Journal of Transport & Health 14 (2019) 100605

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Differences in life space area between older non-cyclists, conventional cyclists and e-bikers

Jelle Van Cauwenberg[a,b,*], Paul Schepers[c], Benedicte Deforche[a,d], Bas de Geus[e]

[a] Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium
[b] Fund for Scientific Research Flanders (FWO), Brussels, Belgium
[c] Department of Human Geography and Spatial Planning, Utrecht University, Netherlands
[d] Physical Activity, Nutrition and Health Research Unit, Department of Movement and Sports Sciences, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Brussels, Belgium
[e] Human Physiology Research Group, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Brussels, Belgium

ARTICLE INFO

Keywords:
Mobility
Pedelec
Physical activity
Active travel
Active ageing

ABSTRACT

Purpose: Conventional and electric bicycles (e-bikes) offer a non-polluting and physically-active alternative to cars to support older adults' access to different life spaces. We aimed to provide an initial exploration of the relationship between cycling status (non-cyclist, conventional cyclist or e-biker) and life space area. Additionally, we examined whether this was moderated by sex, functional health and car driving.

Methods: Cross-sectional survey data on socio-demographics, health characteristics, transport behavior and life space area were collected among 1,333 Dutch and Flemish older adults (≥65 years). Generalized linear models were used to examine the relationship between cycling status and life space area.

Results: After adjustment for socio-demographic, health and transport variables, conventional cyclists ($b = 1.40$, $SE = 0.29$, $p < 0.001$) and e-bikers ($b = 1.59$, $SE = 0.29$, $p < 0.001$) had larger life space areas compared to non-cyclists. The difference in life space area between conventional cyclists and e-bikers was non-significant ($b = 0.19$, $SE = 0.28$, $p = 0.49$). The relationship between cycling status and life space area was not significantly moderated by sex ($chi^2 = 0.82$, $p = 0.66$), functional health ($chi^2 = 1.61$, $p = 0.45$) and car driving ($chi^2 = 1.96$, $p = 0.38$).

Conclusion: Initiatives aimed at promoting conventional cycling as well as e-biking may offer an effective strategy to expand older adults' life space area. Future longitudinal and experimental research using objective assessments of life space area is warranted to examine the causal effects of conventional cycling and e-biking on life space area.

1. Introduction

Mobility is critical to active and healthy ageing (World Health Organization, 2015). Webber et al. (2010) conceptualized mobility as moving through different life spaces, ranging from one's bedroom to the world. To fulfil their mobility needs, older adults (≥65 years) heavily rely on private motorized transport (Haustein and Siren, 2014; Hjorthol, 2013), which raises concerns about air

* Corresponding author. Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium.
E-mail addresses: jelle.vancauwenberg@ugent.be (J. Van Cauwenberg), paul.schepers@rws.nl (P. Schepers), benedicte.deforche@ugent.be (B. Deforche), bas.de.geus@vub.be (B. de Geus).

https://doi.org/10.1016/j.jth.2019.100605
Received 20 December 2018; Received in revised form 25 June 2019; Accepted 25 July 2019

pollution, global warming and congestion (Rosenbloom, 2001). On the contrary, physically active alternatives such as walking and cycling are non-polluting and entail several well-documented health benefits (Bauman et al., 2016). Especially cycling may be a viable alternative for motorized transport since greater distances can be covered by cycling compared to walking. A study among Japanese rural older adults indeed showed cycling to be related to a higher engagement in social activities (Tsunoda et al., 2015). The authors hypothesized that cycling increases older adults' life space area, facilitating participation in social activities. However, perceived difficulty of reaching important destinations by bike was found to be unrelated to the fulfilment of mobility needs among Danish older adults' (Haustein and Siren, 2014). Cycling may be a non-polluting and healthy way to access different life spaces. However, research about cycling's impact on older adults' life space area is currently limited.

E-bikes, which are battery-driven bicycles equipped with a torque or velocity sensor that triggers supporting power only when the cyclist exerts power onto the pedals, are increasingly popular (Fishman and Cherry, 2015). In Belgium and the Netherlands, respectively 23.4% and 21.8% of all bikes sold are e-bikes (CONEBI, 2016) and they are particularly popular among older adults (Declercq et al., 2016). In Flanders (northern, Dutch-speaking region in Belgium), one quarter of all older adults' bike trips are performed by e-bike (Declercq et al., 2016). E-bikes are particularly popular among women and may facilitate maintenance of cycling among functionally limited older adults (Johnson and Rose, 2015; Van Cauwenberg, De Bourdeaudhuij, Clarys, de Geus and Deforche, 2018a). The electric assistance enables older adults to travel longer distances with similar or reduced efforts compared to riding a conventional bicycle. Despite this reduced effort, e-biking has been shown to be sufficiently intensive (i.e. at least moderate-intensity) to provide health benefits (Berntsen et al., 2017; Gojanovic et al., 2011; Sperlich et al., 2012). Furthermore, there is evidence indicating that using an e-bike versus a conventional bicycle is associated with increases in cycling frequency and distance among older adults (Haustein and Moller, 2016; Van Cauwenberg et al., 2018a; Van Cauwenberg, De Bourdeaudhuij, Clarys, de Geus and Deforche, 2018b).

The above suggests that e-bikes may enable older adults to expand their life space area, especially among subgroups who typically have smaller life space areas (women, those with poor functional health and those not driving a car) (Webber et al., 2010). We aimed to provide an initial exploration of the relationship between cycling status (non-cyclist, conventional cyclist or e-biker) and life space area among older adults. Additionally, we examined whether this relationship was moderated by sex, functional health and car driving. We hypothesized life space areas to be smallest among non-cyclists and largest among e-bikers. These differences were hypothesized to be larger among women, those with more functional limitations and those not driving a car.

2. Material and methods

2.1. Participant recruitment

This cross-sectional survey study is part of a larger research project for which we recruited adults aged ≥45 years in the Netherlands and Flanders (northern region in Belgium). In the Netherlands, participants were recruited through the panel of the National Foundation for the Elderly, which consists of older adults volunteering in research projects. From the 2232 invited panel members, 837 completed the paper or online version of the survey (response rate = 37.5%). In Flanders, participants from previous studies about older adults' mobility (reference blinded for peer review), who consented to participate in other studies were contacted by e-mail and asked to complete the online survey. Additionally, we asked 200 Flemish political, socio-cultural and leisure (senior) organizations to disseminate an information letter including a link to the online survey among their members. Forty organizations agreed to disseminate the information letter (response rate organizations = 20%) and in total 1226 Flemish adults completed the online survey. Data were collected from June to September 2017. The study was approved by the ethical committees of the responsible University Hospitals. For the current study adults aged under 65 years, institutionalized persons and those residing outside the Netherlands or Flanders were excluded.

2.2. Measures

Participants self-reported socio-demographics, health characteristics, transport behavior and life space area (see Table 1).

2.3. Analyses

Descriptive statistics were calculated in IBM SPSS Statistics 25. Differences according to cycling status were examined using Chi^2 tests and ANOVAs for categorical and continuous variables, respectively.

To examine the relationships of cycling status with life space area, generalized linear models were applied using the glm-function in R version 3.3.1. Based on Akaike's Information Criterion a model with gamma variance and identity link function was selected. First, twelve models were fitted to examine the unadjusted relationships of socio-demographics, health characteristics and transport behavior with life space area. Second, a fully-adjusted model was fitted including all variables that (1) differed according to cycling status (based on the Chi^2 tests and ANOVAs, see above) and (2) were significantly related to life space area in the unadjusted models. Absence of multicollinearity was ensured based on variance inflation factors. To examine the moderating effects of sex, functional health and car driving, interaction terms of these variables with cycling status were added to the model (in three separate models).

We performed two sensitivity analyses. First, we examined whether the results were influenced by examining four instead of three categories of cycling status (i.e., (1) non-cyclists, (2) conventional cyclists, (3) those only riding an e-bike and (4) those riding both an e-bike and a conventional bike). Second, since older adults with more than 12 years of education were overrepresented in our sample,

Table 1
Measures of socio-demographics, health characteristics, transport behavior and life space area.

Questions	Response options and coding	Recoding and additional information
Socio-demographics		
Age: How old are you?		
Sex: What is your sex?	Woman (0), Man (1)	
Education: How many years of education did you receive?	0 to 6, 7 to 9, 10 to 12 or more than 12 years	Recoded into 12 years or less (0) vs. more than 12 years (1)
Living situation: What is your living situation?	Living alone (0), Living together (1)	
Health Characteristics		
Self-rated health: In general, would you say your health is …	Excellent (5), Very good (4), Good (3), Fair (2), Poor (1)	RAND SF 36-questionnaire (Haywood et al., 2005; Ware et al., 1994)
Functional health: Does your health limit you during the following activities? Moderate activities (moving a table, vacuum cleaning, swimming or cycling)	No, not limited at all (100), Yes, limited a little (50), Yes, limited a lot (0)	Responses on both items were averaged (Haywood et al., 2005; Ware et al., 1994).
Climbing several flights of stairs		
BMI		BMI = (weight in kg)/(height in m)^2 and categorized into normal weight (< 25.0 kg/m^2), overweight (25.0-29.9 kg/m^2) or obese (≥ 30.0 kg/m^2) (World Health Organization, 2018).
What is your height?		
What is your weight?		
Transport behavior		
Car driver/car passenger/public transit user:		
Indicate the transport modes that you have used in the past year:		
Driver (car/motorbike)	Not (0) vs. driven a car in the past year (1)	
Passenger (car/motorbike)	Not (0) vs. been a passenger in the past year (1)	
Public transit	Not (0) vs. used public transit in the past year (1)	
Cycling status: Have you ridden any type of bicycle in the past year?	Yes, No	Coded into: non-cyclist (0), conventional cyclist (1) and e-biker (2).[a]
If yes on the previous question:		
Have you used an e-bike in the past year?	Yes, No	
Life space area		
During the past month, how frequently have you been to the following places: Places in your neighborhood	Never (1), Less than once/week (1), One to three times/week (2), Four to six times/ week (3), Daily (4)	Frequencies were multiplied by one, two and three for places in the neighborhood, outside the neighborhood and outside the village, town or city, respectively. To obtain an overall life space area score, these three products were summed (Baker et al., 2003). Scale range = 6–24.
Places outside your neighborhood (but within their village, town or city)		
Places outside your village, town or city		

[a] E-bikers could have ridden both a conventional bicycle and an e-bike. We have performed additional analyses in which e-bikers were divided into two groups; those only riding an e-bike versus those riding both an e-bike and a conventional bike (see Appendices A and B).

we performed a sensitivity analysis with probability weights based on education using the survey package in R (Lumley, 2018). Level of significance was determined at alpha = 0.05 for all analyses.

3. Results

3.1. Sample characteristics

The survey was completed by 2063 participants, 730 were excluded (631 were younger than 65 years, 7 were institutionalized, 7 did not reside in Flanders or the Netherlands and 85 had missing data on at least one variable), yielding a final analytic sample of 1,333 participants. Descriptive statistics are presented in Table 2. Our sample had a mean age of 73.5 ± 6.4 years, about half were women (51.7%), 65.0% had followed more than 12 years of education and 40.4% was living alone. More than one quarter (27.4%) had not driven a car in the past year. Almost one third (31.0%) had not cycled in the past year, 38.5% had ridden a conventional bicycle and 30.4% was an e-biker.

Significant differences according to cycling status were observed for all variables, except for having been a car passenger. Non-cyclists were older, had poorer self-rated and functional health and the smallest life space area. Non-cyclists also had the highest prevalence of women, Dutch participants, those living alone, obesity and the lowest prevalence of those with more than 12 years of education, car driving and public transit use. Conventional cyclists had the best functional health, the lowest prevalence of women and obesity and the highest prevalence of normal weight and public transit use. E-bike users had the highest prevalence of overweight.

Table 2
Characteristics of the total sample, non-cyclists, conventional cyclists and e-bikers.

	Total sample (n = 1333)	Non-cyclists (n = 414, 31.0%)	Conventional cyclists (n = 514, 38.5%)	E-bikers (n = 405, 30.4%)	Chi^2/F	p
Age (years, M ± SD)[d]	73.5 ± 6.4	76.6 ± 7.6[a]	72.3 ± 5.3[b]	72.0 ± 5.3[b]	58.0	< 0.001
Sex (% women)	51.7	64.0	40.5	53.3	51.5	< 0.001
Education (% more than 12 years)	65.0	57.2	70.0	66.4	17.0	< 0.001
Region (% The Netherlands)	51.4	64.0	45.9	45.4	38.3	< 0.001
Living situation (% living alone)	40.4	59.9	33.7	28.9	97.4	< 0.001
Self-rated health (/5, M ± SD)[e]	3.0 ± 0.8	2.6 ± 0.8[a]	3.2 ± 0.7[b]	3.1 ± 0.7[b]	67.3	< 0.001
Functional health (/100, M ± SD)[f]	71.1 ± 32.9	48.2 ± 36.9[a]	84.4 ± 22.7[b]	77.5 ± 26.9[c]	153.6	< 0.001
BMI (%)					49.1	< 0.001
Normal weight [g]	37.4	31.4	44.6	34.3		
Overweight	41.8	37.4	40.7	47.7		
Obese	20.9	31.2	14.8	18.0		
Car driver (% driven a car in the past year)	72.6	58.7	79.2	78.5	58.6	< 0.001
Car passenger (% been a passenger in the past year)	33.2	34.3	31.3	34.3	1.3	0.53
Public transit (% used public transit in the past year)	46.8	36.7	56.0	45.4	34.8	< 0.001
Life space area (M ± SD)[h]	12.6 ± 4.4	10.3 ± 3.9[a]	13.6 ± 4.2[b]	13.6 ± 4.4[b]	96.2	< 0.001

M = mean, SD = standard deviation, F = ANOVA F (to adjust for heterogeneous variances, the Welch test and Games-Howell post hoc analyses were used).

[a,b,c] Means with different superscript differ significantly from each other.

[d]Age range = 65–97 years.

[e]A higher score denotes better self-rated health.

[f]A higher score denotes better functional health.

[g]The 15 participants who were underweight (BMI < 18.5 kg/m^2) were classified as normal weight.

[h]A higher score denotes a greater life space area (range = 6.0-24.0).

3.2. Relationships of cycling status with life space area

In the unadjusted models, all socio-demographic, health and transport variables were significantly related to life space area, except for having been a car passenger (see Table 3). Life space areas were significantly larger for younger participants, men, those with more 12 years of education, Flemish participants, those not living alone, those with better self-rated and functional health, those with normal weight, car drivers and public transit users. Conventional cyclists (b = 3.32, SE = 0.26, $p < 0.001$) and e-bikers (b = 3.23, SE = 0.28, $p < 0.001$) had significantly larger life space areas compared to non-cyclists.

In the fully-adjusted model, the differences based on cycling status were attenuated, but remained statistically significant. Conventional cyclists (b = 1.40, SE = 0.29, $p < 0.001$) and e-bikers (b = 1.59, SE = 0.29, $p < 0.001$) had significantly larger life space areas compared to non-cyclists. The difference in life space area between conventional cyclists and e-bikers was non-significant (b = 0.19, SE = 0.28, p = 0.49). The interaction effects of cycling status with sex (chi^2 = 0.82, p = 0.66), functional health (chi^2 = 1.61, p = 0.45) and car driving (chi^2 = 1.96, p = 0.38) were non-significant.

The sensitivity analyses yielded similar results (see Appendices A, B and C).

4. Discussion

The current study examined the relationship between cycling status and life space area. Life space areas were smaller among non-cyclists compared to conventional cyclists and e-bikers. This suggests that initiatives aiming to extend older adults' life on a conventional bicycle or e-bike may benefit older adults' life space area. Given that destinations that are located further away can be reached with similar or reduced efforts by riding an e-bike compared to conventional bike, e-bikers were hypothesized to have a larger life space area than conventional cyclists. However, we observed no differences in life space area between conventional cyclists and e-bikers. This may imply that e-bikes do not generate more or longer trips, but rather replace trips that conventional cyclists perform by other transport modes. E-bikes have been shown to substitute older adults’ car as well as conventional bicycle trips (Johnson and Rose, 2015). Among Flemish older e-bikers, 24% also reported to make trips by e-bike that they did not make before e-bike purchase (Van Cauwenberg et al., 2018b). Current findings suggest that these new trips are not sufficient to result in a larger life space area than conventional cyclists. These new trips may also be compensated for by reductions in trips by other transport modes (e.g. by walking or car). More research into the substitution effects of e-bikes and possible compensatory effects is required.

The relationship between cycling status and life space area was not moderated by gender, functional health or car driving. This implies that continuing or taking up conventional cycling or e-biking may have similar benefits on older adults’ life space across gender, functional health and car driving status. It should be noted that, in comparison to conventional cyclists, e-bikers were more likely to be women, to have poorer functional health and to be overweight or obese. These are all risk groups for low levels of conventional cycling and restricted life spaces (Van Cauwenberg et al., 2012; Webber et al., 2010). Apparently, e-bikes particularly

Table 3
Unadjusted and adjusted relationships of cycling status with life space area (n = 1333).

	Unadjusted models			Fully-adjusted model[a]		
	b	SE	p	b	SE	p
Intercept[b]				11.65	1.44	
Age	-0.17	0.02	< 0.001	-0.07	0.02	< 0.001
Sex (ref. = women)	0.70	0.24	< 0.01	-0.13	0.23	0.57
Education (ref. = 12 years or less)	1.61	0.24	< 0.001	0.63	0.22	< 0.01
Region (ref. = Flanders)	-1.53	0.24	< 0.001	0.14	0.25	0.58
Living situation (ref. = living alone)	1.66	0.24	< 0.001	0.26	0.24	0.29
Self-rated health[c]	2.11	0.14	< 0.001	0.87	0.17	< 0.001
Functional health[d]	0.06	0.003	< 0.001	0.02	0.004	< 0.001
BMI (ref. = normal weight)						
Overweight[e]	-0.53	0.28	0.06	-0.20	0.24	0.41
Obese	-1.89	0.31	< 0.001	-0.67	0.28	0.02
Car driver (ref. = not driven a car in the past year)	1.69	0.25	< 0.001	0.44	0.24	0.06
Car passenger (ref. = not been a passenger in the past year)[f]	0.34	0.25	0.19			
Public transit (ref. = not used public transit in the past year)	0.89	0.24	< 0.001	0.13	0.22	0.57
Cycling status (ref. = non-cyclist)						
Conventional cyclist[g]	3.32	0.26	< 0.001	1.40	0.29	< 0.001
E-biker	3.23	0.28	< 0.001	1.59	0.29	< 0.001

Life space area is expressed on a scale from 6-24 with higher scores denoting greater life space areas.
b = regression estimate from a generalized linear model with gamma variance function and identity link function, these estimates can be interpreted as the difference in life space area related to a one-unit difference in the predictor variable; SE = standard error; ref. = reference category.

[a] The fully adjusted model included all variables that (1) differed according to cycling status (based on the Chi^2 tests and ANOVAs, see above) and (2) were significantly related to life space area in the unadjusted models.

[b] There were 12 unadjusted models with 12 different intercepts, therefore no intercept is presented for the unadjusted models.

[c] A higher score denotes better self-rated health (/5).

[d] A higher score denotes better functional health (/100).

[e] The difference in life space area between overweight and obese participants was non-significant (b = −0.48, SE = 0.26, p = 0.07, results from the fully adjusted model).

[f] Car passenger was not included in the fully-adjusted model since it was not significantly related to life space area.

[g] The difference in life space area between conventional cyclists and e-bikers was non-significant (b = 0.19, SE = 0.28, p = 0.49, results from the fully adjusted model).

appeal to these subgroups and may enable these subgroups to maintain a life space area similar to that of conventional cyclists.

While conventional cycling and e-biking may provide health and mobility benefits for older adults, it should be acknowledged that older adults are overrepresented in bicycle, and especially in e-bike, crash and (severe) injury statistics (Schepers, Fishman, den Hertog, Wolt and Schwab, 2014). Furthermore, we found non-cyclists to have poorer self-rated and functional health compared to conventional cyclists and e-bikers. This suggests that they may perceive conventional cycling and e-biking as too difficult and unsafe. Conventional and electric tricycles may offer a solution to promote cycling and mobility among less fit older adults. Overcoming the negative stereotypes about tricycles may be a first challenge when aiming to stimulate their use (Krause et al., 2013).

This was the first study examining cycling status in relationship to life space area. It included a large sample recruited in two regions. However, recruitment strategies in Flanders and The Netherlands differed. To address this, the analyses were adjusted for region. In addition, we have examined the interaction effect of cycling status with region and this was non-significant (data not shown). Given the online recruitment in Flanders, we could not calculate an overall response rate. The included sample was highly educated; 64.9% had received more than 12 years of education while the population prevalence is only 22.5% and 15.2% in Flanders and The Netherlands, respectively. However, the sensitivity analyses weighted based on education yielded similar results. We examined car driving as a potential moderator and not car access. However, we did run additional analyses in which being a car driver and passenger was combined into one variable and this combined variable also did not significantly interact with cycling status (data not shown). Given that The Netherlands and Flanders have a strong cycling culture and a well-developed cycling infrastructure (Buehler and Pucher, 2012; de Geus et al., 2014), the generalizability of our findings may be limited. The study relied on self-report measures for which the assessment period of transport behaviours (i.e. last year) and life space area (i.e. last month) differed. Because of these limitations, this study should be considered an initial exploration of the relationship between cycling status and life space area. Future studies could combine transport behaviours obtained from travel diaries with simultaneously and objectively assessed life space areas obtained from gps tracking. Studies could also use the VERITAS-tool, which enables to simultaneously collect information about participants' trips, transport modes and life space area (Chaix et al., 2012). Lastly, longitudinal and experimental studies are necessary to examine the causal effects of cycling status on older adults' life space area.

To conclude, initiatives aimed at promoting conventional cycling as well as e-biking may offer an effective strategy to expand older adults' life space area. E-biking may particularly appeal to subgroups at risk for restricted life spaces.

Funding

This work was supported by a Postdoctoral Fellowship of the Research Foundation Flanders (FWO, 12I1117N) to JVC.

Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2019.100605.

Appendix A. Characteristics of the total sample, non-cyclists, conventional cyclists, e-bikers and those using both an e-bike and a conventional bike

	Total sample (n = 1333)	Non-cyclists (n = 414, 31.0%)	Conventional cyclists (n = 514, 38.5%)	E-bikers (n = 189, 14.2%)	E-bike + conventional bike (n = 216, 16.2%)	Chi^2/F	p
Age (years, M ± SD)[d]	73.5 ± 6.4	76.6 ± 7.6[a]	72.3 ± 5.3[b]	72.0 ± 5.2[b]	72.0 ± 5.4[b]	38.6	< 0.001
Sex (% women)	51.7	64.0	40.5	59.8	47.7	57.4	< 0.001
Education (% more than 12 years)	65.0	57.2	70.0	67.7	65.3	17.3	0.001
Region (% The Netherlands)	51.4	64.0	45.9	43.9	46.8	38.6	< 0.001
Living situation (% living alone)	40.4	59.9	33.7	32.3	25.9	99.1	< 0.001
Self-rated health (/5, M ± SD)[e]	3.0 ± 0.8	2.6 ± 0.8[a]	3.2 ± 0.7[b]	3.0 ± 0.7[b]	3.1 ± 0.7[b]	45.3	< 0.001
Functional health (/100, M ± SD)[f]	71.1 ± 32.9	48.2 ± 36.9[a]	84.4 ± 22.7[b]	77.5 ± 26.5[c]	77.5 ± 27.3[c]	102.2	< 0.001
BMI (%)						54.3	< 0.001
Normal weight [g]	37.4	31.4	44.6	28.6	39.4		
Overweight	41.8	37.4	40.7	50.8	44.9		
Obese	20.9	31.2	14.8	20.6	15.7		
Car driver (% driven a car in the past year)	72.6	58.7	79.2	81.0	76.4	59.6	< 0.001
Car passenger (% been a passenger in the past year)	33.2	34.3	31.3	36.5	32.4	2.0	0.57
Public transit (% used public transit in the past year)	46.8	36.7	56.0	46.6	44.4	35.0	< 0.001
Life space area (M ± SD)[h]	12.6 ± 4.4	10.3 ± 3.9[a]	13.6 ± 4.2[b]	13.1 ± 4.4[b]	13.9 ± 4.3[b]	65.3	< 0.001

M = mean, SD = standard deviation, F = ANOVA F (to adjust for heterogeneous variances, the Welch test and Games-Howell post hoc analyses were used).

[a,b,c] Means with different superscript differ significantly from each other.

[d] Age range = 65–97 years.

[e] A higher score denotes better self-rated health.

[f] A higher score denotes better functional health.

[g] The 15 participants who were underweight (BMI $< 18.5\,kg/m^2$) were classified as normal weight.

[h] A higher score denotes a greater life space area (range = 6.0-24.0).

Appendix B. Unadjusted and adjusted relationships of cycling status (4 categories) with life space area (n = 1333)

	Unadjusted models			Fully-adjusted model[a]		
	b	SE	p	b	SE	p
Intercept[b]				11.65	1.44	
Age	-0.17	0.02	< 0.001	-0.07	0.02	< 0.001
Sex (ref. = women)	0.70	0.24	< 0.01	0.14	0.23	0.53
Education (ref. = 12 years or less)	1.61	0.24	< 0.001	0.64	0.22	0.004
Region (ref. = Flanders)	-1.53	0.24	< 0.001	0.10	0.25	0.67
Living situation (ref. = living alone)	1.66	0.24	< 0.001	0.24	0.24	0.32
Self-rated health[c]	2.11	0.14	< 0.001	0.85	0.17	< 0.001
Functional health[d]	0.06	0.003	< 0.001	0.02	0.004	< 0.001
BMI (ref. = normal weight)						
Overweight[e]	-0.53	0.28	0.06	-0.17	0.24	0.47
Obese	-1.89	0.31	< 0.001	-0.64	0.28	0.02
Car driver (ref. = not driven a car in the past year)	1.69	0.25	< 0.001	0.44	0.24	0.07
Car passenger (ref. = not been a passenger in the past year)[f]	0.34	0.25	0.19			
Public transit (ref. = not used public transit in the past year)	0.89	0.24	< 0.001	0.12	0.22	0.60

Cycling status (ref. = non-cyclist)						
Conventional cyclist[g]	3.32	0.26	< 0.001	1.41	0.29	< 0.001
E-biker	2.81	0.36	< 0.001	1.26	0.35	< 0.001
E-bike + conventional bike	3.60	0.36	< 0.001	1.90	0.36	< 0.001

Life space area is expressed on a scale from 6-24 with higher scores denoting greater life space areas.
b = regression estimate from a generalized linear model with gamma variance function and identity link function, these estimates can be interpreted as the difference in life space area related to a one-unit difference in the predictor variable; SE = standard error; ref. = reference category.
[a] The fully adjusted model included all variables that (1) differed according to cycling status (based on the Chi^2 tests and ANOVAs, see above) and (2) were significantly related to life space area in the unadjusted models.
[b] There were 12 unadjusted models with 12 different intercepts, therefore no intercept is presented for the unadjusted models.
[c] A higher score denotes better self-rated health (/5).
[d] A higher score denotes better functional health (/100).
[e] The difference in life space area between overweight and obese participants was non-significant (b = −0.46, SE = 0.26, p = 0.08, results from the fully adjusted model).
[f] Car passenger was not included in the fully-adjusted model since it was not significantly related to life space area.
[g] The difference in life space area between e-bikers and those using both an e-bike and conventional bike was non-significant (b = 0.64, SE = 0.41, p = 0.12, results from the fully adjusted model).

Appendix C. Relationships of cycling status with life space area adjusted for socio-demographics, health characteristics and transport behaviour weighted based on education (n = 1333)

	Unadjusted models			Fully-adjusted model[a]		
	b	SE	p	b	SE	p
Intercept[b]				12.29	2.01	
Age	-0.19	0.02	< 0.001	-0.06	0.02	0.01
Sex (ref. = women)	1.00	0.36	< 0.01	0.12	0.33	0.72
Education (ref. = 12 years or less)	1.16	0.26	< 0.001	0.51	0.24	0.03
Region (ref. = Flanders)	-2.27	0.35	< 0.001	-0.51	0.37	0.18
Living situation (ref. = living alone)	2.02	0.34	< 0.001	0.33	0.33	0.33
Self-rated health[c]	2.11	0.20	< 0.001	0.65	0.23	0.01
Functional health[d]	0.06	0.004	< 0.001	0.02	0.01	< 0.001
BMI (ref. = normal weight)						
Overweight[e]	-0.65	0.40	0.11	-0.34	0.33	0.31
Obese	-2.23	0.46	< 0.001	-0.82	0.39	0.04
Car driver (ref. = not driven a car in the past year)	1.71	0.38	< 0.001	0.25	0.32	0.44
Car passenger (ref. = not been a passenger in the past year)[f]	-0.34	0.38	0.37			
Public transit (ref. = not used public transit in the past year)	0.95	0.36	0.01	0.14	0.33	0.67
Cycling status (ref. = non-cyclist)						
Conventional cyclist[g]	3.44	0.40	< 0.001	1.32	0.44	< 0.01
E-biker	3.48	0.40	< 0.001	1.81	0.42	< 0.001

Life space area is expressed on a scale from 6-24 with higher scores denoting greater life space areas.
b = regression estimate from a generalized linear model with gamma variance function and identity link function, these estimates can be interpreted as the difference in life space area related to a one-unit difference in the predictor variable; SE = standard error; ref. = reference category.
[a] The fully adjusted model included all variables that (1) differed according to cycling status (based on the Chi^2 tests and ANOVAs, see above) and (2) were significantly related to life space area in the unadjusted models.
[b] There were 12 unadjusted models with 12 different intercepts, therefore no intercept is presented for the unadjusted models.
[c] A higher score denotes better self-rated health (/5).
[d] A higher score denotes better functional health (/100).
[e] The difference in life space area between overweight and obese participants was non-significant (b = −0.48, SE = 0.37, p = 0.20, results from the fully adjusted model).
[f] Car passenger was not included in the fully-adjusted model since it was not significantly related to life space area.
[g] The difference in life space area between conventional cyclists and e-bikers was non-significant (b = 0.50, SE = 0.42, p = 0.23, results from the fully adjusted model).

References

Baker, P.S., Bodner, E.V., Allman, R.M., 2003. Measuring life-space mobility in community-dwelling older adults. J. Am. Geriatr. Soc. 51 (11), 1610–1614. https://doi.org/10.1046/j.1532-5415.2003.51512.x.

Bauman, A., Merom, D., Bull, F.C., Buchner, D.M., Singh, M.A.F., 2016. Updating the evidence for physical activity: summative reviews of the epidemiological evidence, prevalence, and interventions to promote "active aging. Gerontol. 56, S268–S280. https://doi.org/10.1093/geront/gnw031.

Berntsen, S., Malnes, L., Langaker, A., Bere, E., 2017. Physical activity when riding an electric assisted bicycle. Int. J. Behav. Nutr. Phys. Act. 14. https://doi.org/10.1186/s12966-017-0513-z.

Buehler, R., Pucher, J., 2012. Walking and cycling in western europe and the United States. TR News 280, 34–42.

CONEBI, 2016. European Bicycle Market 2016 Edition - Industry & Market Profile (2015 Statistics). Brussels, Belgium. https://issuu.com/conebi/docs/european_

bicyle_industry_and_market.
Chaix, B., Kestens, Y., Perchoux, C., Karusisi, N., Merlo, J., Labadi, K., 2012. An interactive mapping tool to assess individual mobility patterns in neighborhood studies. Am. J. Prev. Med. 43 (4), 440–450.
de Geus, B., Degraeuwe, B., Vandenbulcke, G., Panis, L.I., Thomas, I., Aertsens, J., ... Meeusen, R., 2014. Utilitarian cycling in Belgium: a cross-sectional study in a sample of regular cyclists. J. Phys. Act. Health 11 (5), 884–894. https://doi.org/10.1123/jpah.2012-0200.
Declercq, K., Reumers, S., Polders, E., Janssens, D., Wets, G., 2016. Onderzoek Verplaatsingsgedrag Vlaanderen 5.1 (2015-2016): Tabellenrapport.
Fishman, E., Cherry, C., 2015. E-bikes in the mainstream: reviewing a decade of research. Transp. Rev. 36, 72–91.
Gojanovic, B., Welker, J., Iglesias, K., Daucourt, C., Gremion, G., 2011. Electric bicycles as a new active transportation modality to promote health. Med. Sci. Sport. Exerc. 43 (11), 2204–2210. https://doi.org/10.1249/MSS.0b013e31821cbdc8.
Haustein, S., Moller, M., 2016. Age and attitude: changes in cycling patterns of different e-bike user segments. Int. J. Sustain. Transport. 10 (9), 836–846. https://doi.org/10.1080/15568318.2016.1162881.
Haustein, S., Siren, A., 2014. Seniors' unmet mobility needs - how important is a driving licence? J. Transp. Geogr. 41, 45–52. https://doi.org/10.1016/j.jtrangeo.2014.08.001.
Haywood, K.L., Garratt, A.M., Fitzpatrick, R., 2005. Quality of life in older people: a structured review of generic self-assessed health instruments. Qual. Life Res. 14 (7), 1651–1668. https://doi.org/10.1007/s11136-005-1743-0.
Hjorthol, R., 2013. Transport resources, mobility and unmet transport needs in old age. Ageing Soc. 33, 1190–1211. https://doi.org/10.1017/s0144686x12000517.
Johnson, M., Rose, G., 2015. Extending life on the bike: electric bike use by older Australians. J. Transp. Health 2 (2), 276–283. https://doi.org/10.1016/j.jth.2015.03.001.
Krause, J., Hagemeister, C., Bunte, H., 2013. Why don't they go by trike? Image of and attitudes towards tricycles for (older) adults. In: Paper Presented at the International Cycling Safety Conference 2013 Helmond, The Netherlands.
Lumley, T., 2018. Package 'survey': Analysis of Complex Survey Samples. Retrieved from. http://r-survey.r-forge.r-project.org/survey/.
Rosenbloom, S., 2001. Sustainability and automobility among the elderly: an international assessment. Transportation 28 (4), 375–408. https://doi.org/10.1023/a:1011802707259.
Schepers, J.P., Fishman, E., den Hertog, P., Wolt, K.K., Schwab, A.L., 2014. The safety of electrically assisted bicycles compared to classic bicycles. Accid. Anal. Prev. 73, 174–180. https://doi.org/10.1016/j.aap.2014.09.010.
Sperlich, B., Zinner, C., Hebert-Losier, K., Born, D.P., Holmberg, H.C., 2012. Biomechanical, cardiorespiratory, metabolic and perceived responses to electrically assisted cycling. Eur. J. Appl. Physiol. 112 (12), 4015–4025. https://doi.org/10.1007/s00421-012-2382-0.
Tsunoda, K., Kitano, N., Kai, Y., Tsuji, T., Soma, Y., Jindo, T., ... Okura, T., 2015. Transportation mode usage and physical, mental and social functions in older Japanese adults. J. Transp. Health 2 (1), 44–49. https://doi.org/10.1016/j.jth.2014.10.003.
Van Cauwenberg, J., Clarys, P., De Bourdeaudhuij, I., Van Holle, V., Verte, D., De Witte, N., ... Deforche, B., 2012. Physical environmental factors related to walking and cycling in older adults: the Belgian aging studies. BMC Public Health 12 14210.1186/1471-2458-12-142.
Van Cauwenberg, J., De Bourdeaudhuij, I., Clarys, P., de Geus, B., Deforche, B., 2018a. E-bike use among older adults: relationships with demographics, health, access to motorized transport and cycling levels. Med. Sci. Sport. Exerc. 50 (9), 1780–1789. https://doi.org/10.1249/MSS.0000000000001638.
Van Cauwenberg, J., De Bourdeaudhuij, I., Clarys, P., de Geus, B., Deforche, B., 2018b. E-bikes Among Older Adults: Benefits, Barriers, Usage and Crash Characteristics *Transportation*. pp. 1–22. https://doi.org/10.1007/s11116-018-9919-y.
Ware, J.E., Kosinski, M., Keller, S.D., 1994. SF-36 Physical and Mental Health Summary Scales: a User Manual and Interpretation Guide. The Health Institute, New England Medical Center, Boston.
Webber, S.C., Porter, M.M., Menec, V.H., 2010. Mobility in older adults: a comprehensive framework. Gerontol. 50 (4), 443–450. https://doi.org/10.1093/geront/gnq013.
World Health Organization, 2015. World Report on Ageing and Health. Geneva, Switzerland. http://apps.who.int/iris/bitstream/10665/186463/1/9789240694811_eng.pdf?ua=1.
World Health Organization, 2018. Global Data Base on Body Mass Index. Geneva, Switzerland. http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.