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European cyclists' travel behavior: Differences and similarities between seven European (PASTA) cities

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ABSTRACT

While the annual number of trips of the average urban inhabitant has grown steadily in recent years, people are becoming less active while doing so. This lack of physical activity causes major health problems for individuals and great economic costs for society as a whole. Replacing short motorized trips by walking and cycling has been shown to increase physical activity in everyday life.

The PASTA “Physical Activity through Sustainable Transport Approaches” project collected data in a longitudinal web-based survey with a cohort design to study the effects of active mobility on overall physical activity and health. An opportunistic sampling approach focusing on cyclists was applied to recruit more than 10000 participants in seven European cities, with half of them completing valid 1-day travel diaries at various time points.

For this study, we compared ‘cyclists’ and ‘non-cyclists’ in terms of their overall travel behavior, physical activity and health. More than 2400 participants were identified as regular cyclists, 90% of which reached at least 30 min of active travel per day (the WHO´s recommended level) only by routine trips. When compared to non-cyclists, the share of women cycling regularly was lower; however, the share of people who had a driver's license and had at least sometimes access to a car was higher for regular cyclists. There were significant differences between cities in terms of cycling mode share, trip rates, trip duration and length, trip purpose and total physical activity, reflecting different geographical, economic, climatic and socio-cultural contexts.

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Our results indicate that cycling as a means of transport can help reach the WHO's physical activity recommendations.

1. Introduction

Levels of physical activity have been decreasing in the past decades (EC, 2014), making physical inactivity one of the leading risk factors for mortality worldwide (Forouzanfar et al., 2015, WHO, 2009). Lee et al. (2012) demonstrated that physical inactivity may cause 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes and 9% of premature mortality. Several studies show that only one third of the European population meets the minimum recommended level of physical activity, which for adults is at least 150 min of moderate-intensity physical activity per week, or e.g. 30 min of moderate-intensity physical activity 5 times a week (Hallal et al., 2012, WHO, 2015, WHO, 2007).

The number of trips done by active modes like walking and cycling has decreased in the past four decades in the United States and Western Europe (Buehler and Pucher, 2012). At the same time continuing expansions of road and highway infrastructure as well as increasing motor vehicle sales and ownership have resulted in increasing motor vehicle volumes (Sperling and Gordan, 2008). Within cities this development coincided with a number of well-known problems such as traffic congestion, air pollution, traffic noise, space consumption by cars and traffic safety issues. However, in some European cities the peak of car driver trips may have been reached (Wittwer et al., 2017), while most cities are well below what is possible in terms of cycling mode share (Mueller et al., 2018).

Reducing sedentary behavior and increasing physical activity are key approaches to address non-communicable diseases (EC, 2007b). Active mobility (walking and cycling for transport, solely or in combination with public transport) is a promising approach to bring physical activity into everyday life while also meeting transport and urban planning goals. Active mobility has shown to have the potential to increase physical activity as it is a convenient mode of transport, is economically affordable and requires less motivation compared to sports or other recreational physical activities (Götschi et al., 2015). It can also reach parts of the population that cannot afford or that are less receptive to sports or exercise in terms of finance or time (De Geus et al., 2008, Sahlqvist et al., 2012, Götschi et al., 2015). The barrier for active mobility is arguably lower for people with a low baseline level of physical activity (e.g. office workers, obese, elderly) when compared to participating in sports or other vigorous physical activity (Warburton et al., 2006). An important component of Sustainable Urban Mobility Plans (SUMP) is a shift towards more sustainable modes of urban mobility (EC, 2013, Wefering et al., 2014). This is also one of the key goals of EU policy and strategy (EC, 2007a, EC, 2011). A shift from individual motorized transport to more active and sustainable modes contributes to improved quality of urban life (Jones, 2009, Woodcock et al., 2009, Wee et al., 2013, Brand et al., 2013) by reducing infrastructure and space requirements and reducing energy use, air pollution and noise.

Despite similar goals and the potential benefit cooperation between transport and health is poor, both in research and practice (Sallis et al., 2004). This paper brings together both fields and translates information crucial for transport planning (actual travel behavior collected by travel diaries) into physical activity an important indicator for public health. It also affords the unique opportunity to explore the similarities and differences in sociodemographic characteristics, travel behavior and physical activity of ‘cyclists’ and ‘non-cyclists’ in seven European Cities. By revealing the share of participants reaching the recommended level of physical activity only by their daily travel, it contributes to the growing evidence on active travel prevalence and potential for change in the European context.

2. Methods

The data was collected between November 2014 (April 2015 in Örebro) and October 2017 under the auspices of the “Physical Activity through Sustainable Transport Approaches” (PASTA) project, funded by the EC under FP7-HEALTH-2013-INNOVATION-1. A longitudinal web-based survey was carried out within the adult population in seven European cities: Antwerp, Barcelona, London, Örebro, Rome, Vienna and Zurich (Dons et al., 2015). The cities covered the geographical areas of Northern, Central and Southern Europe, and were selected to provide a good representativeness of urban environments (size, density, region, culture…). All seven cities have in common that they have the ambition to increase the levels of active mobility in their city within the next years (Wegener et al., 2017). Participants had to be 18 years or older (16 years in Zurich).

An opportunistic sampling approach was used in all cities following a standardized recruitment strategy. During the recruitment process it became apparent that the different recruitment approaches worked differently in the cities so the actual strategies in the cities gradually diverged (Gaupp-Berghausen et al., 2017). For example, in Barcelona more effort was put into street recruitment compared to the other cities, while the only city that partly used random sampling was Örebro. Although the common recruitment strategy was applied slightly differently in the individual cities, similar biases occurred. Whereas study participants in almost all cities were broadly representative in terms of gender, participants in the sample were higher educated and younger compared to the general population.

The selected cities were very different in modal split (share of trips per transport mode). While cycling is very common in Antwerp and Örebro (20% and 24%, respective cycling share), it is hardly present in Barcelona and Rome (2% and 1% cycling share, respectively). To draw conclusions for cyclists it was necessary to oversample cyclists, especially in cities with a small cycling share.

A comprehensive baseline questionnaire collected, among other things, information on sociodemographic characteristics, travel behavior (frequency of use for different transport modes), physical activity level (global physical activity questionnaire - GPAQ), geolocations (home, work, education), commute route and attitudinal and behavioral aspects. A 1-day travel diary collected information on actual trips done on the previous day in detail. Thirteen days after completion of each questionnaire follow-up questionnaires were sent (i.e. FU short) where every third of these follow-up questionnaires also included a 1-day travel diary (i.e. FU long) (Fig. 1).

In the travel diary, participants were asked to report each trip they did the day before and indicate start time, origin, transport mode, trip purpose, destination, end time and duration. The travel diary used is based on the well-established KONTIV-Design (Socialdata, 2009) with some adaptations to be filled in online (see Supplementary Figure S1). For the analyses, total trip duration was calculated as the difference between start and end time, while trip distance was obtained retrospectively feeding origin and destination coordinates to the Google Maps application programming interfaces (API), which returned the fastest route per mode between origin and destination. Because of this design, it was impossible to retrieve information for roundtrips having the same origin and destination. In PASTA, active mobility is defined as: “All regular physical activity undertaken as a means of transport. It includes travel by foot, bicycle and other vehicles which require physical effort. Use of public transport is also included in the definition as it often involves some walking or cycling to pick-up and from drop-off points. It does not include walking, cycling or other physical activity that is undertaken for recreation.” To be in line with this definition, all trips with the purpose ‘recreation’ (roundtrips where the journey is the reward) were removed for all analyzes addressing physical activity as part of the travel behavior. Participants in the sample have to live or work within the city boundaries or live within a radius of 50 km from the city center.

After comprehensive data cleaning, only those trip diaries where all trips per day could be classified as valid were kept. A valid trip had to include at least the following information: duration, distance, transport mode and trip purpose. Outliers in duration and distance were removed. For invalid trips, several different approaches were used to complete missing data, like using the end coordinate to estimate missing trip purposes, and missing return home trips were added if possible. Each participant who reported at least one cycling trip in one of his/her trip diaries was classified as a cyclist. All active trips were considered to be of moderate physical intensity, although cycling is sometimes considered as vigorous intensity physical activity (Costa et al., 2015). For public transport trips, we assessed different scenarios. In the first scenario a 10 min (PT10) walk to and from the public transport stations was assumed per trip. A second and third scenario were chosen based on results from Brög (2017, 2015), where it was determined that public transport users in Germany walk on average 6 min per day on their public transport trips and 14 min in Vienna (PT6 and PT14).

Numerical variables were tested by using the non-parametric Kruskal-Wallis rank sum test. Each significant result ($P < 0.05$) was followed by a Dunn´s test to account for significant differences. Nominal variables (counts within categories) were tested by applying Pearson's Chi-squared test and a post hoc Chi-squared test. All statistical analyses were performed using R (version 3.4.0; The R Foundation for Statistical Computing). Values given throughout the text are mean (± standard deviation (SD)) or % (n).

3. Results

3.1. Sample description

In total 10691 participants were recruited for the survey in the seven cities, 8567 of which completed the baseline questionnaire that included the first travel diary, reporting 76986 trips. The final sample after data cleaning included 5623 participants that completed 13595 travel diaries reporting 46103 trips. The number of participants was well balanced over all cities ranging from 548 participants in Örebro to 988 participants in Rome. The sample contained a large number of participants that filled in only one trip diary (47.5%), but there were also participants that filled in up to 17 diaries, resulting in a wide temporal range of diaries. On average, each participant filled in 2.4 trip diaries. In Örebro, where in addition to the opportunistic sampling also random sampling was done, a significantly lower number of diaries per participant was obtained (1.58, ± 1.2). Compared to the other cities, it seemed

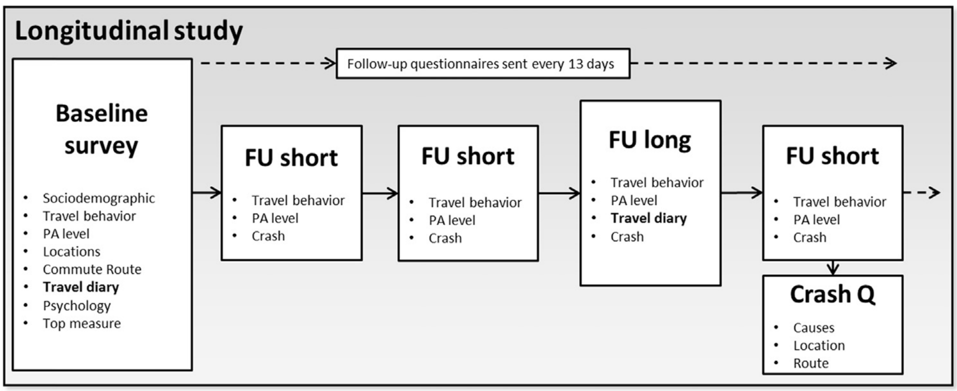


Fig. 1. Longitudinal design with a comprehensive baseline questionnaire and frequent short and long follow-up (FU) questionnaires including travel diaries. PA = Physical Activity; Q = Questionnaire. Baseline and long follow-up questionnaires included a one 1 travel diary.

that participants recruited by opportunistic methods were more interested in the topic and stayed in the survey longer.

The pooled sample was well balanced in terms of gender with 48.9% (2747) male and 51.1% (2876) female participants. However, differences between the cities with respect to gender distribution were significant: there were more female participants in most cities, except in Antwerp (male: 50% (413)) and in Rome (male: 65.4% (646)). Participants were on average 39.7 (± 12.1) years old ranging from 36.0 years in Barcelona to 43.5 years in Örebro. The sample was highly educated with 98.9% (5411) of the participants having at least a secondary or higher education degree, and the majority of participants were employed full-time (64.0% (3542)). The share of participants with a driver's license was very high (88.8% (4994)) as well as the share of participants with access to a car (59.8% (2800) always, 27.8% (1563) sometimes).

Participants reported an average of 3.4 (± 1.8) trips per day ranging from 3.0 (± 1.6) trips per day in Rome to 3.6 (± 1.8) trips per day in Antwerp, Barcelona, and Vienna (Supplementary Table S1). The observed cycling share in the case study cities was between 16.5% (1478) in Barcelona and 54.1% (4301) in Antwerp. As expected due to oversampling cyclists, this proved to be higher than the actual cycling share in all of the cities (Mueller et al., 2018) (Table 1).

Reported trip durations and distances were highly variable, indicating heterogeneous travel behavior of participants in all cities. The average trip distance in the sample was 10.5 (± 28.5) km while the average trip duration was 34.9 (± 45.8) min. These numbers were significantly different in the seven cities. The shortest trip length was reported in Barcelona with 8.0 (± 23.6) km, while the longest trip distances with an average of 12.7 (± 31.8) km were reported in Zurich. The longest trip durations were reported in Rome with 41.3 (± 52.4) min, the shortest durations in Antwerp with 30.1 (± 39.4) min. The majority of trips reported in the sample were trips from and to work (30.4% (14017)), followed by leisure trips (24.7% (11388)) and shopping trips (11.0% (5,047)). All results can be found in more detail in the Supplementary (Table S2).

3.2. Cyclists vs. non cyclists

43.7% (2460) of the participants were classified as cyclists based on their reported trips in the trip diaries. This classification correlated well with the more general self-estimation in the frequency of mode question in the baseline questionnaire (cor = 0.94, $P < 0.05$), thus providing internal validation. 74.9% of participants classified as cyclists reported to use the bike”daily” in the baseline questionnaire, 16.8% reported to use it “1 − 3 days per week” while only 8.3% reported a frequency of use of “1 − 3 days per month” or less. The number of participants classified as cyclists also correlates well with the cycling share of the sample in each city (cor = 0.86, $P < 0.05$) ranging from 31% (310) cyclists in Rome to 76% (631) in Antwerp and thus providing some external validation.

There were significant differences in sociodemographics between cyclists and non-cyclists. Within the group of cyclists, the share of men (54.6% (1343)), participants with higher education (79.6% (1913)) and participants that were employed (66.4% (1610) full time; 18.0% (436) half time) were higher compared to non-cyclists.

When comparing the cities, we found that in all cities except in Antwerp and in Örebro the share of men within the group of

Table 1
Population mode share in the seven cities and in the PASTA sample.

	Sample	Walking	Cycling	Motorized individual transport	Public transport
Total	PASTA sample	23.0% (10,593)	28.8% (13,261)	21.3% (9,799)	27.0% (12,450)
Antwerp	Population[a]	20%	23%	41%	16%
	PASTA sample	11.2% (893)	54.1% (4,301)	27.7% (2,203)	6.9% (548)
Barcelona	Population[b]	32%	2%	26%	40%
	PASTA sample	38.0% (3,396)	16.5% (1,478)	17.1% (1,530)	28.3% (2,533)
London	Population[c]	24%	3%	31%	42%
	PASTA sample	29.4% (1,251)	24.2% (1,030)	12.0% (512)	34.3% (1,459)
Örebro	Population[d]	12%	25%	54%	9%
	PASTA sample	13.2% (357)	36.3% (1,465)	46.0% (1,243)	4.5% (122)
Rome	Population[e]	16%	1%	54%	29%
	PASTA sample	16.4% (1,087)	22.1% (1,465)	32.1% (2,132)	29.5% (1,959)
Vienna	Population[f]	28%	6%	27%	39%
	PASTA sample	23.9% (1,898)	27.4% (2,171)	14.4% (1,144)	34.3% (2,722)
Zurich	Population[g]	27%	4%	30%	39%
	PASTA sample	22.3% (1,711)	23.8% (1,833)	13.5% (1,035)	40.4% (3,107)

Population modal share:
[a] Antwerp (2010); figures from city partner,
[b] Barcelona (2016) (Barcelona, 2017),
[c] London (2012); (London, 2013),
[d] Örebro (2011); Mobility data from city survey,
[e] Rome (2012); Mobility data from city survey,
[f] Vienna (2012); (Wien, 2014),
[g] Zurich (2010); (Zürich, 2013).

cyclists was higher. In these two cities, cyclists were also significantly younger than non-cyclists. The most significant difference at the education level was found in Zurich, where 74.7% of all cyclists (230) had a higher education compared to only 59.2% (281) in non-cyclists. In Rome, Vienna and Zurich the share of students within the group of cyclists was lower, whereas in Örebro it was higher. More cyclists than non-cyclists reported owning a driver's license (91.7% (2255)) and having access to a car (84.4% (2046)) (Table 2). While a difference in owning a driver's license was only significant on a high level in London, a difference in car access could be found in all cities except from Rome and Zurich. Cyclists reported more often to have only sometimes access to a car, while the share of cyclists with no car access was not different from non-cyclists (except for Örebro (12.7% (36) cyclists, 7.5% (20) non-cyclists)).

General travel behavior of cyclists and non-cyclists was also different. Cyclists reported more trips per day but their average trip distance as well as their average trip duration (considering all modes of transports) was shorter, compared to non-cyclists. In both groups, the variation in reported distances and durations was considerable. These differences were found in all seven cities, while trip purposes were different for cyclists in the seven cities. For example in Antwerp and Örebro cyclists reported more trips to and from school, while in Rome, Vienna and Zurich they reported fewer. In Barcelona cyclists were doing more leisure trips, while in London they were doing fewer shopping trips compared to non-cyclists (Supplementary Tables S3 and S4).

3.3. *Physical activity*

The average distance of a cycling trip was 4.8 (± 5.0) km, the average door-to-door duration 25.7 (± 29.8) min resulting in an average cycling speed of 11.2 km/h. Length and duration of cycling trips were significantly different in all seven cities. The shortest average cycling distance was reported in Örebro (3.1 (± 2.6) km) which has also the smallest city area in the sample, while the longest average distance was reported in London (6.5 (± 5.2) km), the city with the largest area. The shortest average duration for

Table 2
Differences in sociodemographics and travel behavior between cyclists and non-cyclists.

	Cyclists	Non-cyclists	P	Test
Gender % (n)				
Men	54.6% (1,343)	44.4% (1,404)		
Women	45.4% (1,117)	55.6% (1,759)	**< 0.001**	**57.269**[a]
Age (years) mean (± SD)	40.0 (± 11.5)	39.5 (± 12.5)	0.022	3,748,100[b]
Education level % (n)				
No degree	0.2% (5)	0.2% (5)		
Primary education	0.5% (13)	1.1% (35)		
Secondary education	19.6% (472)	26.6% (816)		
Higher education	79.6% (1,913)	72.1% (2,210)	**< 0.001**	**43.620**[a]
Employment status % (n)				
Full time	66.4% (1,610)	62.1% (1,932)		
Part time	18.0% (436)	15.2% (474)		
Student	10.9% (264)	15.7% (490)		
Home duties / Other	4.7% (114)	7.0% (217)	**< 0.001**	**45.62**[a]
Driver's license % (n)				
No	8.3% (205)	13.4% (424)		
Yes	91.7% (2,255)	86.6% (2,739)	**< 0.001**	**35.318**[a]
Car access % (n)				
Never	19.9% (490)	24.3% (770)		
Sometimes	32.3% (794)	24.3% (769)		
Always	47.8% (1,176)	51.3% (1,624)	**< 0.001**	**47.148**[a]
Trips n	25,838	20,265		
Trips per day mean (± SD)	3.6 (± 1.9)	3.2 (± 1.7)	**< 0.001**	**19,641,000**[b]
Average distance [km] mean (± SD)	8.57 (± 24.59)	12.96 (± 32.55)	**< 0.001**	**295,870,000**[b]
Average duration [min] mean (± SD)	30.35 (± 38.349)	40.78 (± 52.613)	**< 0.001**	**316,640,000**[b]
Trip purpose % (n)				
Unknown	3.9% (1,009)	4.7% (956)		
To work	29.8% (7,698)	31.2% (6,319)		
For business	6.8% (1,766)	5.9% (1,192)		
To school	4.6% (1,185)	6.0% (1,216)		
Shopping	11.5% (2,962)	10.3% (2,085)		
Personal	6.2% (1,596)	7.0% (1,409)		
Pick/Drop	5.5% (1,410)	4.9% (993)		
Recreation	2.9% (737)	3.1% (632)		
Leisure	25.7% (6,652)	23.4% (4,736)		
Other	3.2% (823)	3.6% (727)	**< 0.001**	**150.160**[a]

[a] Pearson Chi-Square test.
[b] Wilcoxon (Mann-Whitney) - Test.

cycling trips was reported in Zurich with 22.1 (± 24.5) min per trip, the longest in Rome with 32.8 (± 26.1) min. The resulting cycling speed differs between 7.5 km/h in Örebro and 12.5 km/h in London. The high standard deviation for distance and duration indicated that a lot of trips were much longer than the average; the reported distance ranged from a few meters up to 86.5 km for a single cycling trip.

With an average trip duration of 25.7 min for a cycling trip, we anticipated that participants that do one or more cycling trips per day would reach a high level of physical activity only by the domain of transport. When considering only walking and cycling as active modes, cyclists were physically active for an average of 97.3 (± 64.3) min during their daily travel, compared to only 37.1 (± 52.1) min for non-cyclists.

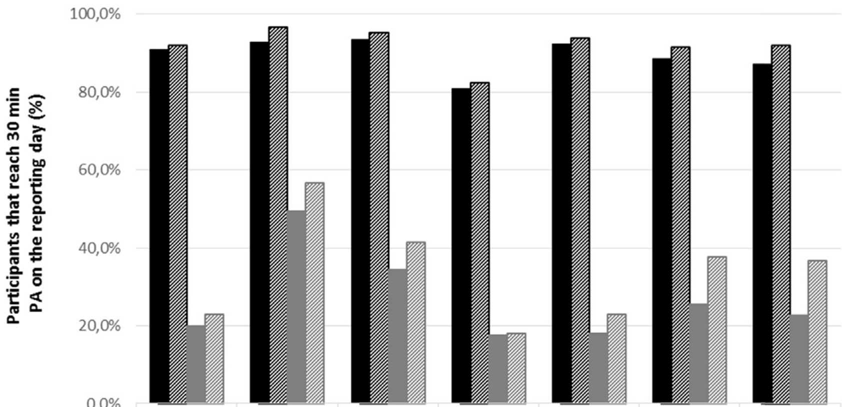
The physical active duration was different in the seven cities, depending on the average trip duration, the size of the city and on the mode share, but for cyclists this was always higher than for non-cyclists.

When identifying all cycling and walking trips as moderate physical activity, independent from speed and duration, 89.7% (2206) of the cyclists in the sample reached a level of 30 min of moderate physical activity on the reported days, compared to only 28.6% (906) of all non-cyclists (Fig. 2). Considering walking as part of a public transport trip as well increased the share of non-cyclists that reached the recommended level to 45.7% (1445) in scenario PT10. When looking at scenario PT14, the percentage of cyclists that reached the recommended level was above 90%, except for Örebro with 82.3% (233). For non-cyclists the share ranged from 18.1% (48) in Örebro to 56.6% (360) in Barcelona (Fig. 2).

The majority of cycling trips were trips to and from work (40%) with an additional 7% that was done as part of the work (for business). As working trips were assumed to be done on 5 days per week, especially by full-time employed persons (like the majority of the sample), a high percentage of cyclists would also reach the weekly recommendation of 150 min of moderate physical activity solely by their daily travel. For non-cyclists walking was most often used for leisure trips where habitual behavior cannot be assumed (Fig. 3). Cyclists used a car most frequently for leisure trips, i.e. visiting friends or family and to/from leisure facilities (37%).

4. Discussion

This paper set out to compare ‘cyclists’ and ‘non-cyclists’ in terms of their overall travel behavior, physical (in)activity and health. This was motivated by the growing evidence that active travel can play a vital role in alleviating the detrimental health effects of inactivity. Although it cannot present direct health benefits for cyclists, it can assist other studies. Several studies reveal that switching from using cars to walking and cycling provides many benefits to people's health as it counteracts sedentary lifestyles. A reduction of trips done by motorized individual transport can bring more physical activity to the general public and improve public health easier than many other (more costly) interventions. As De Geus et al. (2008) showed, cycling to work as a lifestyle intervention has a positive influence on coronary heart disease (CHD) risk factors and can improve the health-related quality of life of previously untrained adults. Bassett et al. (2008) compared national travel surveys of travel behavior and health indicators in Europe, North America, and Australia and showed that countries with the highest levels of active mobility had the lowest obesity rates. Other studies reveal that cycling commuting is associated with a lower risk of cardiovascular disease (CVD), cancer, and all-cause mortality, and walking commuting with a lower risk of CVD (Celis-Morales et al., 2017). Research evidence suggest that the benefits of physical activity due to walking and cycling outweigh detrimental effects of air pollution exposure and the risk of traffic incidents (Mueller et al., 2015, De Hartog et al., 2010).



	Antwerp	Barcelona	London	Örebro	Rome	Vienna	Zurich
Cyclists	91,0%	92,8%	93,6%	80,9%	92,3%	88,6%	87,1%
Cyclists (PT14)	92,1%	96,7%	95,2%	82,3%	93,9%	91,5%	92,0%
Non cyclists	20,0%	49,5%	34,5%	17,7%	18,1%	25,7%	22,9%
Non cyclists (PT14)	23,1%	56,6%	41,4%	18,1%	22,9%	37,7%	36,8%
Cyclists n	631	332	250	283	310	343	311
Non cyclists n	195	636	435	265	678	470	484

Fig. 2. Share of cyclists/non-cyclists that reached 30 min of moderate physical activity (PA) by active modes with and without public transport (scenario PT14).

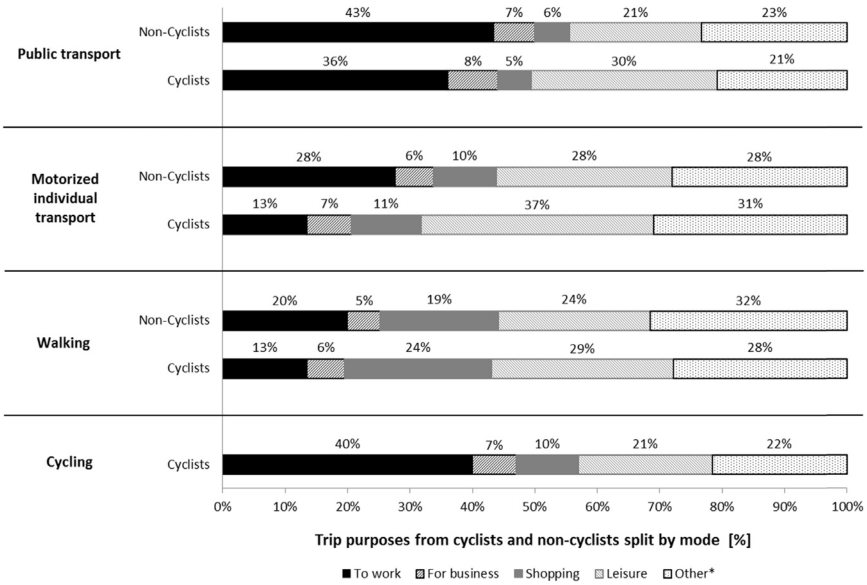


Fig. 3. Trip purposes from cyclists compared to non-cyclists split by mode (cyclist n = 2460, non-cyclist n = 3163); *) Other includes the following main trip purposes: to school, personal business and pick and drop.

This study reported results of primary data collection of individual and population level travel behavior of cyclists and non-cyclists and translated it into physical activity. The results showed that in nearly all cities the bulk of cyclists reached a level of 30 min of moderate intense physical activity per day solely by their active travel. Similar results were found by others who showed that active commuting contributes positively to meeting the physical activity guidelines (Costa et al., 2015). In Barcelona, where the walking share was very high, the percentage of non-cyclists that reached the recommended physical activity level was significantly higher than in cities with a high share of motorized individual transport without high walking shares such as Rome. In larger cities, such as London, Vienna or Zurich, it was also more likely that non-cyclists reached the recommendations than in smaller cities due to the longer trip distances and the availability of a good public transport service. This finding confirms Sahlqvist et al. (2012) who showed that adults who walked or cycled for transport were more physically active compared to people who used only motorized modes of transport. Further, those who reported active travel in combination with public transport were also significantly more physically active than people who only travelled by motorized modes. Similar results were reported by Brög (2017). As 47% of all reported cycling trips were to and from work, it could be assumed that cycling is part of the daily routine and thus provided regular physical activity. Also Engbers and Hendriksen (2010) observed that a relatively large group fulfils the physical activity recommendations merely by cycling to work.

Travel behavior was also influenced by the city profile and the engagement of the city government by supporting and implementing walking and cycling measures. Although Antwerp and Örebro are both smaller cities with a similar cycling share, there were big differences in the average length of a cycling trip. In Antwerp it was 5.2 km (± 6.13), which was above average, while in Örebro the lowest average value of 3.1 km (± 2.60) was reported. For trip duration, the differences were less pronounced possibly because of the different cycling infrastructure in Antwerp resulting in a higher cycling speed (long distance cycling paths (cycle highways) that connect the city with surrounding areas and neighborhoods), and the higher share of electric bikes.

Cyclists in all seven cities had in common that their average trip distance and trip duration was significantly lower than of non-cyclists, which lead to the hypothesis that non-cyclists travel longer distances, which make them more dependent on a car or on public transport. This might be true for some of them, but looking at the trip distances of car or public transport trips of non-cyclists, showed that 43% of these trips were 5 km or shorter and had the potential to be shifted to cycling. Further, cyclists report a higher number of trips per day compared to non-cyclists, which was also observed by Tomschy and Steinacher (2017).

There were only a few significant differences in sociodemographics between cyclists and non-cyclists. Worth mentioning is the fact that in cities where cycling was more common, like in Antwerp and Örebro, cyclists were younger and there was no difference in gender distribution. In Rome, where transport was dominated by motorized individual transport cyclists were older and more likely male. Similar results were found in other countries with a relatively small cycling share (Heesch et al., 2012, Tomschy and Steinacher, 2017).

These results should encourage city planners to continue their efforts and aim for an increase in the cycling share. A high cycling share makes cycling visible and common and is a precondition to reach people from different sociodemographic groups (NACTO, 2016).

A limitation of the study design is the fact that trip distances were retrieved from Google Maps based on the origin and destination coordinates. This reduces participant burden, as trip distance is often hard to estimate, but it does not return results for roundtrips (same start and end point). Therefore walking and cycling trips for recreation were very likely underrepresented in the results focusing on travel behavior. In any case, this has no effect on the results on physical activity as trips for recreation were removed for these analyzes. All active transport was considered to be of moderate physical intensity, independent of their intensity and duration. The definition of physical activity by the WHO is more restrictive: Here physical activity is calculated based on standardized questions (Armstrong and Bull, 2006, WHO, 2015) and only continuous walking and cycling with a duration of 10 min or more are considered as physical activity. For the analyses in this study, travel diary data was used, so a simplification from the definition by the WHO was necessary: On the one hand, to be able to include an assumption of physical activity by walking to and from public transport stations because information on real walking stages was poor; On the other hand, cycling trips with higher speed and taking longer than 10 min could have also been vigorous physical activity but the difference was not apparent in the questionnaire. Due to the opportunistic recruitment approach it is very likely that the sample is biased towards participants that have a positive attitude towards physical activity, walking and cycling and that have a higher education level. The latter is in line with other studies that observed that cycling was predominantly undertaken by highly educated people (Heesch et al., 2012, Tomschy and Steinacher, 2017). With a more representative sample, differences between cyclists and non-cyclists may have been more significant which shows the necessity to concentrate further research also on lower educated people.

The strength of this study was the fact that the same survey instrument with the same questions (online travel diary) was simultaneously used in seven different cities in Europe. This made the results comparable even if the cities were very different in terms of city profile factors and strategies in supporting active transport modes. The reported average distances for cycling trips fitted local travel surveys like e.g. in Vienna (4.1 km (Tomschy et al., 2016)) or in Örebro 3.4 km (AB, 2001).

This paper focused only on physical activity resulting from trips that were reported in a trip diary; no additional physical activity through sports or occupational physical activity was considered. The PASTA dataset does have this information, but we aimed to show that almost all cyclists reach the recommended levels of physical activity solely by the domain of transport. In further research, we will investigate whether non-cyclists are doing more physical activity in other physical activity domains to reveal substitution effects.

Our results support the approach taken in PASTA that active mobility is a simple way to integrate physical activity into everyday life. This finding can help city and transport planners as well as decision makers to better understand the interrelation between urban and transport planning and the determinants of health (e.g. physical activity) to consider public and health outcomes in their planning process. It further highlights the potential if different sectors (namely transport and health) would cooperate more often as they would benefit from the same improvements. A better cycling and walking infrastructure is a major prerequisite to increase the share of active mobility and consequently increases the overall physical activity and health of a city.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://dx.doi.org/10.1016/j.jth.2018.02.006.

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