$; $p < 0.001$; $\Omega^2F = 0.090$). On the contrary, self-rated cycling performance was greater among their female counterparts ($\mu_{\text{diff}} = 1.29$; $p < 0.001$; $\Omega^2F = 0.090$). As for risk perception, no differences were found across genders, even though males self-reported greater rates of traffic rule knowledge ($\mu_{\text{diff}} = 0.21$; $p < 0.001$; $\Omega^2F = 0.020$).

In regard to self-reported cycling behavior, male cyclists reported significantly greater rates of both traffic violations ($\mu_{\text{diff}} = 0.40$; $p < 0.001$; $\Omega^2F = 0.070$) and errors ($\mu_{\text{diff}} = 0.18$; $p < 0.001$; $\Omega^2F = 0.020$). However, no differences were found as for positive behaviors, even though the mean was slightly greater among female riders. Finally, five-year self-reported crash rates of female cyclists doubled those registered by females ($\mu_{\text{diff}} = 0.58$; $p < 0.001$; $\Omega^2F = 0.020$).

3.3. Country comparisons

Regarding specific differences among the countries covered in this study, slight variations were observed in questionnaire scores for variables such as risk perception, self-reported risk behaviors, and crash outcomes, even though the analyses controlled for cyclists' age and gender. [Table 3](#) presents the full set of country-based descriptives, mean comparisons, and effect sizes for each of the study variables..

Overall, the highest self-reported crash rates were recorded in Mexico ($\mu = 1.73$; $SD = 1.54$), while the lowest were reported in Spain ($\mu = 0.73$; $SD = 0.91$). As for traffic violations, the highest scores were observed in Colombia ($\mu = 0.90$; $SD = 0.73$), and the lowest in Spain ($\mu = 0.55$; $SD = 0.61$). In terms of riding errors, the highest rates were found in the Dominican Republic ($\mu = 0.72$; $SD = 0.83$), with the lowest among Spanish cyclists ($\mu = 0.36$; $SD = 0.41$). On the other hand, Chile reported the most frequent positive cycling behaviors ($\mu = 3.14$; $SD = 0.46$), whereas the lowest were observed in Spain ($\mu = 2.70$; $SD = 1.37$).

Moreover, it is noteworthy that no significant differences were found in relation to Sensation Seeking ($F = 1.51$; $p = 0.201$), suggesting that, as this refers to a personality trait, cyclists of similar age may tend to score similar SS values regardless of their country of origin.

3.4. Path analysis

To test the directional hypothesis about how exogenous variables (specifically, sensation seeking scores and risky/positive cycling behaviors) exert an effect on self-reported crash outcomes of riders, a theory-based Structural Equation Model was developed, following three confirmatory modeling steps:

The initial step involved integrating statistical controls (cyclists' age and gender) and structuring the model to assess the direct effects of sensation seeking on cycling behavior, considering as dependent variables both deliberate (i.e., traffic violations, positive behaviors) and undeliberate ones (i.e., riding errors).

The second step added three pathways (traffic violations → self-reported cycling crashes; riding errors → self-reported cycling crashes; positive behaviors → self-reported cycling crashes) to assess the potential mediating role of riding behavior between sensation seeking (trait) scores and crash-related outcomes.

The final step, as discussed in the data analysis section, applied statistical adjustments, including bootstrapping procedures, to address and correct potential biases, thereby reducing the likelihood of type I errors in path significance (see [Andrews & Buchinsky, 2000](#); [Lijarcio et al., 2022](#)).

The goodness-of-fit statistics for the significant model were $\chi^2 = 21.697$, $p < 0.001$; NFI = 0.981; CFI = 0.983; IFI = 0.983; RMSEA = 0.066, with a 90 % CI of [0.030 – 0.102]. Since these fit indices were

Table 2

Gender comparisons of the study variables. Method: Welch.

Study Variable	Group	Mean	SD	SE	95 % CI ^a		Comparative Tests		Effect size ^b	95 % CI ^a		
					Lower	Upper	Statistic ^c	Sig. ^d		Lower	Upper	
Sensation seeking	Female	0.95	0.70	0.04	0.88	1.02	91.28	< 0.001	η^2	0.09	0.06	0.12
	Male	1.41	0.74	0.03	1.35	1.47			ε^2	0.09	0.05	0.12
	Total	1.24	0.76	0.02	1.19	1.29			Ω^2_F	0.09	0.05	0.12
Self-rated performance	Female	6.57	2.23	0.12	6.33	6.80	86.02	< 0.001	η^2	0.09	0.06	0.13
	Male	7.86	1.79	0.07	7.71	8.01			ε^2	0.09	0.06	0.13
	Total	7.37	2.06	0.07	7.24	7.50			Ω^2_F	0.09	0.06	0.13
Risk Perception	Female	3.29	0.79	0.04	3.21	3.38	0.00	0.991	η^2	0.00	0.00	0.00
	Male	3.29	0.73	0.03	3.23	3.35			ε^2	0.00	0.00	0.00
	Total	3.29	0.76	0.02	3.24	3.34			Ω^2_F	0.00	0.00	0.00
Rule knowledge	Female	2.95	0.85	0.05	2.86	3.04	15.44	< 0.001	η^2	0.02	0.00	0.04
	Male	3.16	0.77	0.03	3.10	3.23			ε^2	0.02	0.00	0.04
	Total	3.08	0.81	0.03	3.03	3.13			Ω^2_F	0.02	0.00	0.04
Traffic violations	Female	0.53	0.62	0.03	0.46	0.59	80.12	< 0.001	η^2	0.07	0.04	0.11
	Male	0.93	0.75	0.03	0.87	0.99			ε^2	0.07	0.04	0.11
	Total	0.78	0.73	0.02	0.73	0.83			Ω^2_F	0.07	0.04	0.11
Riding errors	Female	0.52	0.63	0.03	0.46	0.59	15.83	< 0.001	η^2	0.02	0.00	0.04
	Male	0.70	0.67	0.03	0.64	0.75			ε^2	0.02	0.00	0.03
	Total	0.63	0.66	0.02	0.59	0.67			Ω^2_F	0.02	0.00	0.03
Positive behaviors	Female	2.89	1.16	0.06	2.77	3.01	1.22	0.269	η^2	0.00	0.00	0.01
	Male	2.81	0.91	0.04	2.74	2.88			ε^2	0.00	0.00	0.01
	Total	2.84	1.01	0.03	2.78	2.91			Ω^2_F	0.00	0.00	0.01
Cycling crashes	Female	0.57	1.29	0.07	0.44	0.71	24.26	< 0.001	η^2	0.02	0.01	0.05
	Male	1.05	1.64	0.07	0.91	1.18			ε^2	0.02	0.01	0.04
	Total	0.87	1.53	0.05	0.77	0.96			Ω^2_F	0.02	0.01	0.04

Notes: SD= Standard Deviation; SE= Standard Error; ^a Confidence Interval at the level 95 %; ^b Estimated based on the fixed-effect model; ^c Test value; ^d Significance levels: ***=<.001; **=<.010; η^2 = Eta-squared; ε^2 = Epsilon-squared; Ω^2_F Omega-squared (Fixed-effect); Ω^2_R Omega-squared (Random-effect).

Table 3

Country-based figures for the study variables and comparative tests.

Study Variable	Statistic	Total	Chile	Colombia	Mexico	Dominican Republic	Spain	Comparative Tests	Effect size
								Statistic ^c	Sig. ^c
Sensation seeking	Mean	1.24	1.13	1.26	1.25	1.27	1.11	1.51	0.201
	SD	0.76	0.53	0.74	0.62	0.80	0.77		
	SE	0.02	0.11	0.04	0.09	0.04	0.06		
Self-rated performance	Mean	7.37	7.83	7.72	8.30	7.01	6.90	12.29	< 0.001
	SD	2.06	1.03	1.65	1.19	2.32	2.52		
	SE	0.06	0.21	0.08	0.18	0.13	0.20		
Risk Perception	Mean	3.29	3.69	3.37	3.62	3.22	3.08	7.39	< 0.001
	SD	0.75	0.34	0.61	0.36	0.84	0.94		
	SE	0.02	0.07	0.03	0.05	0.04	0.07		
Rule knowledge	Mean	3.08	3.35	3.10	3.34	3.06	2.97	15.97	< 0.001
	SD	0.80	0.47	0.72	0.63	0.89	0.86		
	SE	0.02	0.09	0.03	0.09	0.05	0.07		
Traffic violations	Mean	0.78	0.81	0.90	0.80	0.72	0.55	8.91	< 0.001
	SD	0.73	0.46	0.73	0.43	0.78	0.61		
	SE	0.02	0.09	0.03	0.06	0.04	0.05		
Riding errors	Mean	0.63	0.65	0.66	0.59	0.72	0.36	14.83	< 0.001
	SD	0.66	0.49	0.58	0.37	0.83	0.41		
	SE	0.02	0.10	0.03	0.05	0.05	0.03		
Positive behaviors	Mean	2.84	3.14	2.90	3.11	2.77	2.70	5.83	< 0.001
	SD	1.01	0.46	0.84	0.51	0.11	0.11		
	SE	0.03	0.09	0.04	0.07	0.07	0.09		
Cycling crashes	Mean	0.87	1.04	0.93	1.73	0.81	0.53	5.99	< 0.001
	SD	1.53	1.10	1.46	1.54	1.64	1.37		
	SE	0.05	0.23	0.07	0.23	0.09	0.11		

Notes: SD= Standard Deviation; SE= Standard Error; η^2 = Eta-squared; ε^2 = Epsilon-squared; Ω^2_F Omega-squared (Fixed-effect).

satisfactorily met and the model demonstrated theoretical simplicity and consistency with its theoretical foundations (SEM are confirmatory and not exploratory models), it was deemed suitable and therefore retained along with its composing structural paths.

Specific (full-length) information about the SEM model, including standardized and bootstrap bias-corrected parameter estimates, is presented in Table 4, and visually depicted in Fig. 1. In this plot, solid lines or arrows denote significant predictive relationships between the study variables, while discontinuous arrows represent non-significant predictive paths.

The graphical path model presented in Fig. 1 shows that two out of

the four exogenous-endogenous paths have direct and significant effects on self-reported cycling crashes. While sensation seeking had no direct effects on safety outcomes, the only two exogenous variables significantly impacting cycling crashes were risky behavioral variables, namely: traffic violations and riding errors.

Regarding the predictive paths between sensation seeking (personality trait) and cycling behavioral variables, there were positive and significant associations for both traffic violations ($\beta = 0.508$; $p < 0.010$), and riding errors ($\beta = 0.385$; $p < 0.010$). On the other hand, sensation seeking scores had no significant effects as a predictor of positive cycling patterns.

Table 4

Confirmatory analysis outcomes. The model includes variables, estimates, significance levels, and 95% confidence intervals for the bootstrap bias-corrected values of the drawn paths.

Path			SPC ^a	S.E. ^b	C.R. ^c	p ^d	Bootstrap bias-corrected values ^e				p ^d
							S.E. ^f	Bias ^g	95 % CI ^h		
<i>Direct effects</i>											
Sensation seeking	→	Traffic violations	0.508	0.027	18.129	***	0.025	−0.002	0.462	0.560	**
	→	Riding errors	0.385	0.026	12.835	***	0.029	−0.002	0.329	0.448	**
	→	Positive behaviors	0.035	0.043	1.090	0.276	0.031	0.000	−0.01	0.105	0.143
	→	Cycling crashes	0.022	0.067	0.658	0.510	0.033	−0.001	−0.043	0.091	0.498
<i>Mediated effects</i>											
Traffic violations	→	Cycling crashes	0.302	0.090	7.008	***	0.043	0.001	0.220	0.388	**
Riding errors	→		0.182	0.093	4.524	***	0.040	−0.001	0.093	0.259	**
Positive behaviors	→		−0.001	0.044	−0.031	0.975	0.028	0.004	−0.057	0.054	0.915

Notes: ^a SPC= Standardized Path Coefficients (can be interpreted as Beta-linear regression weights); ^b S.E.= Standard Error; ^c CR= Critical Ratio; ^d p-value: *significant at the level $p < 0.050$; **significant at the level $p < 0.010$; ***significant at the level $p < 0.001$; ^e Bootstrapped (bias-corrected) model; ^f Bootstrapped (bias-corrected) model standardized error; ^g Bias identified (and corrected) in the path; ^h Confidence Interval at the level 95 % (lower bound – left; upper bound – right).

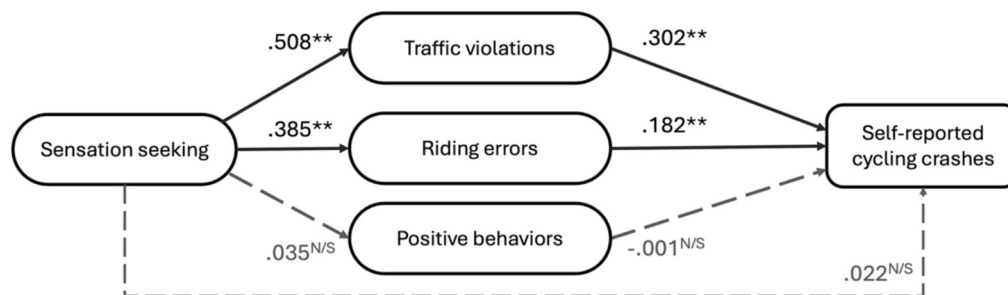


Fig. 1. Path analysis of the predictive relationships among sensation seeking, cycling behavior, and cycling crash involvement. Notes: N/S= Non-significant path; **= All bootstrapped significant paths were $p < 0.010$.

Furthermore, in terms of indirect effects, both types of risky cycling behaviors fully mediated the relationship between sensation seeking and fear of self-reported crashes. Specifically, traffic violations ($\beta = 0.302$; $p < 0.010$) have shown a greater predictive magnitude than riding errors ($\beta = 0.182$; $p < 0.010$) as crash predictors. This suggests that riders' sensation seeking, while not having a direct statistical effect on crash outcomes, is instead linked primarily through its influence on subsequent risk assumptions and, to a lesser extent although still significantly, increased riding errors.

4. Discussion

The core objective of this study was to assess the relationships among sensation seeking, cycling behavior, and safety-related outcomes among a sample of young Hispanic cyclists. Overall, our results suggest that there are relevant, significant, and coherent associations among these variables, whose particularities and theoretical implications will be discussed below in accordance with the three study hypotheses raised in the literature review section.

Is sensation seeking linked to riding outcomes of young cyclists?

The first study hypothesis assumed that significant associations might be found between sensation-seeking scores and both self-reported risky cycling behavior (errors and violations) and cycling crashes involving young cyclists. While this is just a descriptive hypothesis, the obtained results show coherent and plausible directionalities and significance levels when compared with previous research conducted in several countries and with bicycle riders of different age groups.

In brief, this endorses this associative hypothesis from a statistical standpoint. In addition, sensation seeking maintained significant, positive, and consistent correlations with both traffic violations and riding errors, as measured through the Cycling Behavior Questionnaire (CBQ) by Zheng et al. (2019).

On the other hand, it is notable that sensation seeking seems to be poorly (and non-significantly) correlated with risk perception scores.

From a theoretical perspective, it could be assumed that risk perception operates independently of personality traits, given its highly cognitive nature (Horvath & Zuckerman, 1993). Recent evidence shows that young cyclists often perform hazardous behaviors daily (such as invading bus lanes) to avoid heavy traffic (Mora et al., 2024a,b). However, risk-taking, which is theoretically –and consistently– related to decision-making, is elicited by impulsive patterns and further enhanced by such traits. It is suggested to be a major contributor to risky behaviors across various spheres of life, both within and beyond road risks, as evidenced by empirical studies such as those by Baltruschat et al. (2020), Jochimek et al. (2023), and Memarian et al. (2023).

Are there gender differences?

The second study hypothesis Gender differences exist in both sensation-seeking scores and self-reported cycling behavioral factors among cyclists, with males showing greater assumed risks in these regards. While the literature dealing with general populations of cyclists supports gender differences in various aspects of riding behavior (e.g., risk perception, rule knowledge, and attitudes toward safe cycling; see Karras et al., 2024; Prati et al., 2019a; Useche et al., 2018), this study has identified some peculiarities. One of them is that young cyclists of both genders do not seem to have substantial differences in terms of “positive” cycling variables, i.e., risk perception and positive cycling behavior.

Instead, significant differences were observed in terms of risk-targeted variables, especially as for traffic violations and riding errors, both of them significant at the level $p < 0.001$ with bootstrapped data. Similar results have been endorsed by Rad et al., (2024) and Useche et al. (2018).

As for self-reported cycling crash outcomes, the trend seems consistent with those described in studies using both recorded crash data (see Prati et al., 2019b) and survey-based designs (see Fyhri et al., 2019). Subsequently, from a literature-based approach, it could be said that a notable peculiarity found in this study among Hispanic young cyclists is that gender does not appear to be a relevant differentiator in terms of

self-reported risk perception or positive behavior. This finding contrasts with existing research on the matter (Gutiérrez et al., 2020; Rossetti et al., 2018), which suggests that female cyclists in Latin America may tend to be more fearful than their male counterparts on the streets. However, typical significant differences persist in terms of risky cycling and sensation seeking patterns, partially supporting the hypothesis.

Does sensation seeking ‘work’ as a risky behavior/crash predictor?

The third study hypothesis assumed that sensation seeking has a predictive relationship to self-reported cycling crash outcomes of young cyclists, potentially mediated by risky and positive cycling behavior. In this regard, our results suggest two core takeaways: first, while sensation seeking affects the risky cycling behavior of young riders, it may not influence their crash rates in a direct manner; instead (and second), this relationship may occur throughout the full statistical mediation of risky cycling behavior.

As for the first point, previous studies examining hazardous riding behavior as an outcome influenced by personality traits have proposed reasonable interpretations for this finding. For instance, Luo et al. (2023), in a systematic review and meta-analysis, and Zheng et al. (2019), in an original study, highlight that sensation seeking is a reliable predictor of both unsafe driving (in the case of cars) and bicycle riding. This is due to its role in increasing the likelihood of problematic behaviors and common risks, such as intoxicated circulation, aggression, impulsive decision-making, and normlessness.

This is operationally consistent with the theoretical foundations of sensation seeking in general life spheres, as developed by Zuckerman (1994). Similarly, Torres-Quintero et al. (2019) have shown that motorcyclists’ risky behaviors in Colombia are linked to a deep-rooted ‘macho’ culture prevalent in many Hispanic countries. Furthermore, studies in fields unrelated to cycling, such as those by Gardner et al. (2021) and Lasenby-Lessard and Morrongiello (2011), have documented greater engagement in deliberate risk-related activities and risk-compensation behavioral patterns among young high-scorers in sensation seeking.

Moreover, the relationship between risk perception and sensation seeking (SS) has been growingly documented in the literature, highlighting its importance in shaping behaviors in high-risk activities (Zuckerman, 2007), including cycling but not limited to this sphere. Overall, it states that individuals with higher SS are more likely to engage in risky behaviors (Ruedl et al., 2012), such as driving/riding at higher speeds or through heavy traffic, due to their tendency to undervalue possible risks for their safety as a consequence (Hatfield and Fernandes, 2009; Kummeneje and Rundmo, 2020; Traficante et al., 2024). Accordingly, our findings align with this evidence, suggesting that individuals with elevated SS scores tend to report a lower sensitivity to risk perception. Also, the interaction between risk perception and SS could partly explain variations in cycling-related safety outcomes across demographic and cultural contexts.

As for the second point, a limited number of studies have previously linked sensation seeking with crash-related outcomes, and mostly with road users other than cyclists. Nevertheless, evidence such as Verma et al. (2017) supports the idea that a greater risk of severe or major crashes is often observed among bus drivers with high levels of sensation seeking. Similarly, studies with young drivers have shown that safety-related outcomes might be positively, significantly, and consistently associated with sensation seeking through an implicit mediation of risky behaviors, which was successfully tested and initially endorsed in the current study (Grace et al., 2020; Hatfield & Fernandes, 2009).

Practical insights.

This research provides a unique contribution to the field of cycling safety by highlighting the role of individual psychological traits, specifically sensation seeking (SS), as a significant predictor of risky cycling behaviors and crash involvement among young cyclists. Unlike most studies that primarily focus on external factors such as infrastructure or road conditions, this research emphasizes the internal drivers of risk, revealing that personality traits like SS can mediate both intentional (e.

g., traffic violations) and unintentional (e.g., errors) behaviors that lead to crashes.

At a practical level, these results suggest that increasing road safety skills (e.g., through educational programs or enforcement measures), addressing risk-related personality traits, and promoting public awareness could improve both behavior and safety outcomes for young road users, with cyclists being a key group of interest. In other words, both our findings and previous studies imply that encouraging responsible cycling practices from an early age should be prioritized in cycling safety measures and policymaking (Hatfield & Fernandes, 2009; Wang et al., 2019). Conversely, existing risky practices, such as break-free downhill riding –popular among young groups and sometimes promoted by city authorities as touristic events (La Tercera, 2024)– should be discouraged.

While the available evidence in this regard remains scarce, some studies suggest that targeting risk-related personality traits, such as sensation seeking, can enhance interventions aimed at modifying behaviors and improving safety awareness. For example, educational programs for young cyclists can focus on self-regulation skills like impulse control and risk assessment to counteract the impulsivity associated with high sensation seeking (Stephens et al., 2020).

Another factor worth to discussing is the role of cycling culture regarding the current results. In regions where cycling culture is still in its early stages, the applicability of our findings requires careful consideration, particularly in terms of policy and infrastructure development. While demographic characteristics may be comparable (our results endorse that, as a trait sensation seeking transcends geographical and cultural frontiers), the level of cycling adoption, social norms, and public perception of cycling as a viable mode of transport can influence, however, the resulting behaviors.

Accordingly, previous research suggests that in nascent cycling cultures, perceived safety concerns and lack of dedicated infrastructure may discourage cycling participation, even among individuals with higher sensation-seeking tendencies (Aldred & Jungnickel, 2014). This also suggests that interventions should focus not only on individual-level factors such as risk perception and sensation seeking but also on broader systemic changes, i.e., promoting cycling as a safe and accessible mode also helping to shape positive health and social-related outcomes (Pucher & Buehler, 2017; Yang et al., 2019).

Moreover, urban planning measures that consider these risk factors, such as designing safer cycling infrastructure to limit opportunities for high-risk behaviors typical (although not exclusive) of sensation seeking –e.g., segregated cycling lanes and reduced-speed zones– might create safer environments that dissuade behaviors like high-speed cycling or weaving through traffic (Hatfield & Fernandes, 2009). This is particularly important given the early access young populations have to safety-critical activities such as riding bicycles and driving various types of motorized and non-motorized vehicles (Chen et al., 2024; Li et al., 2022).

Finally, this study identifies important gender differences in sensation seeking and safety outcomes, underscoring the need for targeted interventions that consider these psychological traits. These findings are particularly relevant in regions with emerging cycling cultures, such as many Hispanic countries, where the cycling infrastructure is still developing and where safety interventions must adapt to a range of contextual factors. By exploring the under-researched area of personality traits in cycling safety, this study opens new avenues for more personalized, evidence-based interventions aimed at reducing crash risks among young cyclists.

5. Conclusions

In conclusion, this research offers valuable insights into the safety risks associated with young cyclists, emphasizing the significant role of individual psychological traits, particularly sensation seeking (SS), in predicting risky behaviors and crash involvement.

Unlike traditional studies that focus on external factors, this study sheds light on the internal drivers of risk, indicating that SS mediates both deliberate (e.g., traffic violations) and unintentional (e.g., errors) behaviors that contribute to cycling accidents.

The identification of gender differences in sensation seeking further highlights the need for tailored interventions that address these psychological traits. For example, educational campaigns can be implemented in schools, while both active (e.g., responsible risk assumption, avoidance of technological distractors) and passive cycling safety (e.g., helmet use) should be enforced more closely.

These findings are particularly important in regions with emerging cycling cultures, such as many Hispanic countries, where safety measures are still underdeveloped. By exploring the connection between personality traits and cycling safety, this study contributes to a more comprehensive understanding of crash precursors and opens the door to more targeted, evidence-based interventions aimed at reducing crash risks among young cyclists.

Study limitations and further research.

While this questionnaire-based study utilized an extensive dataset and research tools that demonstrated several psychometric strengths, there are significant limitations that warrant acknowledgment by the authors.

Firstly, and while using this information type helps to access greater participation rates, this study relied on self-report measures, this fact poses a significant data-reliability challenge for applied research, as highlighted in similar previous studies focusing on behavioral patterns of road users (see [Stephens et al., 2020](#)). This data gathering method may result in socially desirable responses (especially when addressing potentially sensitive topics), even though the study has made several efforts to mitigate bias through strategies such as ensuring complete anonymity and refraining from collecting identifying information.

Secondly, while the presented analyses accounted for cyclists' age and gender, the sample composition may not have been consistently balanced across all demographic categories (see [Di Milia et al., 2011](#)), thereby confounding assumptions regarding the representation of all possible demographic groups within the sample.

Third, there is a big gap in terms of available research that needs to be bridged. While research on cycling behavior and risk perception has been conducted in various contexts, there remains a notable gap in studies exploring these dynamics across different cycling cultures, particularly in regions similar to those analyzed in this study. The lack of comparative research limits the ability to generalize our findings across diverse cycling environments.

Finally, it is worth acknowledging the latent need to develop further studies addressing sensation seeking in regard to cycling behavior and cycling safety. This could potentially facilitate additional comparisons and cross-cultural analyses of this relevant issue for cycling crash prevention.

CRedit authorship contribution statement

Sergio A. Useche: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Project administration, Validation, Visualization. **Rodrigo Mora:** Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Writing – review & editing. **Francisco Alonso:** Writing – original draft, Software, Resources, Investigation, Formal analysis, Data curation. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Data availability

Data will be made available on request.

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