Revealed Preferences for Utilitarian Cycling Energy Expenditure versus Travel Time

SUPPLEMENTAL INFORMATION

Data processing

GPS data for utilitarian cycling trips (excluding "exercise" trip purpose) were obtained from a 2017 active travel survey in metropolitan Vancouver, Canada, involving 256 participants aged 14 and above who typically cycled at least once a week (Mohamed and Bigazzi 2019). A survey questionnaire included cycling preferences, behavior, and sociodemographic attributes. Participants recorded one week of active travel using a smartphone application with GPS-based location tracking at 1-second intervals. The GPS data were subsequently processed (Berjisian and Bigazzi 2022) and map-matched (Berjisian and Bigazzi 2023) onto a street network obtained from Open Street Maps (OSM) (OpenStreetMap Contributors. 2020). The network was augmented with detailed elevation data (Berjisian, Bigazzi, and Barkh 2023; El Masri and Bigazzi 2019) and cycling infrastructure types (Ferster et al. 2023). Road grade was calculated using elevation differences every 1 meter along the map-matched route, smoothed with a Savitzky-Golay algorithm with knots placed every 5 meters. Each GPS record was assigned a grade value based on its map-match projected location on the network link. Speed was calculated as the geodesic distance between consecutive GPS records divided by their time gap, smoothed with a kernel smoother with a bandwidth of 15 seconds.

Physical parameters for cyclists and their bicycles (which determine μ_1 and μ_3) were taken from a model calibrated on data collected during an intercept survey of the same local cycling population (Tengattini and Bigazzi 2018). Using those data, Ausri and Bigazzi (2024) found that gender, self-reported speed tertile, and bicycle motorization were the most important factors to characterize physical parameters in the cycling population. We applied the calibrated physical parameters to our dataset using the same three segmenting variables. Any sample differences in gender, bike type, or cycling speed tier are accounted for and would not impact the results, and any sample differences within these segments are not expected to substantially impact the physical parameters. A value of 0.058 for δ_1 was taken from Glass and Dwyer (2007), consistent with Bigazzi and Lindsey (2019). A limitation of the analysis is that this value does not differentiate the motor from human sources of motive power for the bicycle.

We considered three measures to aggregate records within cruising events: mean, median, and mode. Figure S.1 shows the distributions of mean, median, and mode MRS across cruising speed events, excluding outliers (with N of 8751, 8700, 8677 respectively). Figure S.2 shows the distributions of within-person standard deviation across persons for each of the three aggregation measures. We chose to aggregate records using the median value primarily because it is robust to outliers, and the calculated MRS is sensitive to inaccuracies in speed and grade. This is likely why the median results in less within-person variability than the mean value. Additionally, unlike the other measures, the median is specific to 1 or 2 records, allowing us to retrieve corresponding grade values for the event-level MRS, which is important for investigating relationships between MRS and grade.

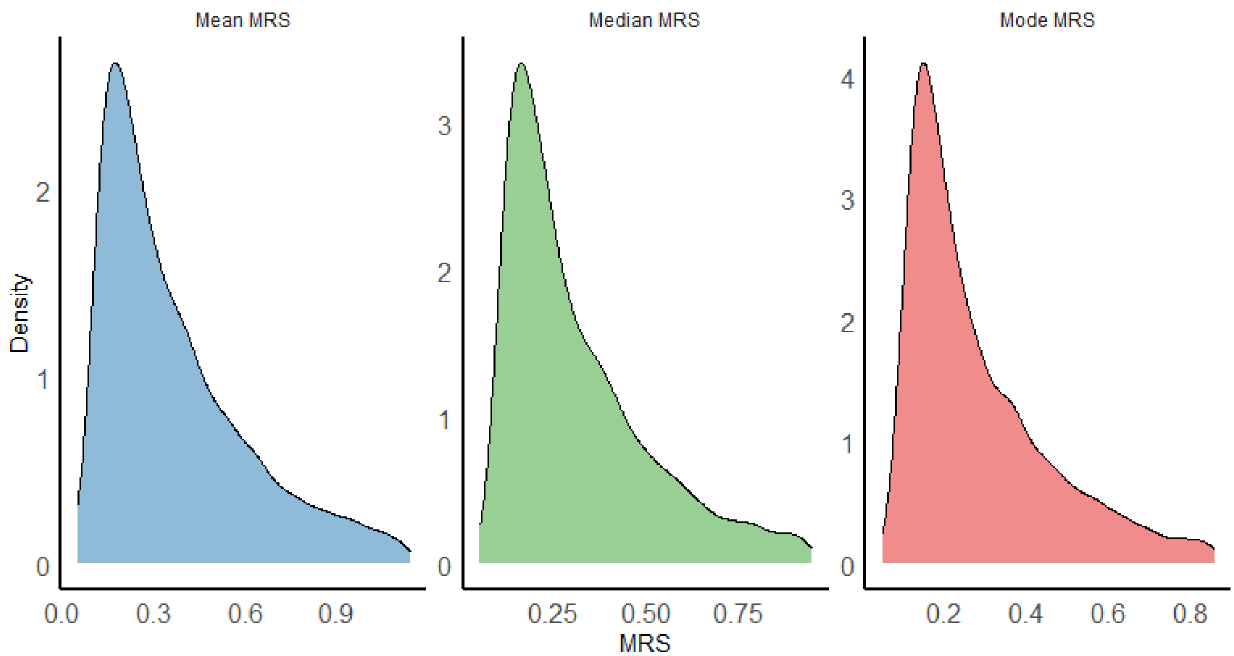

Figure S.1. Distributions of event-level MRS aggregated from records by mean, median, and mode

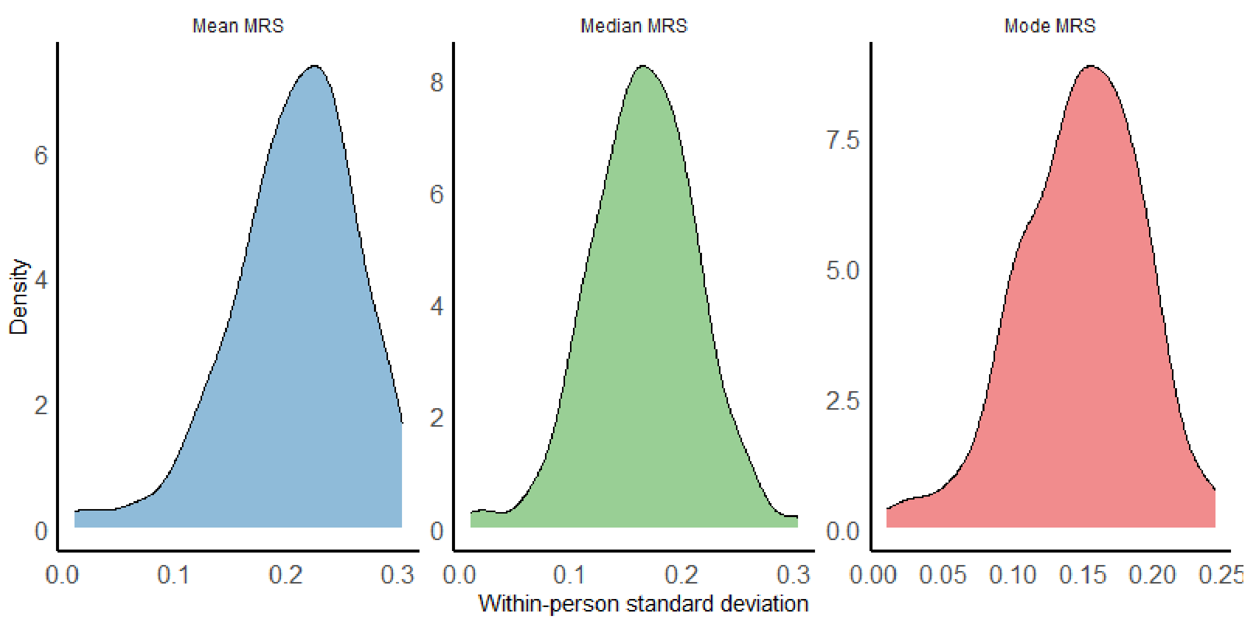

Figure S.2. Distributions of within-person variability (standard deviation) of event-level MRS aggregated from records by mean, median, and mode

MRS on the network summary results

The MRS on network links is illustrated in Figure S.3, with the median value shown for links with multiple MRS event observations.

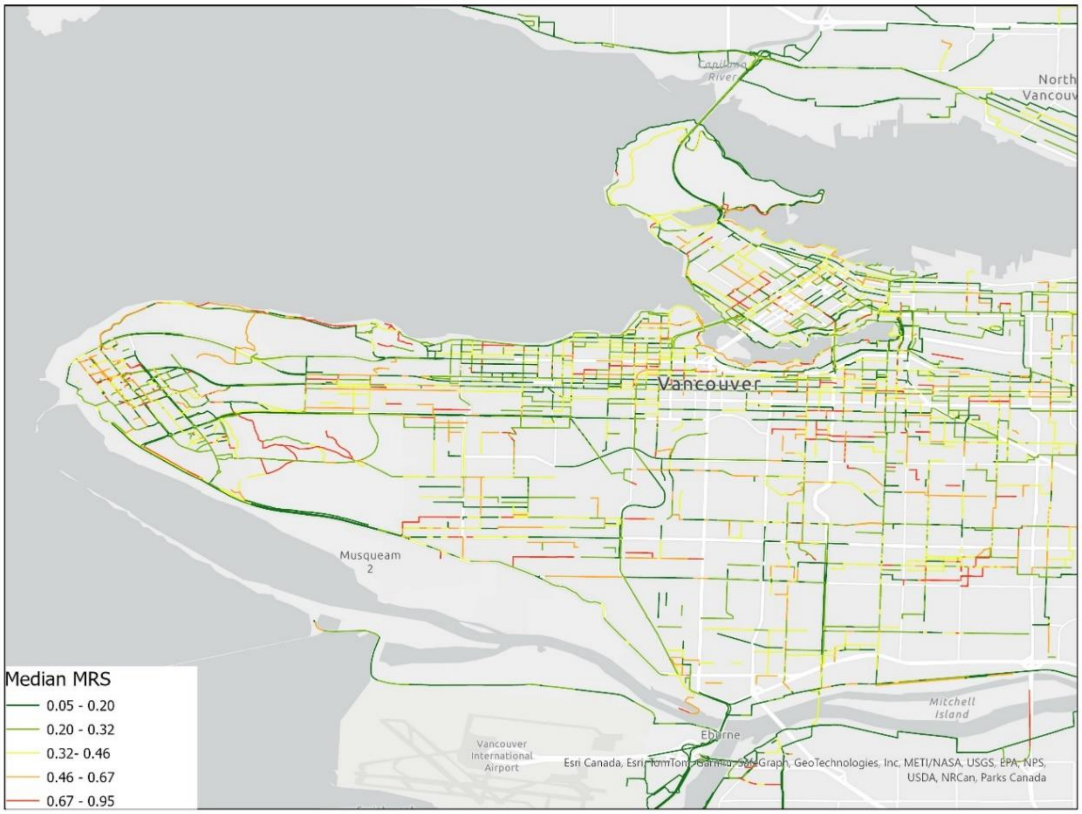

Figure S.3. Distribution of MRS_{et} within the street network

Trip-level model results

The 621,467 records with non-negative power and moderate speeds (2 to 7 m/s) were aggregated to 1620 unique trips using the median MRS_{et}. Of these, 110 were discarded as outliers, and another 47 were excluded due to missing survey data, leaving 1463 trips by 134 people used in regression analysis. The model specification process excluded event-level variables that did not apply to trips and only person-level random effects were included. Table S.1. gives the estimated model results for trip-level MRS_{et}.

Table S.1. Estimated mixed effects regression model of MRS_{et} for trips

Variable	Estimated parameter
Intercept	0.32
Cycling facility type (reference level: local street bikeway)	
Bike path	0.000257[a]
Cycle track	-0.000383[a]
Multi-use path	0.00057
Painted bike lane	-0.000233[a]
Non-conforming trail	0.00117
Non-conforming major road	-0.000241[a]
Non-conforming other	0.000258[a]
None	0.000115[a]
Road grade	1.34
Trip purpose (reference level: commute)	
Errand	0.0390
Leisure	0.0617
Other	0.00947[a]
E-bike	-0.0546
'Dedicated' cyclist type	-0.0628
Woman	0.0784
Household owns motor vehicle	-0.0463
Standard deviation for person-level random intercept	0.09
R^2 (marginal, conditional)	0.18, 0.48

[a] Not statistically significant at $p<0.05$ but retained as part of a categorical variable

Person-level model results

The 621,467 records with non-negative power and moderate speeds (2 to 7 m/s) were aggregated to 140 participants using the median MRS_{et}. Of these, 5 were excluded due to missing survey data, leaving 135 people used in regression analysis. The model specification process excluded event- and trip-level variables that did not apply to persons, and no random effects were included. Table S. gives the estimated model results for person-level MRS_{et}.

Table S.2. Estimated regression model of MRS_{et} for person

Variable	Estimated parameter
Intercept	0.46
'Dedicated' cyclist type	-0.1170
Woman	0.0908
Household owns motor vehicle	-0.1290
R^2 (adjusted)	0.16

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