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Transport mode choice and body mass index: Cross-sectional and longitudinal evidence from a European-wide study

Evi Dons[a,b,*], David Rojas-Rueda[c,d,e], Esther Anaya-Boig[f], Ione Avila-Palencia[c,d,e], Christian Brand[g], Tom Cole-Hunter[c,d,e,h], Audrey de Nazelle[f], Ulf Eriksson[i], Mailin Gaupp-Berghausen[j], Regine Gerike[k], Sonja Kahlmeier[l], Michelle Laeremans[b,m], Natalie Mueller[c,d,e], Tim Nawrot[a,n], Mark J. Nieuwenhuijsen[c,d,e], Juan Pablo Orjuela[f], Francesca Racioppi[o], Elisabeth Raser[j], Arnout Standaert[b], Luc Int Panis[b,m], Thomas Götschi[l]

[a] Centre for Environmental Sciences, Hasselt University, Martelarenlaan 42, 3500 Hasselt, Belgium
[b] Flemish Institute for Technological Research (VITO), Boeretang 200, 2400 Mol, Belgium
[c] ISGlobal, C/Dr. Aiguader 88, 08003 Barcelona, Spain
[d] Universitat Pompeu Fabra (UPF), C/Dr. Aiguader 88, 08003 Barcelona, Spain
[e] CIBER Epidemiología y Salud Pública (CIBERESP), C/Monforte de Lemos 3-5, 28029 Madrid, Spain
[f] Centre for Environmental Policy, Imperial College London, Exhibition Road, South Kensington Campus, SW7 2AZ London, UK
[g] Transport Studies Unit, University of Oxford, South Parks Road, Oxford OX1 3QY, UK
[h] Department of Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO, USA
[i] Trivector Traffic, Barnhusgatan 16, Stockholm, Sweden
[j] University of Natural Resources and Life Sciences Vienna, Institute for Transport Studies, Peter-Jordan-Straße 82, 1190 Vienna, Austria
[k] Dresden University of Technology, Chair of Integrated Transport Planning and Traffic Engineering, 01062 Dresden, Germany
[l] Physical Activity and Health Unit, Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Seilergraben 49, 8001 Zurich, Switzerland
[m] Transportation Research Institute (IMOB), Hasselt University, Wetenschapspark 5/6, 3590 Diepenbeek, Belgium
[n] Environment & Health Unit, University of Leuven, Herestraat 49, box 706, 3000 Leuven, Belgium
[o] World Health Organization Regional Office for Europe, Denmark

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ABSTRACT

Background: In the fight against rising overweight and obesity levels, and unhealthy urban environments, the renaissance of active mobility (cycling and walking as a transport mode) is encouraging. Transport mode has been shown to be associated to body mass index (BMI), yet there is limited longitudinal evidence demonstrating causality. We aimed to associate transport mode and BMI cross-sectionally, but also prospectively in the first ever European-wide longitudinal study on transport and health.

Methods: Data were from the PASTA project that recruited adults in seven European cities (Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich) to complete a series of questionnaires on travel behavior, physical activity levels, and BMI. To assess the association between transport mode and BMI as well as change in BMI we performed crude and adjusted linear mixed-effects modeling for cross-sectional (n = 7380) and longitudinal (n = 2316) data, respectively.

Results: Cross-sectionally, BMI was 0.027 kg/m^2 (95%CI 0.015 to 0.040) higher per additional day of car use per month. Inversely, BMI was −0.010 kg/m^2 (95%CI −0.020 to −0.0002) lower per additional day of cycling per month. Changes in BMI were smaller in the longitudinal within-person assessment, however still statistically significant. BMI decreased in occasional (less than once per week) and non-cyclists who increased cycling (−0.303 kg/m^2, 95%CI −0.530 to −0.077), while frequent (at least once per week) cyclists who stopped cycling increased their BMI (0.417 kg/m^2, 95%CI 0.033 to 0.802).

Conclusions: Our analyses showed that people lower their BMI when starting or increasing cycling, demonstrating the health benefits of active mobility.

* Corresponding author at: Centre for Environmental Sciences, Hasselt University, Martelarenlaan 42, 3500 Hasselt, Belgium.
E-mail address: evi.dons@uhasselt.be (E. Dons).

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1. Introduction

Europe is facing an overweight and obesity epidemic (Berghöfer et al., 2008). A relatively new approach to tackle this problem is through increasing physical activity levels as part of daily routines, which includes commuting to work or education, notably through walking or cycling (referred to as active mobility). While a rise in population obesity coincides with a decrease in physical activity, countries where active mobility is most common also happen to have the lowest obesity rates (Bassett et al., 2008; Prentice and Jebb, 1995; Pucher et al., 2010). Although this association does not prove causality, it warrants further investigation.

The use of different transport modes, e.g. car driving, walking and cycling, requires different energy expenditure and this may be related to body weight and body mass index (BMI). Wanner and colleagues reviewed 30 studies (mainly cross-sectional studies, with only one longitudinal study in middle-aged men) evaluating associations between the use of active mobility and body weight: in 25 of these studies an association was found (Wanner et al., 2012). There is also evidence that active mobility adds to total physical activity, and that physical activity reduces body weight (Celis-Morales et al., 2017a; Physical Activity Guidelines Advisory Committee, 2008; Wanner et al., 2012). These associations suggest that physical activity may act as a mediator in the relationship between active mobility and body weight. Similarly, within transport modes there may be differences in body weight and BMI that could be explained by a different use. Martin and colleagues found a larger reduction in BMI among those switching to active mobility with journey times over 30 min compared to those traveling for < 10 min (Martin et al., 2015). Celis-Morales and colleagues found that cycling longer distances was more strongly associated with health outcomes (incident cardiovascular disease, cancer, and mortality) than cycling shorter distances; and cycling shorter distances was better than no cycling (Celis-Morales et al., 2017b). Considering all of this, it seems plausible that active mobility acts as a key factor in body weight management through transport-related physical activity. However, this association may also be driven by reverse causality: lean individuals might be more likely to walk or cycle (further) than overweight individuals (Ekelund et al., 2008; Ekelund et al., 2017; Wanner et al., 2012).

This study aimed to address several gaps in the existing literature. Foremost, we included a longitudinal assessment to investigate the association between active mobility and BMI – longitudinal or intervention studies are essential to study the direction and size of the effect and changes over time, and estimate the importance of self-selection or other confounding variables (Faulkner et al., 2009; Xu et al., 2013). The few longitudinal studies that are available are national studies, mainly in the UK and US; to the best of our knowledge, no international multicenter studies have been reported (Bell et al., 2002; Braun et al., 2016; Flint et al., 2016; Martin et al., 2015; Mytton et al., 2016). We included seven European cities in our study, with different baseline levels of BMI and physical activity levels, different climates, different built environment and transport infrastructure, and a varying share of transport modes to increase generalizability and representativeness (Table S1).

There is a lack of standardized definitions and measurements (self-reported or measured) to identify a dominant transport mode or to quantify the amount of active mobility leading to imprecise exposure assessment and bias in the results (Wanner et al., 2012; Xu et al., 2013). The heterogeneity of studies makes it nearly impossible to perform a meta-analysis or to compare effect sizes found in different studies. Moreover, a number of other factors, like occupational or leisure-time physical activity or diet, could alter the association between transport mode and BMI (Aadahl et al., 2007; Aires et al., 2003; Celis-Morales et al., 2017a; Flint and Cummins, 2016; Kim et al., 2017).

The overall aim of this study is therefore to evaluate the association between transport mode choice and BMI in an international multicenter longitudinal study, while accounting for a number of known influencers. Additionally, we wanted to compare the cross-sectional and the longitudinal approach.

2. Materials & methods

2.1. Study design

An online questionnaire on physical activity, travel behavior and health was developed as part of the pan-European PASTA project (Physical Activity through Sustainable Transport Approaches) (Dons et al., 2015). Participants were opportunistically recruited in seven cities (Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich). Several recruitment methods were applied simultaneously with the most successful being direct targeting of local stakeholders, community groups, and workplaces, and the use of social media. In order to have sufficiently large sample sizes for different transport modes, users of rare transport modes were oversampled with targeted actions. A sample size of 2000 registrations per city was aimed for, taking into consideration attrition during follow-up. Finally, 10,722 participants entered the study on a rolling basis between November 2014 and November 2016 by filling out a baseline questionnaire (t_0). In November 2016 all participants who finished the baseline questionnaire were invited to complete a final questionnaire (t_1). Short follow-up questionnaires were sent every two weeks between t_0 and t_1 (Dons et al., 2015). To increase response rates and ensure understanding of the questions, all questionnaires could be completed in the local language. Data quality and completeness was guaranteed by including a number of programming rules and constraints in the questionnaires. Participants had to be 18 years of age (16 years in Zurich) or older, and had to give informed consent at registration. Data handling and ethical considerations regarding confidentiality and privacy of the information collected, are reported in the study protocol (Dons et al., 2015).

2.2. Outcome variables

Body mass index (BMI; weight (kg)/height (m^2)), as a direct risk indicator of disease, was the outcome of interest. 8789 participants provided at least a valid height and weight ($14\ kg/cm^2 < BMI < 45\ kg/cm^2$) in the baseline questionnaire; 3292 of them additionally provided a valid height and weight in the final questionnaire. Height and weight were self-reported, but weights were well correlated in a validation subsample of 119 participants using direct measurements ($r = 0.95$; underreported by 2.4 kg on average; supplemental material). Differences between self-reported and measured weight were non-differential between the different transport modes. Absolute change in BMI over the follow-up period was calculated by subtracting t_0 data from t_1 data (for the longitudinal analysis).

2.3. Exposure variables

Non-recreational transport mode usage was quantified using the question "How often do you currently use each of the following methods of travel to get to and from places?", rated on a five-point scale ranging from "Daily or almost daily" to "Never" (Table S2). Modes considered were walking, cycling, e-biking (electrically assisted cycling), motorcycle or moped, public transport, and car or van. Subsequently, frequencies were assigned to each of the categories, transforming this into a days-per-month variable ("Daily or almost daily" = 24 days per month; "on 1-3 days per week" = 8 days per month; "on 1-3 days per month" = 2 days per month; "Less than once per month" = 1 day per month; "Never" = 0 days per month). For the longitudinal assessment, absolute changes in frequency between t_0 and t_1 were calculated. Secondly, a categorical variable looking at cycling frequency was considered: participants were categorized as frequent cyclist (at least once per week), occasional cyclist (less than once per