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Article

Campus Commuting Modes and Health-Related Quality of Life: A Mixed-Methods Study

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ABSTRACT

Background/aim: Evidence on how campus commuting modes relate to health-related quality of life (HRQoL) among university students remains limited. This study examined whether commuting mode is associated with differentiated HRQoL profiles among university students and explored how they experience the relationship between everyday mobility and well-being. **Methods:** An explanatory sequential mixed-methods design combined a cross-sectional survey conducted with 467 university students, assessing campus commuting, stress, self-rated health, BMI, and life satisfaction, with 24 semi-structured interviews analyzed through reflexive thematic analysis. **Results:** Students using active commuting reported higher life satisfaction than those commuting to campus by private vehicles or public transport, while the latter reported higher travel-related stress. Active commuting remained positively associated with life satisfaction. The qualitative analyses indicated autonomy and physical activation among active mode users, whereas public transport users described unpredictability, crowding, and schedule dependency. **Conclusions:** Campus commuting mode was associated with differentiated HRQoL profiles and relevant differences in students' everyday mobility experiences. Universities may benefit from mobility policies that promote safe active commuting and improve public transport predictability.

Modos de Desplazamiento al Campus y Calidad de Vida Relacionada con la Salud: Un Estudio Mixto

Palabras clave:
Estudiantes universitarios
CVRS
Bienestar subjetivo
Políticas universitarias de salud
Comportamiento sostenible
Movilidad en el campus

RESUMEN

Antecedentes/objetivo: La evidencia sobre cómo los modos de desplazamiento se relacionan con la calidad de vida relacionada con la salud (CVRS) en estudiantes universitarios sigue siendo limitada. Este estudio analizó si el modo de desplazamiento se asocia con perfiles diferenciados de CVRS y exploró los mecanismos experienciales subyacentes mediante un enfoque complementario. **Método:** Se utilizó un diseño mixto secuencial explicativo que combinó una encuesta transversal a 467 estudiantes universitarios, sobre desplazamiento al campus, estrés, salud autopercibida, IMC y satisfacción vital, con 24 entrevistas en profundidad. **Resultados:** Los estudiantes que utilizaban transporte activo mostraron mayor satisfacción vital que quienes se desplazaban al campus mediante vehículos privados o transporte público, mientras que estos últimos reportaron mayor estrés de viaje. El desplazamiento activo mantuvo una asociación positiva con la satisfacción vital. Las entrevistas señalaron autonomía y activación física entre usuarios de medios activos, mientras que los usuarios de transporte público describieron impredecibilidad, aglomeración y dependencia de horarios. **Conclusiones:** El modo de desplazamiento al campus se asoció con perfiles diferenciados de CVRS y con diferencias relevantes en su experiencia cotidiana de movilidad. Las universidades podrían beneficiarse de políticas de movilidad que promuevan desplazamientos activos seguros y mejoren la predictibilidad del transporte público.

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Introduction

Daily mobility constitutes a recurrent behavioral exposure embedded in everyday life. Commuting structures time allocation, influences physical activity levels, and shapes exposure to environmental and psychosocial conditions. A substantial body of evidence has shown that active travel modes, particularly walking and cycling, are associated with lower cardiovascular risk, improved metabolic profiles, and reduced all-cause mortality (Hamer & Chida, 2008; Oja et al., 2011; Saunders et al., 2013; Useche et al., 2026; Warburton & Bredin, 2017). In contrast, prolonged commuting duration and sedentary travel patterns have been associated with negative physical health outcomes, greater commuting stress levels, and lower subjective well-being (Chatterjee et al., 2020; Stutzer & Frey, 2008; Useche et al., 2024).

Despite this expanding literature, much of the empirical work has focused on working adults or heterogeneous population samples. University students remain comparatively underrepresented. This gap is particularly relevant given that early adulthood is a key life stage for the consolidation of lifestyle habits, including physical activity routines and mobility preferences (Arnett, 2000; Nelson et al., 2008). Moreover, most research has been conducted in Anglo-Saxon or Northern European contexts, whereas evidence from Southern European and Latin American settings remains limited. This is especially relevant in Spanish-speaking contexts, where urban structures, public transport systems, and cultural factors may shape commuting experiences differently.

Active Mobility and Health-Related Quality of Life

Health-related quality of life (HRQoL) offers a multidimensional framework for examining how individuals perceive their physical, psychological, and social functioning in everyday life (Ware et al., 1996; WHOQOL Group, 1995). Unlike disease-centered measures, HRQoL incorporates subjective evaluations of health status and broader cognitive assessments of life conditions (EuroQol Group, 1990; Lima-Castro et al., 2024). This multidimensional perspective acknowledges that well-being encompasses not only absence of illness but also positive functioning and life satisfaction.

This framework has progressively been incorporated into transport and mobility research. In this context, everyday practices such as commuting have been examined in relation to both physiological indicators and perceived well-being (Alfaro et al., 2024; Bopp et al., 2011; Chatterjee et al., 2020). Recent comparative analyses have reported differentiated health and well-being profiles across commuting modes, including active, public, and private motorized travel (Alfaro et al., 2025c; Useche et al., 2024). Routine active mobility has been linked to better subjective well-being and lower levels of mental health issues (Mytton et al., 2016; Pucher & Buehler, 2010). Conversely, prolonged commuting duration and sedentary patterns have been associated with higher perceived stress and lower subjective well-being (Chatterjee et al., 2020; Stutzer & Frey, 2008; Useche et al., 2023; Wener & Evans, 2011).

Alongside these findings, commuting experiences differ in their psychosocial characteristics. Travel time, unpredictability, congestion, and crowding have been associated with elevated stress and reduced well-being (Chatterjee et al., 2020; Wener & Evans, 2011). This suggests that commuting mode may relate to multiple interrelated factors, including physical activation, exposure to stressors, and perceived temporal control (Avila-Palencia et al., 2017; Stutzer & Frey, 2008). Although the mobility–health link is increasingly acknowledged, a substantial proportion of studies have examined relatively isolated outcomes rather than positioning these indicators within a broader HRQoL framework. More recent work has begun to address this gap by connecting transport behaviors with multidimensional health and well-being outcomes.

University Students as a Strategic Population

University students are situated in a developmental stage characterized by increasing autonomy and gradual stabilization of daily routines. Early adulthood has been described as a period in which behaviors related to physical activity, time organization, and mobility begin to consolidate (Arnett, 2000; Nelson et al., 2008). In this sense, commuting practices adopted during the university years may extend beyond the academic context and persist over time, making this population strategically important for understanding the formation of sustainable mobility habits.

At the same time, students' mobility patterns are embedded in broader structural conditions. Residential location, housing affordability, and urban restructuring processes influence commuting distances and available transport options (Shi, 2021). In several metropolitan contexts, rising rental prices and gentrification dynamics have relocated student populations toward peripheral areas, frequently increasing daily travel times, which alters the practical feasibility of walking or cycling and often reinforce dependence on public or private motorized transport (Piñeira et al., 2025; Schnake-Mahl et al., 2020). These dynamics create structural constraints that interact with individual preferences in shaping commuting behavior.

Moreover, a substantial proportion of students combine academic commitments with paid employment, internships, or family responsibilities. Commuting, therefore, becomes integrated into tightly organized daily schedules characterized by limited time flexibility (Shi, 2021). Under these circumstances, transport mode selection is often constrained by distance, cost, timetable coordination, and the need to reconcile study with other obligations. In this context, the university setting offers a suitable framework for examining how daily commuting intersects with structural constraints and habit formation processes during early adulthood (Arnett, 2000).

Study Aims and Hypotheses

The present study examines the association between commuting mode and health-related quality of life among undergraduate students within a mixed-methods design.

The quantitative strand assesses whether differences in commuting practices are associated with variations in self-rated physical and mental health, body mass index, perceived commuting stress, and life satisfaction. In addition, regression analyses evaluate whether commuting mode remains associated with life satisfaction after adjustment for relevant sociodemographic and contextual variables. The qualitative strand seeks to explore how students interpret and describe the relationship between their everyday mobility and their perceived well-being. Given its exploratory and

interpretive purpose, this strand was not framed through a separate formal hypothesis, but through an analytical aim focused on identifying experiential mechanisms that could help contextualize the quantitative findings.

Based on prior literature linking active mobility with improved physical health indicators and higher levels of subjective well-being (Hamer & Chida, 2008; Martin et al., 2014; Oja et al., 2011; Useche et al., 2024), the following hypotheses were formulated:

Hypothesis 1 (H1). Students who report active commuting as their primary travel mode will show higher levels of self-rated physical health and life satisfaction compared to students using private motorized or public transport.

Hypothesis 2 (H2). Students who primarily use active commuting will report lower levels of commuting-related stress compared to those using public or private motorized transport.

Hypothesis 3 (H3). After adjusting for age, size of municipality of residence, and commuting duration, commuting mode will significantly predict life satisfaction, with active commuting showing a positive association relative to private motorized transport.

Method

Study Design and Setting

This mixed-methods study integrated a cross-sectional quantitative survey with a qualitative phase based on semi-structured interviews. The quantitative phase was designed to examine statistical associations between commuting mode and indicators of health-related quality of life and subjective well-being among university students. The qualitative phase was subsequently conducted to deepen the interpretation of quantitative findings, focusing on students' lived experiences of daily commuting, perceived physical and psychological effects, and the practical constraints shaping mobility choices.

The study was conducted within the Valencian university system (Spain) and targeted undergraduate students who regularly commute to campus. The research protocol was reviewed and approved by the INTRAS – University of Valencia ethics committee (Code: HE0001170924). Participation was voluntary, informed consent was obtained electronically prior to survey completion and again before interviews, and all data were anonymized in accordance with GDPR regulations.

The integration of both approaches followed an explanatory sequential logic. Quantitative findings were first analyzed to identify patterns of association between commuting mode, stress, trip duration, and life satisfaction. The qualitative phase was then structured to explore how students interpret these experiences, what mechanisms may underlie observed statistical differences, and how contextual factors such as time pressure, infrastructure, and social expectations relate to actual commuting behavior.

More specifically, the qualitative phase was designed after the initial quantitative analyses and focused on patterns that required further interpretation: the higher life satisfaction observed among active commuters, the higher commuting stress reported by public transport users, the role of trip duration, and the unexpected differences in self-rated physical and mental health across commuting groups. This sequencing supported an analytical, rather than only descriptive, use of the interview-based findings, helping to interpret how students experienced the statistical patterns observed in the survey from a mixed-methods standpoint.

Quantitative Phase

Participants and Procedures

The quantitative phase included undergraduate students who reported regular commuting to campus as part of their academic routine. A total of 486 students completed the survey. After excluding cases with missing data in the variables required for main analyses, the final analytical sample comprised 467 participants.

Participants were recruited through institutional mailing lists, classroom announcements, and campus-wide dissemination channels. The survey was administered online through Google Forms and remained accessible for several weeks in order to allow participation across faculties and academic schedules. The average completion time was approximately 12 minutes.

Eligibility criteria required participants to be undergraduate students currently enrolled at the university and regularly commuting to campus as part of their academic routine. The online form required completion of the main characterization and study variables, so no missing data were observed for the variables included in the main analyses. Cases were excluded only when respondents did not report a usual commuting mode or did not meet the eligibility criteria.

The final sample was predominantly female (60.8%). Age ranged from 17 to 24 years (M = 20.80, SD = 1.89). The relatively narrow age distribution corresponds to the undergraduate stage and reduces variability linked to different life phases.

With regard to commuting behavior, public transport was the most frequent mode (n = 292), followed by active transport (n = 96), and private motorized transport (n = 79). Although the sample included students using the three main commuting modes considered in this study, it should not be interpreted as statistically representative of the full university population. The sampling strategy was non-probabilistic and aimed to obtain sufficient variability across commuting profiles rather than to estimate population parameters. For this reason, no formal comparison with population statistics was included.

Variables and Instruments

The questionnaire included sociodemographic, mobility-related, and health-related indicators, as follows:

Sociodemographic variables comprised age, sex, and size of city/municipality of residence, the latter serving as a contextual indicator of urban structure and transport availability.

Commuting mode was the main independent variable. Participants reported the transport mode they used most often during a typical academic week, categorized into three groups: private motorized transport (car or motorcycle), public transport (bus, metro, tram), and active transport (walking or cycling). For regression analyses, dummy variables were constructed using private motorized transport as the reference category.

Daily commuting length was assessed in minutes, capturing the average time required for the primary trip to campus. This variable was treated as continuous in all analyses.

Commuting-related stress was measured using the Multimodal Commuting Stress Scale (Useche et al., 2023, 2024), a 21-item

Likert-type instrument designed to capture stress-related cognitive and emotional appraisals associated with routine commuting. The scale includes items applicable across multiple transport modes, allowing consistent measurement across heterogeneous mobility patterns. Participants respond based on their typical commuting experience, and a composite mean score is computed to represent overall perceived commuting stress. In this sample, internal consistency was excellent (α = .945, ω = .943).

Self-rated health indicators included self-rated physical health and self-rated mental health, both assessed on 0–10 scales. Although self-reported, these indicators are commonly used in HRQoL research and show consistent associations with behavioral and environmental determinants.

Body Mass Index (BMI) was calculated using self-reported weight and height, expressed as kg/m². Although self-reported anthropometric data may introduce reporting bias, BMI remains a widely used proxy indicator of weight status and cardiometabolic risk in population-based research (Wu et al., 2024; Zierle-Ghosh & Jan, 2025).

Life satisfaction, which theoretically constitutes a strong subjective well-being indicator, was assessed using the Harmony in Life Scale combined with the Satisfaction with Life framework (HLS + SWL) (Kjell et al., 2016; Kjell & Diener, 2021). This six-item instrument assesses global life satisfaction and psychological balance. Participants responded based on their general life circumstances, and a composite mean score was calculated to represent overall subjective well-being. Higher scores indicate greater satisfaction. Internal consistency was adequate (α = .811, ω = .810).

Data Analysis

Descriptive statistics were calculated for all study variables. Internal consistency reliability of multi-item scales was assessed using both Cronbach's alpha and McDonald's omega coefficients. One-way ANOVAs examined differences between commuting groups. When the omnibus F test reached statistical significance, Tukey HSD post-hoc comparisons were conducted while controlling for familywise error rates across pairwise comparisons within each outcome. No additional correction was applied across the full set of outcome variables; therefore, ANOVA results were interpreted jointly with effect sizes and with the qualitative findings. Effect sizes were estimated using eta-squared (η²).

Hierarchical linear regression assessed whether commuting mode predicted life satisfaction after adjusting for potential confounders. Age, city size, and commuting duration were entered in Step 1 as control variables. Commuting mode dummy variables were introduced in Step 2. Commuting stress was included in Step 3 to examine whether perceived stress accounted for part of the association. Multicollinearity diagnostics were examined using tolerance and variance inflation factors. All analyses were performed using IBM SPSS Statistics 30.0.

Qualitative Phase

Participants and Data Collection

Twenty-four undergraduate students participated in the interview phase. Participants were recruited from survey respondents who had indicated willingness to be contacted for follow-up research. Sampling followed a purposive logic aimed at ensuring heterogeneity across commuting modes, gender, and study programs, while giving priority to profiles that could help interpret the quantitative contrasts observed for life satisfaction, commuting stress, trip duration, and self-rated health. The sample included: private motorized transport (n = 6), public transport (n = 9), and active commuting (n = 9). Table 1 presents the basic demographic features of this sample.

Interviews were conducted in quiet university facilities, lasting 35-60 minutes. The interview guide addressed: daily commuting routines; perceived physical and psychological effects of commuting; experiences of stress and time pressure; perceived advantages and disadvantages of different transport modes; barriers and facilitators for active commuting; and the perceived relationship between mobility patterns and academic or personal well-being.

All interviews were audio-recorded with participant consent and transcribed verbatim. Sample size was determined based on the principle of information power rather than numerical saturation alone (Guest et al., 2006; Hennink et al., 2017). Given the focused research aim, the relatively specific study population, and the integration with quantitative findings, approximately 20 interviews were considered sufficient to achieve thematic depth (Guest et al., 2006; Hennink et al., 2017).

Table 1
Qualitative Sample Characteristics (Core Demographic Data)

Participant	Sex	Age	Main commuting mode
P01	Male	22	Motorized
P02	Female	21	Motorized
P03	Female	19	Public transport
P04	Female	20	Public transport
P05	Female	22	Motorized
P06	Male	18	Active
P07	Female	20	Public transport
P08	Female	20	Active
P09	Female	21	Public transport
P10	Male	19	Active
P11	Male	22	Active
P12	Female	23	Public transport
P13	Male	20	Public transport
P14	Female	24	Active
P15	Female	19	Active
P16	Male	21	Motorized
P17	Female	22	Public transport
P18	Male	23	Active
P19	Female	20	Public transport
P20	Male	24	Motorized
P21	Male	23	Motorized
P22	Female	19	Active
P23	Male	21	Public transport
P24	Female	22	Active

Analytic Domains

The interview guide addressed the following domains: daily commuting routines; perceived physical and psychological effects of commuting; experiences of stress and time pressure; perceived advantages and disadvantages of different transport modes; barriers and facilitators for active commuting; and the perceived relationship between mobility patterns and academic or personal well-being.

The guide was informed by prior research on commuting stress, mobility behavior, and HRQoL, as well as by preliminary quantitative findings from the survey. In particular, probes were added or refined to explore the higher life satisfaction observed among active commuters, the higher stress reported by public transport users, the relevance of commuting duration, and the unexpected pattern of self-rated physical and mental health across commuting groups. After the first few interviews, minor adjustments were introduced to clarify wording and expand probes related to time management and perceived fatigue. These refinements did not alter the core structure of the interview protocol but improved clarity and depth of responses. All interviews were audio-recorded with participant consent and transcribed verbatim. Identifying information was removed during transcription to ensure confidentiality.

Data Analysis

The data were analyzed using reflexive thematic analysis following the six-phase framework proposed by Braun & Clarke, whose approach has been supported throughout specialized literature (Bergin, 2018; Braun & Clarke, 2006). This approach was selected because it allows for systematic identification of patterns across a dataset while acknowledging the interpretive role of the researcher.

The analysis proceeded through repeated familiarization with the transcripts, initial line-by-line coding, and the development of candidate themes. Coding was primarily inductive, allowing themes to emerge from the data, while remaining conceptually informed by the study's focus on commuting, stress, and health-related quality of life. Both semantic content (explicit statements) and more latent dimensions (e.g., structural constraints, institutional expectations, temporal pressures) were considered during theme development.

Candidate themes were iteratively reviewed against the full dataset to examine internal coherence and distinctiveness across participants and commuting modes. Themes were then defined and refined to strengthen conceptual clarity and ensure alignment with the research questions. NVivo 14.0 was used to support data management and coding, facilitating systematic organization of excerpts and auditability of coding decisions. Analytic judgments, however, were based on repeated reading of the transcripts and ongoing interpretive engagement with the data, consistent with the principles of reflexive thematic analysis.

Rigor and Trustworthiness

Several steps were taken to enhance analytic transparency and trustworthiness. First, coding decisions and theme development processes were documented throughout the analysis. Second, reflexive notes were maintained to acknowledge the researchers' positionality as academics familiar with the university context and potentially influenced by prior assumptions regarding mobility and health.

Third, attention was given to coherence between research questions, interview design, and analytic interpretation. Rather than relying on frequency counts alone, themes were developed based on interpretive depth and conceptual relevance (see Nowell et al., 2017). Reporting of the qualitative phase was structured in accordance with COREQ recommendations, particularly with regard to sampling, data collection context, and analytic procedures, in order to strengthen transparency and consistency between data, interpretation, and reported findings (Tong et al., 2007).

Results

Quantitative Findings

Differences Across Commuting Modes

Table 2 presents descriptive statistics for all study variables, split by participants' most usual university commuting mode.

Table 3 summarizes the omnibus ANOVA results for all main study outcomes according to commuting mode and reports the statistically significant Tukey HSD post-hoc comparisons. This combination makes it possible to assess not only whether overall between-group differences were observed, but also which specific commuting groups differed significantly from one another.

Public transport users reported significantly longer commuting times and higher commuting stress than both motorized and active commuters. Regarding self-rated health, public transport users reported higher physical health scores than active commuters, while both motorized and public transport users reported higher mental health scores than active commuters. These differences should be

Table 2
Descriptive Statistics of Study Variables by Commuting Mode

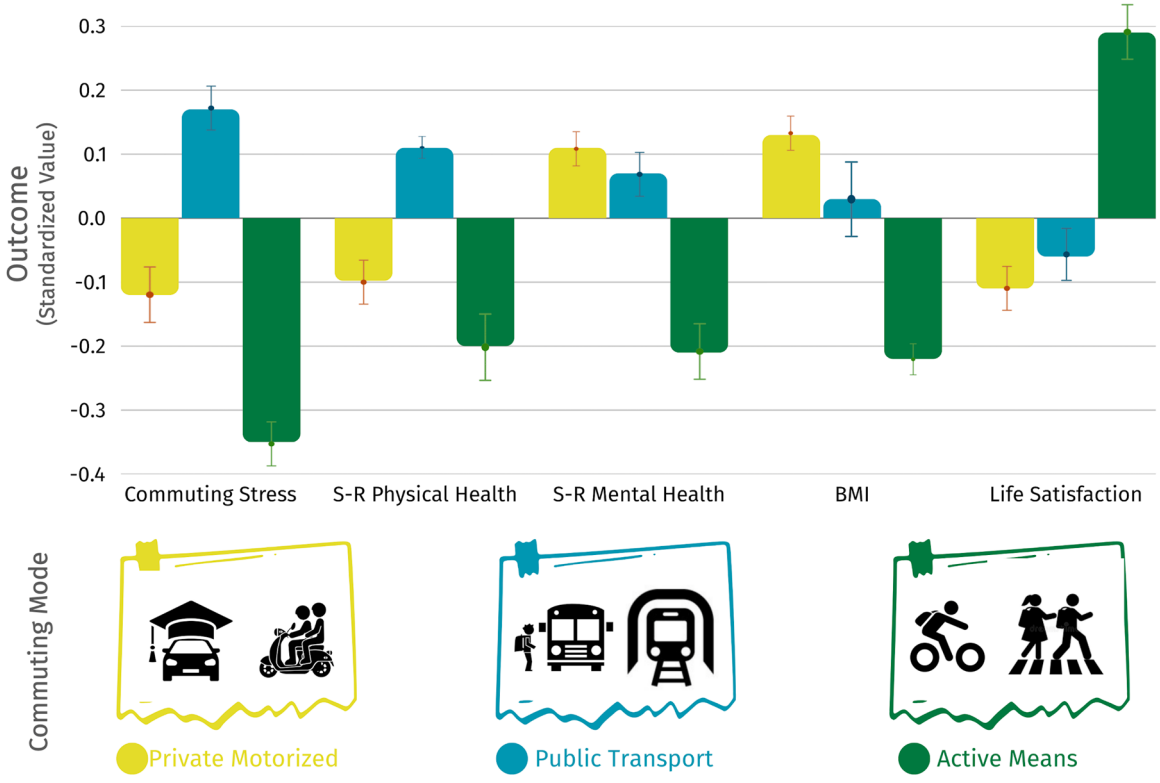
	Motorized		Public Transport		Active Transport	
Variable	***M***	***SD***	***M***	***SD***	***M***	***SD***
Trip Length (minutes)	21.71	13.70	27.00	20.22	23.23	10.56
Commuting Stress	1.59	0.94	1.87	.93	1.31	.86
Self-Rated Physical Health	7.20	1.85	7.59	1.69	6.90	1.97
Self-Rated Mental Health	8.05	1.79	7.95	1.88	7.27	2.00
Body Mass Index (BMI)	24.60	6.29	23.89	8.09	22.24	3.04
Life Satisfaction	1.89	1.58	1.95	1.66	2.54	1.61

Table 3
Omnibus Analysis of Variance (ANOVA) Outcomes for the Full set of Study Variables (Categorical Factor: Commuter Type) and Post-Hoc Comparisons (Tukey HSD)

Variable	*F*	*df*1	*df*2	*p*	η^2	95% CI (η^2)		Significant post hoc comparisons
						Lower	Upper	
Trip Length (minutes)	3.66	2	464	< .050	.016	.000	.042	Public > Motorized*
Commuting Stress	14.14	2	464	< .001	.057	.022	.101	Public > Active**
								Public > Motorized*
Self-Rated Physical Health	5.91	2	464	< .010	.025	.003	.057	Public > Active**
Self-Rated Mental Health	5.33	2	464	< .010	.022	.002	.053	Motorized > Active*
								Public > Active**
Body Mass Index (BMI)	2.72	2	456	.067	.012	.000	.036	---
Life Satisfaction	5.31	2	464	< .010	.022	.002	.053	Active > Motorized*
								Active > Public**

Note. η^2 = partial eta-squared derived from the omnibus ANOVA. Confidence intervals for η^2 were obtained via inversion of the noncentral F distribution and converted to η^2 scale; *df* = Degrees of freedom; **p* < .05; ***p* < .01; ****p* < .001.

Figure 1
Mean Differences in HRQoL-Related Outcomes Across the Three Commuter Groups of University Commuters



Note. The y-axis is expressed in standardized (*z*) scores (i.e., each unit represents one standard deviation) to facilitate comparability across outcomes. Vertical bars represent score dispersion.

interpreted as self-reported health appraisals rather than objective health differences. BMI differences did not reach statistical significance, although active commuters showed descriptively lower values. Active commuters reported significantly higher life satisfaction than both other groups.

Figure 1 offers a graphical breakdown of the full set of health-related outcomes used, differentiated by university commuting means.

Hierarchical Regression Predicting Life Satisfaction

Table 4 presents the regression results. In Step 1, trip length was a significant negative predictor (B = −.011, $p < .050$), indicating that longer commuting duration was associated with lower life satisfaction. Age and city size were not significant predictors.

The introduction of commuting mode in Step 2 significantly improved the model ($\Delta R^2 = .021$, $p < .001$). Active commuting

Table 4
Hierarchical Linear Regression Predicting Life Satisfaction (Endogenous Factor)

Predictor	*B*	*SE*	β	*t*	*p*	R^2	ΔR^2
Step 1						.016	—
Age	.025	.041	.028	.614	.539		
City Size	.002	.049	.002	.034	.973		
Trip Length (minutes)	−.011	.004	−.120	−2.583	< .050		
Step 2						.037	.021*
Age	.026	.040	.029	.631	.528		
City Size	−.006	.049	−.006	−.119	.905		
Trip Length (minutes)	−.011	.004	−.114	−2.464	< .050		
Public Transport (ref: Motorized)	.130	.210	.038	.617	.537		
Active Transport (ref: Motorized)	.681	.249	.167	2.733	< .010		
Step 3						.038	.001
Age	.024	.041	.028	.605	.546		
City Size	−.011	.049	−.010	−.215	.830		
Trip Length (minutes)	−.011	.004	−.118	−2.529	< .050		
Public Transport (ref: Motorized)	.116	.211	.034	.550	.582		
Active Transport (ref: Motorized)	.701	.251	.172	2.795	< .010		
Commuting Stress	.062	.084	.035	.739	.461		

Note. *ΔR^2 significant at < .010; Unstandardized coefficients (*B*), standard errors (SE), and standardized coefficients (β) are reported. Private motorized transport served as the reference category. ΔR^2 indicates change in explained variance relative to the previous step.

was positively associated with life satisfaction (B = .681, β = .167, $p < .010$), indicating higher well-being among students using walking or cycling compared to private motorized transport. Public transport was not significantly associated with life satisfaction after controlling for trip length.

In Step 3, commuting stress was entered but did not significantly increase explained variance ($\Delta R^2 = .010$), and was not a significant predictor ($p = .461$). The association between active commuting and life satisfaction remained significant (B = .701, β = .172, $p < .010$), suggesting that this association was not accounted for by perceived commuting stress. The final model explained 3.8% of the variance in life satisfaction. Given the broad evaluative nature of life satisfaction, this result, while significant, should be interpreted as a specific mode-related association rather than as a comprehensive explanatory model of student well-being.

Qualitative Findings

The qualitative strand aimed to deepen the understanding of how commuting experiences are embedded in students' daily routines and how they relate to perceived well-being. While the quantitative findings identified statistically significant differences in life satisfaction and stress levels across commuting modes, the interviews provided insight into how students interpret and experience those differences in everyday contexts. Four interrelated themes were identified through reflexive thematic analysis.

Commuting as Daily Structuring Time

Across commuting modes, students described their trip to campus as a predictable but consequential part of their routine. However, the meaning attached to commuting time differed substantially across modes.

Public transport users frequently described commuting as time-consuming and externally structured. Delays, waiting times, and schedule dependency were mentioned as recurrent sources of friction in otherwise tightly organized academic days. One participant explained: "*Sometimes it's not even the length of the trip, it's that you depend on the bus. If it's late, your whole day starts differently*" (P04, female, 20, public transport). Another public transport user described commuting as an externally regulated segment of the day: "*You're always adjusting to something – a delay, a connection, or how crowded it is. It's not just movement, it's adapting*" (P13, male, 20, public transport). This sense of external dependency appeared to generate cognitive load beyond the trip itself.

In contrast, active commuters often framed commuting time as more integrated into their daily rhythm. Walking or cycling was described not simply as transport but as a transitional space between academic and personal life: "*When I walk to campus, I feel like I'm already starting my day in a better way. It's not just moving from one place to another*" (P11, male, 22, active transport). Another active commuter complemented this by emphasizing the preparatory dimension of the trip: "*Walking is more practical, but you never know… Cycling gives me time to wake up properly. I arrive more present, not rushed*" (P06, male, 18, active transport).

Private motorized commuters emphasized efficiency and control, particularly when distance or schedule constraints were salient. For some, the car was associated with predictability rather than speed alone: "*Driving gives me control. I know how long it takes, and I don't have to adjust to anyone else's timetable*" (P02, female, 21, motorized). Similarly, another motorized commuter highlighted

logistical flexibility: "*With the car I can organize my day more tightly. I don't lose time waiting... and considering how far I live, I have no choice*" (P21, male, 23, motorized).

These accounts suggest that commuting is experienced not only in terms of duration but also in terms of perceived autonomy and temporal control, dimensions that may help contextualize the quantitative association between trip length and life satisfaction.

Physical Activation and Mental Transitions

A second theme addressed how students linked commuting mode to perceived physical and mental states. Active commuters frequently described their trips as contributing to bodily activation, energy, or mood regulation. Cycling and walking were sometimes framed as informal exercise embedded in routine: "*I don't go to the gym every day, but cycling to campus makes me feel like I've already done something good for myself*" (P15, female, 19, active transport). Another active user described this activation in more functional terms: "*If I ride, I arrive more awake. It's like my body has already started working before I start the day. I just dislike sweating too much in summer, but still…"* (P06, male, 18, active transport).

Several participants also associated active commuting with clearer mental transitions, particularly before exams or demanding academic tasks: "*After walking for twenty minutes, I feel more focused when I arrive. You never get late if you're constant. It's like I've had time to organize my thoughts"* (P18, male, 23, active transport). Similarly, another participant emphasized the gradual shift between personal and academic roles: "*It's a kind of buffer. I leave home stressed sometimes, but by the time I get to campus, I'm calmer*" (P14, female, 24, active transport).

In contrast, public transport users more frequently referred to crowding, noise, or uncertainty as influencing their mental state. While not all accounts were negative, variability in travel conditions appeared central: "*Some days it's fine, but if it's crowded, you arrive already a bit overwhelmed (…) and the trains are never on time here, which is an extra concern*" (P07, female, 20, public transport). Another public transport commuter expressed a similar sentiment, focusing on sensory load: "*When it's noisy or packed, you can't disconnect, whether for the lack of comfort or the pickpockets. You're already tired at the end of the morning trip*" (P19, female, 20, public transport).

Interestingly, motorized commuters did not systematically report higher stress, but several described commuting as neutral or purely functional: "*For me it's just a necessity. I don't think it affects my mood much*" (P01, male, 22, motorized). Another participant articulated a comparable view: "*Driving is just practical. Rather mechanical, so I wouldn't say it makes me feel better or worse*" (P20, male, 24, motorized).

Taken together, these accounts indicate that commuting modes are associated with distinct experiential profiles. Active commuting was more frequently linked to physical activation and cognitive preparation, whereas public transport use was described as more variable and context-dependent. Motorized commuting, in turn, tended to be framed as efficient but emotionally neutral. These distinctions provide interpretive depth to the quantitative findings, particularly the stronger association observed between active commuting and life satisfaction compared to other modes.

Trade-Offs, Constraints, and Structural Conditions

A third theme concerned the structural and material conditions shaping commuting practices. Across interviews, students rarely described their commuting mode as a purely voluntary choice. Instead, decisions were presented as negotiated outcomes influenced by housing location, economic constraints, distance to campus, and compatibility with work or family schedules.

Public transport users frequently framed their commuting mode as the most viable option given rental prices and spatial dispersion. Living farther from campus was described as economically necessary, even when it implied longer daily travel times: "*I would walk if I lived closer, but where I rent (shared flat, though), it's just too far. It's not really a choice*" (P09, female, 21, public transport). Another public transport commuter emphasized the economic trade-off more explicitly: "*Thanks to gentrification (ironically speaking), it's cheaper to live outside the city, but that means spending almost an hour commuting every day. You save money, but you lose time*" (P13, male, 20, public transport). Importantly, long commutes also affected broader aspects of daily life beyond the trip itself. One participant noted: "*The fact of living in a peripheral area of the city makes me think twice before spending time with my friends at the university (…) getting late makes you feel it's also too late to catch the last bus, so I literally do not interact with the city in the evening time, as before*" (P19, female, 20, public transport). This account suggests that commuting duration may influence social participation and extracurricular life, not only travel experience per se. For these students, commuting duration was embedded within broader housing dynamics rather than framed as an isolated mobility decision, and it also appeared to condition extracurricular activities, leisure, and social life.

Motorized commuters similarly described car use as conditional rather than preferential. In several cases, private vehicles were linked to work schedules or combined responsibilities that required flexible timing: "*I work in the afternoons in a shopping mall, so I need the car to move between university and work. Otherwise it would be tricky*" (P05, female, 22, motorized). Another participant highlighted logistical coordination within the family: "*I share the car with my brother, who is in the faculty next door, so we organize around each other's timetables. It's more about practicality than preference*" (P21, male, 23, motorized).

Active commuters, in contrast, were more likely to reside closer to campus or in areas with adequate infrastructure. However, even among this group, commuting mode was described as contingent on environmental conditions such as safety or weather: "*I cycle because I live nearby (no more than two kilometers), but if the route felt unsafe, I probably wouldn't*" (P10, male, 19, active transport). Another active commuter pointed to seasonal variability: "*When it rains or I have things to carry, I switch to the bus. It depends on the day. But fits well most of the time*" (P08, female, 20, active transport).

These accounts show that commuting practices are situated within layered structural conditions. Distance to campus, urban design, and economic factors appear intertwined with daily mobility decisions. Such contextual factors may help contextualize the statistical association observed for commuting duration in the quantitative analyses, while mode differences alone fall short of accounting for the full complexity of students' mobility experiences.

Active Commuting as Routine Alignment and Everyday Balance

A fourth theme concerned the way some students described active commuting as aligned with their broader orientation toward daily organization and self-regulation. Rather than presenting walking or cycling as a planned health intervention, participants often referred to these modes as naturally integrated into how they preferred to structure their day.

Several active commuters framed their commuting choice as consistent with a general preference for movement over sedentary routines: "*I don't like starting the day sitting down. Walking helps me feel like I'm already doing something instead of just waiting for things to happen*" (P15, female, 19, active transport). Another participant implied a similar alignment between commuting and personal routine: "*It matches my rhythm. I prefer moving at my own pace instead of depending on traffic or schedules*" (P18, male, 23, active transport).

Beyond routine alignment, active commuting was associated with a sense of gradual adjustment between home and campus environments. The physical movement was described as creating a transition space that helped balance academic demands: "*When I cycle, it's like I have time to switch mentally. I'm not just arriving suddenly*" (P06, male, 18, active transport). Similarly, another active commuter emphasized emotional steadiness rather than intensity: "*It's not that I feel amazing or anything, but I feel more stable when I walk to the Uni*" (P24, female, 22, active transport).

Importantly, these positive descriptions were accompanied by recognition of contextual limits. Active commuting was portrayed as contingent on infrastructure and situational comfort: "*If the traffic feels too heavy, I avoid cycling. It depends on how safe it feels that day. I don't imagine myself cycling from other neighborhoods, so I feel grateful to live where I do*" (P22, female, 19, active transport).

These narratives indicate that active commuting is not framed as an absolute preference but as a context-sensitive practice embedded in daily organization. For a subset of students, it appears to support a sense of routine coherence and embodied engagement, while remaining dependent on environmental and situational factors, consistent with the quantitative pattern observed for life satisfaction. It also suggests that the association with active commuting may operate through everyday experiential processes rather than through commuting duration alone.

Discussion

This study examined whether commuting mode is associated with differences in HRQoL indicators among a sample of Spanish undergraduate students, combining quantitative comparisons with qualitative accounts of everyday mobility experiences. Overall, active commuters reported higher life satisfaction and more favorable profiles in some indicators, while public transport users showed higher commuting-related stress. Rather than pointing toward a single linear pattern, results suggest differentiated associations between commuting practices and distinct well-being dimensions.

Interpretation of Quantitative Findings

The quantitative outcomes of this study suggest that commuting mode is associated with differentiated patterns across several indicators related to HRQoL. Students who primarily engaged in active commuting reported higher levels of life satisfaction compared to those relying on both public transport or private motorized travel. This association is consistent with prior comparative research situating daily mobility within broader well-being frameworks. Longitudinal analyses have shown that individuals who transition from car use to walking or cycling report improvements in psychological well-being over time (Martin et al., 2014). Cross-sectional research has similarly described more favorable subjective profiles among active commuters when compared with sedentary modes, particularly when well-being is assessed through multidimensional instruments (Bergstad et al., 2011; Olsson et al., 2013, 2020; Useche et al., 2024).

Higher commuting stress among public transport users aligns with research linking crowding, service variability, and limited control over travel conditions to elevated stress appraisal (Chatterjee et al., 2020; Wener & Evans, 2011). Previous studies have also suggested that travel-related stress is associated not only with duration but also with perceived predictability and autonomy – dimensions that vary across transport modes (Stutzer & Frey, 2008).

Understanding the Peculiarities of Self-Rated Health

The finding that active commuters reported lower self-rated physical and mental health than other groups warrants careful interpretation, as it contrasts with life satisfaction patterns and with the descriptive tendency observed for BMI. This pattern is relevant, but it should not be interpreted as evidence of poorer objective health among active commuters. Several considerations may help explain this apparent paradox.

First, these measures address subjective appraisals rather than objective health status. Self-rated health depends on individual reference standards and interpretation, a phenomenon documented in studies addressing "health paradoxes" where individuals report good health despite objectively unfavorable conditions (Whitmore et al., 2022). It is plausible that such appraisals are influenced by beliefs about comfort, control, and what constitutes "healthy" daily living (Egset & Nordfjærn, 2019).

Second, selection processes may operate: students with particular health constraints, chronic conditions, or physical limitations may systematically avoid active commuting due to feasibility concerns (Alfaro et al., 2025b; Soto et al., 2022). Another possible explanation could be that, if students who perceive their health as poorer are less likely to walk or cycle, the observed pattern could reflect reverse causation rather than an effect of commuting mode on health perception.

Third, active commuters may hold higher standards for evaluating their own health, particularly if physical activity and wellness form part of their identity. A student who regularly exercises may rate their health against an idealized standard, whereas a sedentary commuter may apply fewer demanding criteria.

Finally, the pattern may reflect unmeasured confounders. Students who cycle or walk may face other life stressors (financial pressure, intensive study programs, limited family support) that independently affect self-rated health while being correlated with residential proximity to campus.

From a practical standpoint, this finding suggests that modal shift strategies in university settings should address not only infrastructural barriers but also students' perceptions of commuting,

comfort, and well-being. The divergence between life satisfaction and self-rated health also supports the use of multidimensional HRQoL assessment, as different indicators may follow different patterns across commuting groups. Future studies may benefit from incorporating complementary health and mobility measures when feasible.

Mixed-Methods Integration: Experiential Mechanisms

The qualitative findings help interpret the quantitative patterns observed by showing how students attached different meanings to commuting time, autonomy, stress, and bodily activation across modes. Active commuters frequently referred to feelings of energy, mental clarity, and emotional regulation associated with walking or cycling to campus. These descriptions resonate with previous research suggesting that active travel can be linked to improved mood regulation and daily vitality (Martin et al., 2014; Olsson et al., 2013). Rather than being framed exclusively as physical exercise, active commuting was often described as a transition space between academic and personal domains, a feature that has also been identified in studies examining the experiential dimension of everyday travel (Bergstad et al., 2011; Chatterjee et al., 2020). In this sense, the higher life satisfaction observed among active commuters may be situated within this broader pattern, which seems coherent with participants' awareness of the benefits of their commuting practices.

Public transport users, in contrast, emphasized variability in service conditions, crowding, and time-related uncertainty. These narratives align with transport psychology literature linking perceived lack of control, unpredictability, and exposure to shared environments with elevated travel-related stress (Stutzer & Frey, 2008; Useche et al., 2023; Wener & Evans, 2011). Research conducted in urban commuting contexts has similarly shown that stress appraisals are wrought not only by travel duration but also by perceived reliability and environmental conditions (Cendales et al., 2023; Chatterjee et al., 2020; Useche et al., 2023). The convergence between the higher stress levels detected quantitatively and these qualitative accounts is therefore consistent with established findings on the psychosocial dimensions of public transport use.

Experiences reported by private motorized users were frequently organized around notions of autonomy, schedule flexibility, and environmental control. Such themes are coherent with evidence suggesting that perceived control is an important determinant of commuting satisfaction and stress appraisal (Egset & Nordfjærn, 2019; Wener & Evans, 2011). These facts may help contextualize the slightly higher self-rated mental health scores observed among motorized users in the present sample. At the same time, prior comparative research has noted that convenience and perceived comfort do not necessarily translate into higher overall life satisfaction when broader evaluative indicators are considered (Olsson et al., 2013; Useche et al., 2024), which aligns with the absence of an elevated self-reported degree of life satisfaction in this group.

Across commuting modes, interviews revealed trade-offs rather than unidirectional advantages. Principally, active commuting was occasionally described as weather-dependent or physically demanding; public transport was acknowledged as accessible yet unpredictable; private motorized travel was linked to convenience alongside economic and environmental costs. Similar multidimensional evaluations have been documented in qualitative mobility studies emphasizing that commuting practices are embedded in contextual constraints and subjective appraisals rather than simple preference structures (Bopp et al., 2013; Chatterjee et al., 2020; Simonn et al., 2025), which correspond with the quantitative pattern indicating that commuting mode relates to differentiated well-being dimensions rather than to a single uniform outcome.

Practical Implications for Student Well-Being and University Health Promotion

From a practical perspective, these results support approaching university mobility policies not only as sustainability measures but also as part of student well-being. Differences in life satisfaction and commuting-related stress, together with interview accounts on temporal control and day-to-day trade-offs, are consistent with the idea that commuting practices relate to quality-of-life indicators in ways that go beyond emissions or modal share (Neumeier et al., 2020; Useche et al., 2024).

In terms of actionable measures, several implications emerge. First, campus-based programs that integrate infrastructure with student-facing strategies may be more effective than isolated measures. Prior research has shown that active travel can be promoted through packages combining secure bicycle parking, basic end-of-trip facilities, clear wayfinding, and communication emphasizing convenience and everyday feasibility rather than idealized narratives (Bopp et al., 2018; Martin et al., 2014; Palma-Leal et al., 2023). In this study, interviews repeatedly emphasized routine fit and predictability as central concerns.

Second, given the higher stress levels observed among public transport users and frequent qualitative references to uncertainty and disruptions, strategies that improve perceived reliability may be more relevant than generic encouragement to "use public transport" (Alfaro et al., 2025a). Universities can contribute through coordination with operators (e.g., timetable alignment with class schedules) and student-oriented schemes where applicable. This approach is consistent with commuting research linking perceived control and reliability with stress appraisal (Chatterjee et al., 2020; Li et al., 2017; Wener & Evans, 2011).

A third implication concerns feasibility constraints shaped by housing and distance. Interviews rarely framed commuting mode as a fully open choice, and evidence suggests that housing markets and displacement affect both commuting distances and mobility options (Gregory, 2020; Schnake-Mahl et al., 2020). In this context, promoting active commuting can function more realistically as enabling partial shifts, including active travel to and from transit hubs, rather than assuming an all-or-nothing change to walking or cycling for the full trip (Ricchetti et al., 2025; Rodríguez-Rad et al., 2023).

Finally, the differentiated pattern across well-being indicators suggests that practical actions should not assume that all outcomes move in the same direction. The higher life satisfaction observed among active commuters was not mirrored by higher self-rated mental health. This supports initiatives that improve the everyday experience of active commuting, such as route safety and perceived acceptability, while also addressing barriers that make active travel

difficult on specific days, including time pressure, heavy loads, or adverse weather (Chatterjee et al., 2020; Martin et al., 2014; Palma-Leal et al., 2023).

From a longer-term perspective, commuting routines established during university years may extend into later roles, including work commuting and family-related travel, which makes campus-level action relevant beyond the student period, as these routines may extend into later mobility habits.

Limitations and Future Research

This study has key limitations that should be considered when interpreting these findings. First, the quantitative strand relied on a cross-sectional design, which limits causal inference and does not allow temporal ordering to be established. Associations between commuting mode and outcomes such as life satisfaction and commuting-related stress may partly reflect selection processes, including students with particular routines or constraints being more likely to rely on specific modes, e.g., female commuters tend to be more often harassed in daily transport environments than their male counterparts, and this can influence differential behavioral changes (Alfaro et al., 2025b; Soto et al., 2022).

Second, the regression model explained a modest proportion of variance in life satisfaction. This should be interpreted in light of the broad nature of life satisfaction, which is influenced by multiple domains beyond commuting, including academic demands, social relationships, housing conditions, economic resources, and personal circumstances (Diener et al., 1985; Pavot & Diener, 1993). Therefore, the regression model should be read as evidence of a limited but statistically detectable association between commuting mode and life satisfaction, rather than as a comprehensive explanatory model of student well-being.

Third, most variables were self-reported, including trip length, perceived health indicators, and BMI. This introduces recall and reporting biases, particularly for measures based on "typical" commuting patterns (Althubaiti, 2016; García-Bajos et al., 2018). When travel conditions vary across days, estimates of commuting time may rely on salient episodes rather than stable averages. Self-rated health indicators also depend on individual reference standards and interpretation, as systematically shown by studies addressing the so-called "health paradoxes" (see Whitmore et al., 2022), in which perceiving 'good health' despite a context of non-healthiness could be attributed to both attitudinal/perceptual distortions and the valuation of individual health outcomes. For this reason, future studies should consider complementing self-reported health with objective or multimethod indicators, including device-based physical activity measures, measured anthropometrics, or clinical and administrative health data where feasible.

Fourth, the study did not directly measure several structural and inequality-related factors that may influence both commuting mode and perceived well-being. Housing affordability, residential displacement, and unequal access to transport resources can affect travel distances and constrain feasible mode choices Orozco-Fontalvo et al. (2026), yet the quantitative data did not include detailed measures of socioeconomic position, housing precarity, or neighborhood opportunity structures. Given current urban dynamics affecting student residential patterns and near-campus change, omission of these variables may have contributed to residual confounding and heterogeneity within commuting groups (Schnake-Mahl et al., 2020; Revington et al., 2020; Revington, 2021).

Fifth, while the qualitative strand strengthened contextual interpretation, interviews remain vulnerable to underreporting, particularly for experiences perceived as uncomfortable or socially sensitive. Students may avoid discussing financial hardship, unsafe situations, harassment, or other stigmatized experiences. This limitation is consistent with research showing that omissions and selective reporting can occur even without deliberate deception, and that omitted information may affect the completeness of verbal accounts (Vrij et al., 2025). More broadly, memory-based reporting is not a simple retrieval process and may privilege central elements over peripheral details, with implications for what remains unreported in interview settings (Montes et al., 2024; Selaya et al., 2024). Interview conditions may also influence response quality, including factors related to cognitive load and interactional dynamics (Giorgianni et al., 2025). Although these studies are not specific to commuting, they support a cautious reading of qualitative accounts, particularly when topics are sensitive or socially regulated.

Future research would benefit from longitudinal designs examining changes in commuting practices and well-being over time, as well as from incorporating more detailed indicators of socioeconomic context, housing conditions, and neighborhood accessibility. Other multi-methods designs could also explore sensitive commuting experiences using approaches that may reduce social desirability pressures. Finally, combining self-reports with objective mobility measures, such GPS or app-supported estimation of travel time and route characteristics (Llopis et al., 2025), may reduce reliance on recall and provide a more precise representation of daily travel exposure.

Conclusions

This mixed-methods study examined whether commuting mode is associated with differentiated HRQoL-related profiles among university students. Results suggest that mode-related differences are not uniform across outcomes, with clearer contrasts for life satisfaction and commuting-related stress, and more mixed patterns for perceived health indicators. Specifically:

Regarding *Hypothesis 1*, active commuters reported higher life satisfaction than students relying on public transport or private motorized travel. However, self-rated physical health followed a different distribution, with public transport users reporting slightly higher physical health scores than active commuters. This contrast between an evaluative indicator of well-being and a global health appraisal is consistent with the idea that these measures do not necessarily move in parallel in daily life.

In relation to *Hypothesis 2*, commuting-related stress was higher among public transport users compared to both motorized and active commuters. The interview accounts provided a coherent background to this pattern, particularly through repeated references to variability in service conditions, disruptions, and day-to-day unpredictability.

With respect to *Hypothesis 3*, hierarchical regression results showed that active commuting remained positively associated with life satisfaction after adjustment for age, municipality size,

and commuting duration. Commuting stress did not add explanatory variance in the final step, whereas commuting duration showed a modest negative association with life satisfaction, which aligns with the relevance of time constraints repeatedly raised in the qualitative strand.

At a practical level, these findings support treating student mobility as a topic connected to HRQoL and daily well-being, rather than only a sustainability target. Measures that make active commuting more feasible within students' routines, while improving predictability and reducing friction in public transport commutes, appear consistent with the patterns observed across both strands of the study.

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