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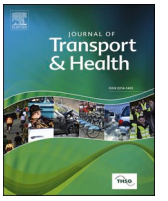

Good for the planet… and for you too? Comparing five travel and health-related outcomes among active, motorized, and public transport commuters

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ABSTRACT

Aligned with sustainable development goals, the promotion of active and public transport commuting has gained ground in the last decade. However, literature empirically addressing the individual outcomes of different commuting modes remains scarce.

Aim: The core aim of this research was to assess and compare a literature-based set of travel, health, and welfare-related outcomes among three different groups of urban daily commuters: private motorized, public transport, and active commuters.

Methods: This cross-sectional study used a nationwide sample of n= 2370 urban daily commuters from all 17 regions of Spain. Participants, aged between 18 and 70, with an average of M= 33 years, were drawn from all 17 regions of Spain, and responded to an electronic survey on commuting issues.

Results: As hypothesized, different groups of commuters had different psychosocial trip- and welfare-related outcomes. Indeed, most indicators, except for travel satisfaction, showed a favorable association with the sustainability value attributed to each commuting means. Particularly, active travelers had significantly lower commuting stress and Body Mass Index (BMI) values, and higher rates of life satisfaction and pro-environmental behavior in areas beyond transport, in stark contrast to private motorized users. Public transport users, although 'in the middle' in most aspects, report the highest commuter stress rates.

Conclusion: The results of this research endorse the assumption that the commuting mode matters, but the relationship between transport sustainability and user outcomes cannot be understood as 'totally linear'. These insights can be valuable for initiatives aimed at promoting shifts towards more sustainable –and active– transportation patterns among commuters, who constitute an interest group in current mobility planning and decision-making.

1. Introduction

Years of accumulated evidence supporting the role of improving population travel behavior as part of urban sustainability, coupled with a growing political commitment and social involvement, have propelled the idea of incentivizing active and public transport-

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based commuting trips instead of private vehicle use in many countries (Griffiths et al., 2021; Mahadevia et al., 2023). In fact, urban transport transformations are anticipated to emerge as key alternatives in the short and mid-term battle against climate change. This expectation is grounded in the significant volume of emissions and environmental challenges associated with current urban transportation practices and users' subsequent health outcomes (Aliakbari et al., 2022; Winkler et al., 2023).

However, key constraints remain to be overcome. For instance, recent studies underscore the challenge of achieving sustainable urban transport fitting all possible peoples' needs, despite being a globally shared goal (Hinckson, 2015; Watkins, 2018; Plowden et al., 2023). This difficulty becomes particularly relevant when attempting to induce long-lasting behavioral changes among users in cases where the focus is on promoting mass public transportation or active modes, such as commuting by bicycle or on foot (Alonso et al., 2023; Sucha et al., 2024). In brief, shifting daily trip modalities to active ones implies the need to make sustainable transport more attractive and explicitly beneficial for both its current and potential partakers (Alonso et al., 2023; Mahadevia et al., 2023).

Among various alternatives, applied research emphasizes the need for a wider political involvement for invigorating the adoption of active forms of transport on the basis of information, awareness, and cost-benefit increases for users (De Nazelle et al., 2011; Oviedo-Trespalacios et al., 2021). In essence, it is believed that promoting active transport might not only provide numerous environmental advantages but should also entail compelling benefits for transportation dynamics and the physical and mental health of commuters (Schäfer et al., 2020; Palma-Leal et al., 2022).

1.1. Active commuting and health: a quick summary of its theorized benefits

The potential health-related outcomes of *active* commuting in urban environments have been predominantly studied from the point of view of walking and cycling (Bassett et al., 2008; Schäfer et al., 2020). Overall, there is a wealth of scientific evidence supporting its positive impact on both commuters' mental and physical health issues (Henriques-Neto et al., 2020; Neumeier et al., 2020).

From a physiological standpoint, engaging in active commuting contributes to increased cardiovascular fitness, improved muscular strength, and enhanced overall physical fit (Martin et al., 2014). Regular participation in active transportation modes has been linked to lower risks of chronic conditions such as cardiovascular disease, obesity, type 2 diabetes, and even sickness absence (Mytton et al., 2016; Wu et al., 2021). Furthermore, previous studies conducted in European countries highlight that the promotion of active commuting might constitute a useful resource to strengthen public health milestones related to regular physical activity for optimal health (Bassett et al., 2008), even though the specific dynamics, drives, and encouraging factors may differ in accordance with contextual features (Ek et al., 2021).

In addition to the physical health benefits, active commuting has been associated with notable advantages in the non-despicable field of mental health, especially when implying a greater contact to greener environments and user-friendly infrastructures (Ranjbarnia al., 2022; Zijlema et al., 2018). In brief, the routine engagement in physical activity during commuting has been linked to reduced stress levels, improved mood, and enhanced cognitive function (Ruiz-Hermosa et al., 2019; Useche et al., 2023b). Moreover, other scientific studies addressing commuting trips of further populations such as bicycle commuters, university students, and school-aged children have found that individuals who incorporate active transportation into their daily routines often experience lower levels of psychological distress and a greater sense of well-being (Lizana et al., 2021; Schneider, 2019).

Further, it is worth remarking that the positive impact of active commuting trips on mental health is not only attributed to the physical exercise itself but also to the potential reduction in exposure to traffic-related stressors, fostering a more pleasant and 'mentally stimulating' commuting experience. For instance, studies such as Fyhri et al. (2023) highlight the beneficial character of active urban trips to avoid contagion-related stress during the recent COVID-19 pandemic. Also, in regard to contemporary settings and as cities globally grapple with issues related to sedentary lifestyles and urban congestion, understanding and promoting the mental and physical health benefits of active commuting emerges as a crucial component in shaping sustainable and health-invigorating urban environments, especially as for the fact that it seems to be related to the development of more sustainability-related attitudes, habits, and practices (Echeverria et al., 2023; Panter et al., 2016).

Indeed, it is expected that individuals who opt for eco-friendly modes of transportation, such as walking, cycling, or using public transport, may exhibit a heightened environmental consciousness (Panter et al., 2011; Ruiz-Hermosa et al., 2019). This conscientiousness tends to extend beyond their commute, influencing daily practices like energy conservation, waste reduction, and mindful consumption. In practical terms, this may represent the chance to benefit general environmental outcomes through the promotion of sustainable commuting, given that they are usually attuned to the environmental impact of their choices, and become catalysts for positive change by fostering a holistic approach to eco-conscious living (Barnett et al., 2019; Panter et al., 2011; Plowden et al., 2023).

Nevertheless, despite the numerous advantages of sustainable transport such as bicycling, using public transport, or walking, there are empirically-supported risks that increase the vulnerability of these users. Firstly, the literature consistently shows that safety concerns for non-motorized users remain significant and pose a considerable burden in many respects.

For example, apart from the well-known increased risk of injury and death in crash situations involving these modes, recent studies have found that cyclists and pedestrians involved in severe safety incidents often report poor health-related quality of life indicators, including anxiety and depression (Kovacevic et al., 2021; Myhrmann et al., 2022). Moreover, empirical research on security-related issues indicates that these transport modes can sometimes be focal points for stressful situations such as harassment, thefts, and inter-user aggressions, which can negatively impact the psychological well-being of these users. These findings support a growing emphasis of the current literature on the need for further and sustained improvements in these areas, as a manner of invigorating more contributions of sustainable transport traveling to health and welfare (Alfaro et al., 2024; Conceição et al., 2022; Lee and Sener, 2016; Useche et al., 2023b).

1.2. 'Active' commuting and two key satisfaction indexes

Among several issues currently considered for measuring users' satisfaction in transport, both travel satisfaction and life satisfaction have been gaining ground during the last two decades (Lättman et al., 2019; Wang et al., 2022). While it is true that the user's psychological experience constitutes only a part of the compendium of variables to be analyzed, assuming that active transportation is a healthy and beneficial alternative for its users, there is a substantial body of relevant evidence that suggests a great potential to positively influence these two outcomes (Lades et al., 2020; Scrivano et al., 2023).

In relation to the concept of travel satisfaction, which pertains to an individual's overall contentment and fulfillment derived from their travel experiences, recent studies exploring the connections between active commuting by bicycle/walking and travel satisfaction indicate a positive correlation. These studies suggest consistently higher levels of travel satisfaction associated with active commuting compared to motor vehicle usage (De Angelis et al., 2021; Rissel et al., 2016).

Specifically, individuals who opt for active modes of commuting often report greater satisfaction with their travel experiences, potentially attributing this outcome to a combination of factors (De Angelis et al., 2021; Lades et al., 2020). Also, the inherent physical activity associated with walking or cycling, apart from contributing to improved health outcomes, has been shown to contribute to aligning individuals' beliefs and practices with of sustainable urban transportation, fostering a sense of environmental responsibility (Alonso et al., 2023). Further, other studies suggest that this alignment with broader societal values may also strengthen the overall satisfaction of active commuters and a more positive perception of the urban environment, positioning their mode of travel as congruent with personal and societal well-being (Lades et al., 2020; Ettema et al., 2017).

As for the second, 'life satisfaction' is commonly understood in specialized literature (especially from the standpoint of positive psychology and health-related quality of life) as a mental health indicator. Even though, they represent distinct constructs for psychological research, given that they correspond to different hierarchical levels (Michalski et al., 2022). From a conceptual point of view, speaking of mental health refers to a broader and more comprehensive category encompassing several spheres. On the other hand, life satisfaction pertains to an individual's overall evaluation of the contentment with their life as a whole. In any case, several studies imply that LS must be understood as a non-non-negligible component under the wide umbrella of mental health indicators (Michalski et al., 2022; Fergusson et al., 2015).

At a methodological level, life satisfaction is often measured through self-report assessments where individuals rate their overall well-being and happiness in consideration of (e.g.) their relationships, work, daily activities, and personal achievements (McCarthy et al., 2018; Olsson et al., 2013). In addition, the existing body of research consistently suggests a positive association between active commuting and higher levels of life satisfaction. This connection can be attributed to various factors, including the psychological and emotional benefits derived from physical activity during commuting, something also associated with a relatively improved mood and a sense of well-being among 'regularly active' users in comparison with other groups of commuters (Humphreys et al., 2013; Olsson et al., 2013).

At the practical level, the relevance of active trips has also been underscored by empirical literature. For instance, the outcomes of a longitudinal study conducted in the United Kingdom during the last few years suggest that the positive psychological well-being and satisfaction-related effects of active traveling might even benefit the further interventions aimed at promoting it regardless of individuals' age or gender, given the suitable cost-benefit assessment that among most of its users tend to self-report (Martin et al., 2014).

1.3. Study aim and hypotheses

Taking into account the aforementioned considerations, the core objective of this study was to compare a set of literature-endorsed transport and health-related outcomes among three groups of urban daily travelers: private motorized, public transport, and active commuters.

Also, once considering the available literature and the shreds of evidence presented in the literature review, two hypotheses were raised for this study, as follows.

Hypothesis 1. There would be significant associations in terms of both trip- (i.e., commuting stress and travel satisfaction) and welfare-related factors among groups of active, public transport, and private motorized commuters.

Hypothesis 2. Users who are more engaged in sustainable practices may report lower rates of commuting stress, greater travel- and life-related satisfaction, more general pro-environmental behavior, and healthier Body Mass Indexes compared to private motorized commuters.

2. Methods

2.1. Study sample

For this cross-sectional study, there were used the data provided by a nationwide sample of $n = 2370$ Spanish commuters (55.6% females and 44.4% males) daily urban commuters from all 17 Autonomous Communities of the country. The study sample was aged $M = 32.95$ with an $SD = 13.67$ years. Further demographic information in regard to the study sample and their main commuting means is available in Table 1.

The sample representativeness was assessed considering the full Spanish census of individuals aged over 16 as population size (approximately 44 million inhabitants), given that no specific travel data on commuters and their trip patterns are officially available

in Spain. Thus, it was estimated a minimum sample size of 685 participants with a 95% confidence level, a 5% margin of error (α = .050), and 80% power (β = .200). Nevertheless, it is important to note that, despite its nationwide coverage and large size, this sample is not fully representative of the entire population, due that the participant selection corresponded to a convenience (pseudo-probabilistic) sampling method focused on urban commuters. Therefore, the generalizability of the findings should be assumed as limited to this group.

2.2. Procedure

The data for this study were collected through an electronic questionnaire completed by a nationwide sample of Spanish urban commuters. Participants were invited to participate in the study using a pre-existing mailing list shared among various research groups and academic centers in Spain. This implies the use of a non-probabilistic (convenience) sampling method. The choice of employing an electronic survey was driven by practical considerations and the heightened challenges and reluctance associated with conducting face-to-face interviews. This decision aligns with social distancing and security protocols, adhering to guidelines endorsed by research agencies, universities, and research groups.

Regarding the recruitment process, each potential partaker received a link containing a detailed description of the survey, its objectives, and conditions. An informed consent form, emphasizing current data treatment and protection policies and the exclusive scientific use of research data, accompanied the description. Participants read and agreed to this consent form before proceeding to the questionnaire. The inclusion criteria stipulated that participants must regularly undertake urban commuting roundtrips various times a week. Notably, participants were emphatically informed that the data would be solely utilized for research and scientific purposes.

As for the response rate of the study, it was estimated at approximately 58%, given that 2370 commuters successfully completed and submitted the electronic form used for the data collection, out of about 4100 electronic invitations sent.

2.3. Description of the survey tool

The electronic questionnaire used to gather the data for this study was composed of four main sections, structured as follows:

In the first part, demographic and trip-related data were addressed. Namely, participants gave information on their basic data, such as age, gender, educational attainment, and current occupation. Afterwards, they were inquired about their basic daily commuting patterns, focusing on the most frequently used transportation means, their typical travel length, and the frequency of their commuting trips (filter question).

The second section covered psychosocial trip-related factors, concretely commuting stress, and travel satisfaction:

Commuting stress was measured through the Multimodal Commuting Stress Scale (MCSS) (Useche et al., 2023b). This is a 21-item Likert-type questionnaire measuring users' stress-related appraisals on their typical commuting trips, using items applicable to the dynamics of several transportation means (e.g., private vehicles, public transport, cycling, walking trips), allowing the calculation of a composite mean index of commuting stress. The scale internal reliability and consistency indexes were Cronbach's alpha (α) = .962 and McDonald's omega (ω) = .958.

Travel satisfaction was assessed using the Satisfaction with Travel Scale (STS) (Singleton, 2019). This semantic differential scale is

Table 1
Sociodemographic information and commuting trip-based features of participants.

Variable	Label	Frequency (n)	Percentage (%)
Gender	Female	1318	55.6%
	Male	1052	44.4%
Age Group	Young Adult (≤25)	1102	46.5%
	Adult (26–50)	880	37.1%
	Aging Adult (>50)	388	16.4%
Educational level	Primary studies or lower	117	4.9%
	Secondary-high school	542	22.9%
	Technical studies	304	12.8%
	University studies	1089	45.9%
	Post-graduate studies	318	13.4%
Occupation	Student	1065	44.9%
	Employed	908	37.3%
	Independent worker	183	7.7%
	Other	214	9.0%
Most frequent commuting transport mode	Private motorized means	781	33.0%
	Public transport means	1214	51.2%
	Active commuting (cycling or walking)	375	15.8%
Daily commuting time (round trip)	<1 h	1008	42.3%
	1–1.9 h	754	31.8%
	2–2.9 h	248	10.5%
	3–3.9 h	51	2.1%
	>4 h	61	2.5%
	N/R	248	10.5%

composed of 9 items, ranging between −3 and 3, in consideration of both emotional and cognitive appraisals of commuters about the satisfaction produced by their trips. The whole scale internal reliability and consistency indexes were Cronbach's alpha (α) = .851 and McDonald's omega (ω) = .840.

The third part of the questionnaire addressed issues related to psychological and physical health of the study participants. For this purpose, satisfaction with life (*AKA* life satisfaction) was measured through the Harmony in Life Scale (HLS + SWL) (Kjell et al., 2016; Kjell and Diener, 2021). This is a brief Likert-type scale encompassing 6 items emphasizing both overall life satisfaction and psychological balance/flexibility in life (Kjell et al., 2016). The composite scale internal reliability and consistency indexes were Cronbach's alpha (α) = .812 and McDonald's omega (ω) = .815.

In order to provide a reliable and standardizable index of overall physical health, the Body Mass Index (commonly labeled as BMI) was used. This is a numerical ratio between an individual's height and weight, widely used as a screening indicator in the determination of potential future health issues, also relevant in the determination of public health policies (Khanna et al., 2022; Zierle-Ghosh et al., 2023).

Lastly, participants were inquired about their 'environmentally-friendly' behaviors in different life spheres using the Pro-Environmental Behaviors Scale (PEBS). This is a 5-item Likert-type scale presenting a set of everyday practices and patterns related to environmental care, such as energy saving, waste management/recycling, consumption, and transport emission reduction (this item was dismissed to avoid endogeneity with transport habits). The composite scale's internal reliability and consistency indexes were Cronbach's alpha (α) = .802 and McDonald's omega (ω) = .801.

2.4. Ethics

To conduct this research, the Research Ethics Committee at the Research Institute on Traffic and Road Safety – University of Valencia was consulted, in order to assess its adherence to the overarching ethical principles outlined in the Declaration of Helsinki, a prerequisite for research involving human subjects (IRB approval number HE0001140923).

2.5. Data analysis

After careful data curation, descriptive data were processed, and the scales described in the previous section were scored and quantified following the directions provided by their authors and/or validation studies. Given the statistical shortcomings of using a single indicator for this purpose (Adam et al., 2023; Useche et al., 2023), the internal reliability/consistency of the scales was assessed through two complementary indexes (Cronbach's alpha – α and McDonald's omega – ω).

In order to assess the bivariate relationships between the study variables, there were used *Rho* (Spearman's σ) correlational analyses, which nature is advised for the case of studies using variables of an ordinal nature, such as questionnaire-based research using Likert scales. Furthermore, the comparative analyses performed in this study used three reference groups (splitting criteria), and were conducted through: (*i*) analysis of covariance (ANCOVA), a statistical technique that combines ANOVA and regression to assess the main and interaction effects of categorical independent variables on a continuous dependent variable while controlling for the effects

Table 2
Bivariate parametric (Spearman *rho*) correlations between study variables.

Study variable(s)			M	SD	2	3	4	5	6	7	8	9
1	**Age**	Coefficient (σ)	32.95	14.12	.032	.057[e]	.184[e]	−.063[e]	.010	−.126[e]	.053[e]	.276[e]
		Sig. (2-tailed)			.121	.005	<.001	.002	.639	<.001	.009	<.001
2	**Education**	Coefficient (σ)	–[d]	–	–	.111[e]	−.027	−.021	.052*	.031	.056[e]	−.058[e]
		Sig. (2-tailed)				<.001	.191	.302	.012	.130	.006	<.006
3	**City Size**	Coefficient (σ)	–[d]	–		–	.010	.122	−.081[e]	−.065[e]	.124[e]	.050*
		Sig. (2-tailed)					.635	<.001	<.001	.002	<.001	.018
4	**Daily Commuting Length (min.)**	Coefficient (σ)	64.63	44.25			–	.031	−.066[e]	−.090[e]	.078[e]	.061[e]
		Sig. (2-tailed)						.133	.001	<.001	<.001	.004
5	**Commuting Stress**[a]	Coefficient (σ)	1.79	1.02				–	−.074[e]	−.086[e]	.056[e]	.048*
		Sig. (2-tailed)							<.001	<.001	.006	.021
6	**Travel Satisfaction**[b]	Coefficient (σ)	2.46	1.45					–	.490[e]	−.063[e]	.056[e]
		Sig. (2-tailed)								<.001	.002	.008
7	**Life Satisfaction**[a]	Coefficient (σ)	3.44	1.17						–	−.033	−.098[e]
		Sig. (2-tailed)									.104	<.001
8	**Pro-environmental Behavior**	Coefficient (σ)	3.73	1.23							–	−.062[e]
		Sig. (2-tailed)										.003
9	**Body Mass Index (BMI)**[c]	Coefficient (σ)	24.62	4.24								–
		Sig. (2-tailed)										

Notes: *M* = Arithmetic Mean; *SD*= Standard Deviation.
[a] (0–4) scale.
[b] (-3 – 3) scale.
[c] Reference value is 25.0.
[d] Ordinal variable.
[e] Correlation is significant at the.010 level (2-tailed*. Correlation is significant at the .050 level (2-tailed).

of continuous covariates; and *ii*) Tukey's Honestly-Significant-Difference (HSD) multiple comparison Post Hoc tests, which are useful to compare specific levels or categories of a certain nominal factor (i.e., type of commuter; active; public transport; private motorized) in terms of the scores or quantitative outcomes of ordinal and (optimally) continuous study variables. Descriptive and comparative tests for this study were conducted using IBM SPSS Statistics for Mac OS (Version 28.0; IBM Corp., Armonk, NY).

3. Results

3.1. Descriptive data

Overall, the study sample had a mean age of $M \approx 33$ years, with a standard deviation of $SD = 14.12$. Concerning participants' Body Mass Index (BMI), for which the commonly used cut-off value is 25.0 (greater values suggest overweight issues in different degrees), the average for the full sample was $M = 24.62$. The complete set of descriptive data, including mean scores and standard deviations of the study variables, is available in Table 2.

3.2. Bivariate correlations

Among the significant bivariate correlations among the study variables, certain associations between individual and psychosocial factors are noteworthy. First, users' age was negatively correlated with commuting stress and life satisfaction scores, while being positively associated with self-reported pro-environmental behaviors and individuals' Body Mass Index. The length of daily commuting trips showed positive correlations with age, pro-environmental behavior, and Body Mass Index, and negative correlations with both commuting stress and travel satisfaction scores (all $p_s < .001$).

Commuters' educational attainment was positively associated with travel satisfaction indexes (even though with a slight magnitude; *rho* = .052; $p < .050$) and self-reported pro-environmental behavior ($p < .010$). On the other hand, it negatively correlated with commuters' Body Mass Index (BMI; $p < .010$). No significant associations between education and life satisfaction or commuting stress were found.

Regarding travel-related variables, commuting stress was negatively related to both travel and life-related satisfaction, but positively correlated with commuters' Body Mass Indexes. Life satisfaction showed a positive correlation with travel satisfaction and a negative correlation with Body Mass Indexes. The full set of parametric (Spearman) correlations is presented in Table 2.

Another interesting outcome is provided by analyzing the correlates of commuters' city size and the five key subjective variables addressed in this study. In short, the population density of their cities (a common splitting criterion; see OECD, 2021) was positively correlated with higher rates of self-reported commuter stress ($p < .001$) and higher Body Mass Indexes ($p < .050$). Conversely, population density was negatively correlated with both travel satisfaction and life satisfaction ($p < .010$). Nonetheless, city size also correlated with personal pro-environmental behaviors, with this association being positive and statistically significant ($p < .001$).

3.3. Mean comparisons and post hoc analyses

After examining the variable distribution, multivariate normality, and other essential statistical parameters, mean comparisons (ANCOVA tests) controlling for commuting trip length (minutes) were conducted. These analyses are beneficial for exploring potential specific differences in the five key measured factors, considering the three reference groups of daily commuters used in this study. The full set of descriptive values (i.e., means, standard deviations, and errors) for each group of users is presented in the left data columns of Table 3, splitting by the specific scores self-reported by private motorized, public transport, and active commuters.

Overall, statistically significant differences were identified for all five study factors. Four out of the five sets of inter-group differences (i.e., commuting stress, life satisfaction, pro-environmental behavior, and Body Mass Index) were significant at the level $p < .001$, while travel satisfaction was significant at $p < .010$. The greatest effect sizes were found in the case of commuting stress, in which the greatest effect size parameters ranged between [.027–.053], and the lowest corresponded to travel satisfaction, within a [.002–.005] interval. The full set of effect sizes and their confidence intervals at the 95% level are summarized in the right columns of Table 3.

In comparative terms, specifically regarding the Post Hoc analyses of the three user groups, the highest rates of commuting stress were observed among public transport commuters, followed by private motorized commuters. Conversely, active commuters displayed comparatively lower commuting travel-related stress values than the other two reference groups. Accounting for average commuting trip length (i.e., the average of minutes spent on their most usual trip), these differences in commuting stress among the three groups were statistically significant, with $F = 87.288$; $p < .001$, with Post Hoc differences between active commuters and both motorized and public transport users ($p < .001$).

In addition, post hoc (Tukey HSD) analysis outcomes suggest that commuting stress differences are significant when comparing every possible binary combinatory of commuter groups among the three levels addressed in this study. Specifically, public transport users report significantly higher commuting stress rates than the other two study groups, namely private vehicle users and active commuters. On the other hand, private vehicle commuters fall 'in the middle' between public/massive transport and active transport users. These specific differences and their detailed coefficients are shown below in Table 4.

The second commuting trip-related variable compared was travel satisfaction. Although the effect sizes were the slightest among all the variables measured, there are significant inter-group differences ($F = 6.350$; $p < .010$). Namely, public transport users exhibit the highest rates of trip-related satisfaction, while active users have the lowest scores in this regard. However, at the level of specific

Table 3
Descriptive category-based descriptive values and robust mean comparisons on the five key user-related study variables.

Study Variable	User Category	Mean	SD	SE	95% CI[a]		ANCOVA[b]		Effect Sizes[c]		95% CI[a]	
					Lower	Upper	Test value[d]	Sig.[e]	Parameter	Estimate	Lower	Upper
Commuting Stress	Private motorized transport	1.683	1.001	.036	1.613	1.753	87.288	***	η^2	.053	.037	.071
	Public transport	1.995	1.018	.029	1.938	2.053			ε^2	.053	.036	.071
	Active transport	1.346	.948	.049	1.250	1.443			Ω^2_F	.053	.036	.071
	Total	1.790	1.029	.021	1.748	1.831			Ω^2_R	.027	.018	.037
Travel Satisfaction	Private motorized transport	2.543	1.367	.049	2.447	2.639	6.162	**	η^2	.005	.001	.012
	Public transport	2.365	1.519	.044	2.279	2.450			ε^2	.004	.000	.011
	Active transport	2.627	1.389	.072	2.486	2.768			Ω^2_F	.004	.000	.011
	Total	2.465	1.453	.030	2.406	2.524			Ω^2_R	.002	.000	.006
Life Satisfaction	Private motorized transport	3.399	1.123	.040	3.320	3.478	9.904	***	η^2	.010	.003	.018
	Public transport	3.386	1.212	.035	3.318	3.454			ε^2	.009	.002	.018
	Active transport	3.726	1.108	.057	3.614	3.839			Ω^2_F	.009	.002	.018
	Total	3.444	1.173	.024	3.397	3.491			Ω^2_R	.004	.001	.009
Pro-environmental Behavior	Private motorized transport	3.600	1.278	.046	3.510	3.690	5.282	***	η^2	.006	.001	.013
	Public transport	3.791	1.201	.034	3.724	3.859			ε^2	.005	.000	.012
	Active transport	3.832	1.175	.061	3.713	3.951			Ω^2_F	.005	.000	.012
	Total	3.735	1.226	.025	3.685	3.784			Ω^2_R	.003	.000	.006
Body Mass Index (BMI)	Private motorized transport	25.403	4.118	.151	25.107	25.698	17.1943	***	η^2	.022	.011	.035
	Public transport	24.450	4.394	.129	24.196	24.703			ε^2	.021	.010	.034
	Active transport	23.564	3.650	.192	23.187	23.941			Ω^2_F	.021	.010	.034
	Total	24.622	4.237	.089	24.448	24.797			Ω^2_R	.011	.005	.017

Notes: SD= Standard Deviation; SE= Standard Error.

[a] Confidence Interval at the level 95%.

[b] Analysis of covariance, controlling for commuting trip length.

[c] Estimated based on the fixed-effect model.

[d] Test value (corrected model).

[e] 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).

differences, Post Hoc analyses depict significant differences between public transport and active commuters, but not between public transport and private motorized daily travelers. These differences are graphically shown in Fig. 1.

Regarding welfare and life-quality-related factors, there were notable results worth describing. Firstly, in terms of overall satisfaction with life, differences were significant ($F = 11.487$; $p < .001$). Specifically, the highest means were found in the case of active commuters (i.e., those walking or cycling), while the lowest means corresponded to motorized commuters. In terms of specific differences, Post Hoc results show that life satisfaction rates significantly differ between active transport commuters and both the other two reference groups. However, no significant differences were found when comparing public transport and Private motorized commuters.

Pro-environmental behaviors reported by study participants were also compared based on their commuting type, revealing significant inter-group differences ($F = 7.227$; $p < .001$). While motorized commuters self-reported the lowest scores in these terms, active transport users had significantly higher scores than both public transport and motorized commuters. Additionally, upon closer examination of the differences between public transport and motorized groups of users, it was observed that the former also had a significantly greater mean in this regard, as graphically shown in Fig. 2.

Finally, Body Mass Indexes –the physical health indicator used in this study– showed significant differences among the three groups ($F = 25.503$; $p < .001$). Specifically, Post Hoc analyses suggest that BMI values are greater among private motorized users ($M > 25$), while the other two groups had significantly lower values, with active commuters having the lowest value ($M = 23.56$). However, these differences are significant even when comparing active and public transport users, who, although having an average BMI under 25.0, still have a higher Body Mass Index than cycling and walking commuters (see Table 4 for detailed mean scores).

4. Discussion

The core aim of this research was to assess and compare a range of transport and health-related outcomes, supported by existing literature, among three distinct groups of urban daily commuters: private motorized, public transport, and active commuters. Consequently, this section delves into its most significant outcomes on the basis of the discussion of the study hypotheses formulated based on the literature reviewed.

Table 4
Post Hoc (Tukey HSD) analyses among groups for the five study variables.

Dependent Variable	(I) Commuter Type	(J) Commuter Type	I-J[a]	SE[b]	Sig.	95% CI[c]	
						Lower	Upper
Commuting Stress	Private motorized transport	Public transport	−.312[d]	.046	<.001	−.420	−.205
		Active transport	.336[d]	.063	<.001	.189	.484
	Public transport	Private motorized transport	.312[d]	.046	<.001	.205	.420
		Active transport	.649[d]	.059	<.001	.510	.788
	Active transport	Private motorized transport	−.336[d]	.063	<.001	−.484	−.189
		Public transport	−.649[d]	.059	<.001	−.788	−.510
Travel Satisfaction	Private motorized transport	Public transport	.177[d]	.067	.021	.022	.334
		Active transport	−.083	.091	.628	−.297	.130
	Public transport	Private motorized transport	−.177[d]	.067	.021	−.334	−.022
		Active transport	−.261[d]	.086	.006	−.463	−.061
	Active transport	Private motorized transport	.083	.091	.628	−.130	.297
		Public transport	.261[d]	.086	.006	.061	.463
Life Satisfaction	Private motorized transport	Public transport	.013	.054	.968	−.113	.139
		Active transport	−.327[d]	.073	<.001	−.499	−.155
	Public transport	Private motorized transport	−.013	.054	.968	−.139	.113
		Active transport	−.340[d]	.069	<.001	−.502	−.179
	Active transport	Private motorized transport	.327[d]	.073	<.001	.155	.499
		Public transport	.340[d]	.069	<.001	.179	.502
Pro-environmental behavior	Private motorized transport	Public transport	−.191[d]	.056	.002	−.323	−.060
		Active transport	−.232[d]	.077	.007	−.412	−.052
	Public transport	Private motorized transport	.191[d]	.056	.002	.060	.323
		Active transport	−.040	.072	.839	−.210	.129
	Active transport	Private motorized transport	.232[d]	.077	.007	.052	.412
		Public transport	.040	.072	.839	−.129	.210
BMI	Private motorized transport	Public transport	.952[d]	.197	<.001	.492	1.414
		Active transport	1.838[d]	.268	<.001	1.210	2.467
	Public transport	Private motorized transport	−.952[d]	.197	<.001	−1.414	−.492
		Active transport	.885[d]	.252	.001	.294	1.477
	Active transport	Private motorized transport	−1.838[d]	.268	<.001	−2.467	−1.210
		Public transport	−.885[d]	.252	.001	−1.477	−.294

Notes.
[a] Inter-Group Mean Difference.
[b] SE= Standard Error.
[c] Confidence Interval at the level 95%.
[d] The mean difference is significant at the .05 level.

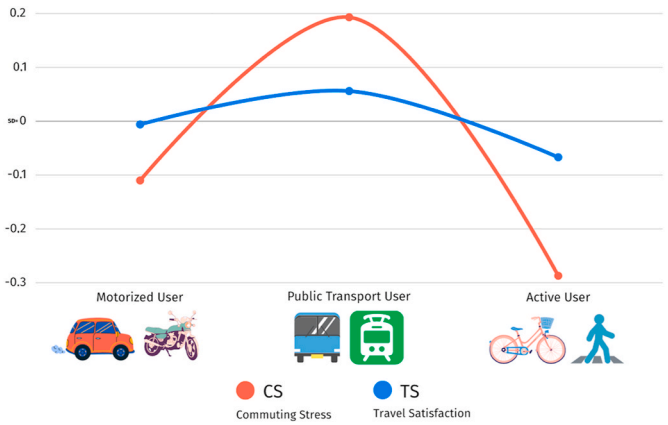

Fig. 1. Mean differences in commuting stress and travel satisfaction among the three reference commuter groups. *Notes:* Axis Y (left column) is graphically scaled in terms of standardized (Z) scores to favor fair comparability.

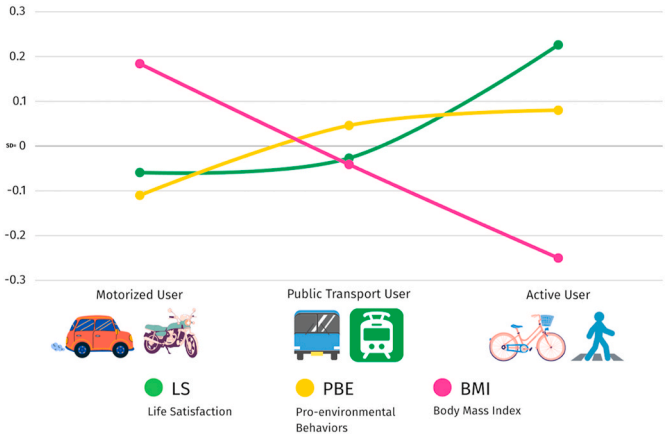

Fig. 2. Mean differences in health and welfare-related psychosocial variables among the three reference commuter groups. *Notes:* Axis Y (left column) is graphically scaled in terms of standardized (Z) scores to favor fair comparability.

4.1. Does the mode of transportation 'differentiate' users' outcomes?

The first hypothesis of this research anticipated that statistically significant differences might exist in terms of both trip-related factors (specifically, commuting stress and travel satisfaction) and welfare-related factors (life satisfaction, pro-environmental behavior, and Body Mass Index) among active, public transport, and private motorized commuters. Similar hypotheses have been previously explored in studies conducted with both the general population and road users, generally assuming that transportation habits are linked to various outcomes across domains within the transport domain (Lunke, 2020) but also outside it, such as life satisfaction (Panter et al., 2011; Schneider et al., 2019), mental and physical health (De Nazelle et al., 2011; Neumeier et al., 2020; Schäfer et al., 2020).

Overall, the findings of this study endorse the assumption that the choice of a specific commuting means (in this instance, categorized into three types) is significantly linked to both trip- and welfare-related issues, showing interesting trends in five psychosocial factors. Specifically, there were noteworthy differences and effect sizes in all five key study factors examined, collectively indicating that at least four of these literature-based variables may yield better outcomes for more sustainable urban commuters, particularly those who have previously shifted to active transportation means (i.e., cycling and walking), initially suggesting that becoming a "sustainabilized" commuter might entail key individual advantages besides the typically underlined environmental gains.

4.2. Is it necessarily "better" to be a more sustainable commuter?

The second hypothesis of the study anticipated that be more favorable outcomes among more 'sustainabilized' users. Said otherwise, lower rates of commuting stress, greater travel- and life-related satisfaction, more general environmental behavior, and healthier Body Mass Indexes were expected especially among active and public transport commuters. Considering the outcomes of the nationwide sample analyzed in this research, if a straightforward response to the question were sought, the most responsible (though

still insightful) option would be: "Yes, being a sustainable commuter is more beneficial, but with certain reservations," or "It could be beneficial for (almost) everything".

In certain instances, the desirability of trip- and welfare-related outcomes among commuting types was found to be partially incongruous with the initial research expectations, although coherent literature-based rationales can be provided. Firstly, commuting stress rates were significantly higher among public transport commuters compared to both motorized and active daily travelers. Similar findings have been reported in studies specifically focusing on Spanish travelers, suggesting that large-scale transportation systems are more likely to involve potential stressors such as crowding, safety, and security issues (Alfaro et al., 2024; Currie et al., 2013; Soto et al., 2022; Useche et al., 2024). Additionally, commonly unforeseeable situations (e.g., delays, route changes, seasonal constraints) appear to impact its convenience, exposing commuters to various factors contributing to the increased likelihood of commuting stress (Legrain et al., 2015; Lunke, 2020).

On the contrary, and consistently with both the research Hypothesis 2 and previous studies such as Kumagai (2021) and Wener and Evans (2011), active commuters were those self-reporting the lesser commuting stress rates. This outcome is largely explainable by the fact that active commuting provides individuals with a sense of control over their travel, avoiding issues like traffic or delays typical of public transport and driving commute (Cendales et al., 2023), thus leading to a more positive commuting experience, reduced perceived stress levels among those who choose active modes of transportation.

Nevertheless, it is worth underscoring that one of the common deterring factors linked to active transportation is its lack of convenience (Buttazzoni et al., 2023). Studies conducted in several countries have found that both risk- and convenience-related factors may decrease the likelihood of resorting to active transport means for daily displacements, especially considering 'side' factors such as a collateral increase in physical effort, significant dependence on external conditions (e.g., weather and infrastructure), exposure to air pollution (Engström et al., 2019), and reduced suitability of active trips for covering long distances, which is typical in large urban areas (Oviedo-Trespalacios et al., 2021; Useche et al., 2019). This could be related to the fact that self-reported trip satisfaction scores remain significantly higher than those corresponding to active commuters.

Another factor worth considering when interpreting these outcomes, especially in the case of long-distance trips, is the broad set of relationships between city size and key subjective variables among commuters. Our results indicate that higher city densities are associated with increased commuter stress and higher Body Mass Indexes (BMI). These findings align with previous research which suggests that urban living, characterized by higher density and congestion, contributes to greater stress levels and adverse health outcomes, including decreased life satisfaction indicators at high urbanization levels (Lenzi and Peruca, 2018). Conversely, our study shows that higher population density is negatively correlated with both travel satisfaction and overall life satisfaction. This is supported by studies indicating that the complexities and challenges of urban commuting can detract from individual well-being and satisfaction (De Vos et al., 2013, 2015; Stutzer and Frey, 2008).

However, an interesting positive correlation was found between city size and personal pro-environmental behaviors, the latter also being associated with individuals' educational attainment. This suggests that commuters in larger, denser cities may be more engaged in behaviors beneficial to the environment, possibly due to heightened environmental awareness and improved access to sustainable options in several spheres (Milfont and Schultz, 2016).

4.3. Health and wellbeing indicators from a comparative approach

The results related to the three welfare-related variables provide valuable insights into the positive implications of active commuting for mental health. In this study, individuals who cycled or walked for their daily commute reported higher rates of both life satisfaction and pro-environmental behavior in areas beyond transport. While our data suggests a somewhat 'linear' association (car commuters had the lowest scores, and active ones had the highest), this fact must be carefully seen in the glance of external factors. For instance, studies like Perchoux et al. (2017) imply that sedentary and active transportation profiles are not necessarily opposing and may co-occur, especially among people with high travel lengths. Therefore, it is worth considering individual mobility needs as a potentially confounding factor when interpreting this particular outcome.

Similarly, other previous research conducted in Europe supports the idea that commuters shifting from car trips to cycling or walking movements might experience several short- and mid-term physical and mental health improvements (Jacob et al., 2021; Palma-Leal et al., 2022). Among them, the current literature suggests non-negligible increases in commuters' subjective well-being in both genders and improved physical fitness, especially among women. This is consistent with the outcomes observed when comparing the single (but widely used) physical health indicator used in this study, i.e., commuters' Body Mass Index, for which it can be proposed that "the more sustainable the commuter is, the healthier their BMI might be".

In summary, the Body Mass Index (BMI) of commuters has shown an inverse association with the sustainability value of their common transport means. The average BMI of private motorized commuters, the most sedentary among the three groups, surpassed the widely accepted threshold of BMI >25.0, indicative of overweight (Zierle-Ghosh and Jan A, 2023), although it was used solely for screening purposes in this study. On the other hand, both public transport and active commuters had Body Mass Indexes within the normal range of BMI $=$ [18.5–25], with the latter group having a significantly lower average.

4.4. Limitations of the study and further research

As lengthily detailed in the paper, the current research was supported by both theoretical and empirical findings of previous studies and gathered data from a nationwide and representative sample of urban Spanish commuters. All the data provided by them were accurately collected, processed, and scrutinized, using the most appropriate statistical procedures and parameters for each of the

analyses presented. However, this study also has various inherent limitations that warrant consideration when interpreting its findings.

Firstly, self-report-based studies, compared to objective ones, carry a heightened risk of biases influencing outcomes. There are extensive pieces of evidence on the fact that self-reported data may be susceptible to Common Method Biases (CMBs) associated with issues such as omitted information, memory flaws (Leal et al., 2023; Sarwar et al., 2014), social desirability, confirmation bias, and memory lapses (Pan et al., 2022), as the questionnaire addresses both public behavior and daily commuting details that may be accurately recalled or not during the response phase (Branion-Calles et al., 2019).

Moreover, the questionnaire's comparative utility is restricted to specific spheres and settings. Although items are generic and applicable to three conventional and widespread commuting modes, there are many more already existing and others such as personal mobility vehicles (PMV) are emerging and gaining ground in several countries. Also, it is suggested to consider other potential sources of 'life satisfaction' beyond the realm of transportation. While this study generally supports the idea that modes of transport can impact satisfaction levels beyond the journey itself, these findings may also be influenced by variables characteristic of other domains, such as socioeconomic status, educational attainment, social support, personal beliefs, among others (Diener et al., 2015; Fergusson et al., 2015).

In addition, comparing groups of users simultaneously employing diverse commuting modes can be challenging due to the combinatory nature of the issue and the difficulty in determining specific commuting patterns (Soto et al., 2022; Useche et al., 2023b). For such cases, methodological literature often recommends mixed-method approaches, incorporating qualitative techniques alongside psychometrically interpretable scales (Bergin, 2018).

Additionally, the core contributions of this study remain valuable but at a limited level, given that insights on the topic could still benefit from other complementary measures and methodologies to assess trip-related factors in commuting contexts through observational and longitudinal perspectives.

5. Conclusions

The results of this study suggest relevant user-based differences and potentialities linkable to active commuting and its growing promotion. Its core conclusions are presented below in correspondence with the hypotheses tested and their key insights:

First, commuters had different psychosocial trip- and welfare-related outcomes according to their mode of transport, supporting (even though non-directionally) the assumption that the commuting mode is associated with the psychosocial outcomes of daily urban travelers, who constitute a key group to address in mobility planning and decision-making.

Secondly, four out of the five key study variables tended to show more favorable outcomes among more 'sustainabilized' users, even though the relationship cannot be extrapolated to all issues.

Finally, among the studied variables, travel satisfaction appears to be an exception, remaining greater among motor vehicle users. This highlights the ongoing need to improve user experience and convenience-related issues for sustainable commuting means.

Practical implications

At a practical level, the outcomes of this research offer several relevant points:

Given that it sheds light on the relationships between commuting trip modalities and both health and well-being-related outcomes, policymakers might find support for invigorating actions aimed at promoting more sustainable transport means for commuting.

From a practitioner's standpoint, these insights could be beneficial in actions and interventions aimed at increasing public acceptance of measures designed to foster more sustainable (and active) transportation dynamics among commuters.

Finally, researchers and scholars addressing modal shifts and travel behavior might find valuable these associations between travel modes and subjective outcomes, allowing them to further test these relationships and provide additional insights on the matter.

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CRediT authorship contribution statement

Sergio A. Useche: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francisco J. Llamazares:** Writing – original draft, Validation, Software, Resources, Investigation, Data curation. **Cristina Marin:** Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation.

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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