

Travel Modes and Obesity

Walking, Cycling, and Obesity Rates in

Europe, North America, and Australia

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Abstract = 184 words, Text = 4,348 words

Running Head: Active Transportation and Obesity

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## ABSTRACT

**Purpose:** This study was designed to examine the relationship between active transportation (defined as the percentage of trips taken by walking, bicycling, and public transit) and obesity rates ( $\text{BMI} \geq 30 \text{ kg m}^{-2}$ ) in different countries. **Methods:** National surveys of travel behavior and health indicators in Europe, North America, and Australia were used in this study; the surveys were conducted in 1994-2006. In some cases raw data were obtained from national or federal agencies and then analyzed, while in other cases summary data were obtained from published reports. **Results:** Countries with the highest levels of active transportation generally had the lowest obesity rates. Europeans walked more than United States residents (382 versus 140 km per person per year) and bicycled more (188 versus 40 km per person per year), in 2000. **Discussion:** Walking and bicycling are far more common in European countries than in the United States, Australia, and Canada. Active transportation is inversely related to obesity in these countries. While the results do not prove causality, they suggest that active transportation could be one of the factors that explain international differences in obesity rates.

**Key Words:** active transportation, bicycling, walking, commuting, transportation, physical activity, exercise, travel, obesity

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### INTRODUCTION

Walking and bicycling are far more common in Europe than in North America and Australia.<sup>1</sup> The use of public transit, which normally requires walking or cycling to reach the transit stop,<sup>2,3</sup> is also more common in Europe. Travel-related walking, bicycling, and use of public transit are collectively referred to as active transportation. Active transportation is common in Europe, due to several factors:<sup>1,3,4</sup>

- (1) Compact, dense cities with mixed land uses that generate short trips;
- (2) Restrictions on car use such as car-free zones, low speed limits, and prohibitions of through traffic;
- (3) Extensive, safe, and convenient facilities for walking and cycling;
- (4) Traffic calming of residential neighborhoods;
- (5) Coordination of public transit with walking and cycling to transit stations and stops, including bike parking, as well as safe sidewalks and bikeways;
- (6) Traffic regulations and enforcement policies that favor pedestrians and cyclists over motorists; and
- (7) High cost of owning and operating a car due to expensive driver licensing, high gasoline prices, and high taxes on car purchases.

Some researchers have suggested that the physical activity generated by active transportation is helpful in weight control.<sup>5,6</sup> Walking and bicycle commuting usually fall into the moderate intensity range, and if performed regularly can result in substantial amounts of energy expenditure.<sup>7</sup> In addition, the use of public transit (trains, subways, and buses) usually involves walking or cycling to and from transit stops and hence would

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also be expected to promote weight control, as well as a host of other physical and mental health benefits.<sup>8, 9</sup>

The purpose of this study was to determine if variations in active transportation (defined here as the percentage of trips taken by walking, bicycling, and public transit) are related to international differences in obesity prevalence. It was hypothesized that developed nations where active transportation is common would have lower obesity rates than those with high automobile dependency. We limited our comparison to Europe, North America, and Australia since industrialized countries on those continents have similar, high levels of income and standards of living.<sup>10, 11</sup> This reduced the likelihood that obesity rates would be influenced by food availability, as is the case for developing nations.<sup>11</sup>

## METHODS

To be able to draw valid conclusions, representative data on active transportation and obesity prevalence in different nations were needed. The approach we used was to synthesize data from various sources. This included both raw data from national surveys of travel behavior and health indicators obtained from government agencies (which were then analyzed by our colleagues or ourselves), as well as summary data obtained from published reports.

### Transportation Data.

At present, there are no standardized travel surveys that gather data for the purpose of allowing international comparisons.<sup>12</sup> However, in many countries national travel surveys are conducted by, or under the direction of, national or federal authorities. An

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article by Pucher,<sup>4</sup> cited by the Transportation Research Board of the National Academy of Sciences,<sup>3</sup> compiled data on the percentage of trips in the mid-1990s taken by various transportation modes in 10 countries of Europe and North America. We expanded this dataset by including more countries and updated travel data for most of the ten previously included countries by using the most recent national transportation studies conducted between 1994 and 2006. We consulted a review of short distance travel patterns in Europe,<sup>12</sup> and gathered additional data from ministries of transportation in various countries. By using this combination of all available data sources, we produced a synthesis of the best and most recent information on the percentage of trips taken in each country by walking, cycling, public transit, and automobiles. All of these studies attempted to obtain a representative sample of the residents of that country. The age of eligible participants was usually 6 years and older, but in the United States it is 5 years and older, while in Denmark it was 10 years and older. The data in these travel surveys did not include long-distance trips, but were restricted mostly to daily travel.<sup>4</sup>

Most travel surveys use an additional diary in which the respondent records each place visited during the course of a day, the starting and ending time of each trip, transportation mode, and trip distance.<sup>13</sup> In some countries, the travel diary is supplemented by a computer-assisted telephone interview (CATI) to enable interviewers to verify and edit the individual's responses. This combined method (diary + CATI) has been reported to increase the numbers of respondents who made trips by 7%.<sup>14</sup> Germany, the Netherlands, Norway, Switzerland, and the United States are examples of countries that use this technique.<sup>14</sup> Other factors limiting comparability between surveys are the response rate, method of survey administration, and the inclusion/exclusion of weekend

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travel.<sup>14, 15</sup> Despite some inconsistencies, it is still possible to obtain a rough estimate of active transportation in different countries by using data from national surveys.

Further information on the specific design characteristics of various national transportation surveys is available in several reviews. For instance, Schafer<sup>14</sup> reported on the comparability of travel surveys from 11 industrialized countries, between 1981 and 1995. More recently, Kunert et al.<sup>13</sup> published an international comparison of travel surveys from 10 countries in Europe and North America, conducted between 1988 and 2000.

Obesity Prevalence Data. We examined obesity rates in selected European nations, the United States, Canada, and Australia for the period of 1995 to 2005, using several sources of data. To identify primary sources of data, we conducted Medline searches to identify the obesity prevalence in various countries during this time period. In addition, we consulted the International Association for the Study of Obesity,<sup>16</sup> the Organization for Economic Co-operation and Development (OECD) Health at a Glance report,<sup>17</sup> and the World Health Organization (WHO) website. We included studies on obesity prevalence if they: (a) defined obesity as a body mass index (BMI)  $\geq 30 \text{ kg}\cdot\text{m}^{-2}$ , (b) included nationally representative data, and (c) had fieldwork periods ending between 1995 and 2005. (Since published studies of obesity prevalence are not published annually in all countries, we searched for ones that were conducted within the same approximate time period as the transportation surveys.)

Data Analysis. The obesity prevalence studies were grouped into two categories, those using self-report data and those using measured data. Since BMI values computed on the basis of self reported height and weight usually underestimate BMI values

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determined from measured height and weight,<sup>18</sup> it was necessary to consider these separately. One study obtained both self-report and clinical measurements of height and weight in the Netherlands.<sup>19</sup>

The data on active transportation and obesity rates were graphed to show the relationship between these variables. Two separate graphs were constructed, one for studies using self-report data and the other for studies using clinical measurements.

## RESULTS

Data on travel behavior and health indicators were used to construct two figures showing the modal shares of walking, bicycling, and public transit, as a percentage of the total number of trips, for 17 countries (**Figure 1**). The lowest rate of active transportation was seen in the United States (only 8% of trips by walking + cycling + public transit), whereas the highest rate was seen in Latvia (67% of trips by walking + cycling + public transit). The main characteristics of the national travel surveys are shown in **Table 1**.

The obesity rates in different countries, based on self-reported height and weight, are shown in **Table 2**. These national health interview surveys tended to yield lower obesity prevalence values than those based on clinical measures. Based on these self-report data, the lowest rates of obesity were seen in Switzerland (8%), the Netherlands (8.1%), and Sweden (9.4%). The United States (23.9%) had the highest rate of obesity, using self-report data. The Pearson correlation coefficient between active transportation and obesity rates (based on self-report data) was  $r = -0.86$  ( $P < 0.001$ ).

The obesity rates in different countries, based on measured height and weight, are shown in **Table 3**. Based on anthropometric measurements, the lowest rates of obesity

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were seen in the Netherlands (11.2%) and Latvia (13.7%). The United States had the highest rate of obesity (34.3%). The Pearson correlation coefficient between active transportation and obesity rates (based on measured height and weight) was  $r = -0.76$  ( $P < 0.05$ ).

There are large differences between nations in their use of active transportation, and obesity rates (**Figures 2 and 3**). European countries that rely heavily on walking and cycling have lower rates of obesity. In contrast, the United States, Australia, and Canada demonstrate extreme automobile dependence and have the highest rates of obesity.

## DISCUSSION

The main finding of this study is that countries in Europe, North America, and Australia where active travel is most common have the lowest obesity rates, while those countries with the highest rates of car use for travel have the highest obesity rates. The data are cross-sectional and we did not adjust for possible confounders such as energy intake; hence, causality cannot be shown. However, consideration of the causes for this inverse association between active transportation and obesity rates is warranted.

A possible explanation for the observed findings is that the increased energy expenditure required by walking, cycling, and public transit contributes to lower rates of obesity. Supporting evidence for this view comes from the developing nation of China, where the use of automobiles is rapidly increasing. In the 1980s, very few households in China owned motor vehicles, but 14% of Chinese households acquired a motor vehicle between 1989 and 1997. Bell et al.<sup>5</sup> conducted a longitudinal study of 2485 adults (aged 20 to 45 years) during this time period. They found that Chinese men who acquired a car



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experienced a 1.8 kg greater weight gain and were twice as likely to become obese, compared to men whose vehicle ownership remained unchanged. These findings held even after adjusting for diet.

In both the United States and Europe, walking is the most common leisure-time physical activity (LTPA).<sup>20, 21</sup> On both continents, a high percentage of adults report having walked for exercise in the past 1-2 weeks, and walking participation is high for all age groups. However, although walking for health and fitness is popular in both Europe and North America, Europeans are more likely to walk for utilitarian purposes such as shopping, commuting to work, and school trips.<sup>3, 4</sup> Short trips in Europe are often taken by walking<sup>22</sup>, but in the United States they are usually taken by automobile. In the U.S., the automobile is used for 55% of trips that are about 0.5 km in length, 85% of trips that are 1.0 km in length, and >90% of longer trips.<sup>14</sup>

Even within the U.S., there are variations in the use of active transportation. Active transportation tends to be more prevalent in older cities with mixed land use (having residential, commercial, and civic buildings interspersed), sidewalks, and well-developed public transit systems.<sup>23-25</sup> Frank et al.<sup>6</sup> studied 10,878 people in the Atlanta area and showed that land-use mix had a strong association with obesity, with each quartile increase in land-use mix yielding a 12.2% reduction in the likelihood of obesity. They concluded that each hour spent driving was associated with a 6% increase in the likelihood of being obese, and that each additional kilometer walked per day was associated with a 4.8% reduction in the likelihood of obesity. The use of public transit has been shown to help Americans achieve recommended levels of physical activity. For example, Greenberg et al.<sup>2</sup> found that 78% of New Jersey train commuters met the

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national recommendation for physical activity, compared to 45% of all U.S. adults.

Having a good transit system encourages more walk trips through walk-to-transit and reduces dependence on automobiles.

Another measure of active transportation is the number of kilometers walked and cycled per person per year. The European Commission's Directorate-General for Energy and Transport<sup>26</sup> has compiled summary data on walking and bicycling. In 2000, Europeans walked an average of 382 km (237 miles) per year, almost three times as much as the U.S. average of 140 km (87 miles) per year. The average distance cycled each year in Europe is about 187 km (117 miles) per year, compared to 40 km (25 miles) per year in the United States (**Figure 4**). We estimated the Calories burned per day by active transportation, based on the European Commission's figures. Published values for the energy expenditure of bicycling at 8-10 mph (4 METs) and walking at 3 mph (3.3 METs) were used to arrive at these Calorie estimates.<sup>7</sup> In 2000, Europeans expended between 48 and 83 Calories per person per day in active transportation, compared to 20 Calories per person per day in the United States (**Figure 5**).

The metabolic energy requirements for active transportation in Europe are roughly equivalent to oxidation of 5-9 pounds of fat per person per year, compared to only 2 pounds in the United States. Considering the substantial effects of daily travel mode choice, and the fact that adequate levels of physical activity are helpful in weight control,<sup>27</sup> it is reasonable to conclude that active transportation contributes to the lower rates of obesity seen in Europe. This conclusion is supported by longitudinal studies showing that habitual physical activity attenuates age-related weight gain. On the basis of such studies, DiPietro<sup>28</sup> has concluded that over decades, small reductions in excess

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weight gain accumulate into net savings that are quite significant in terms of obesity prevention.

Strengths and Limitations. The present study has both strengths and limitations. The main strength is that it provides a comprehensive, cross-sectional view of the link between active transportation and obesity prevalence. We used national surveys of travel and health behaviors, derived from representative samples of the residents of those countries, to establish that an inverse association exists between active transportation and obesity rates in developed nations on three continents.

The study also has several limitations. BMI, even if computed from clinical measures, is not the most accurate measure of adiposity. However, it is widely used in epidemiological research and the World Health Organization recommends this method for population studies.<sup>29</sup> In addition, the obesity data and transportation data were not collected at precisely the same time, and the age range for participants varied.

Another limitation is that we were not able to control for other factors that could influence obesity rates. For instance, international differences in diet could contribute to obesity disparities. Unfortunately, energy intake cannot be readily be compared among nations, due to differences in the surveys and methods of analysis,<sup>30</sup> as well as the subjective nature of dietary recall. However, there is some evidence of differences in portion sizes between countries. For example, Rozin et al.<sup>31</sup> found larger portion sizes in the United States compared to France. In our view, international differences in energy intake probably do exist and this may be another factor contributing to disparities in obesity rates.

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It is possible that differences in other physical activity domains (leisure-time, occupational, or domestic) could contribute to obesity disparities. However, just as in the case of energy intake, differences in physical activity surveys have hindered international comparisons. To our knowledge, there are no studies showing that differences in leisure-time, occupational, or domestic activity among developed nations are linked with differences in obesity rates. The International Physical Activity Questionnaire (IPAQ)<sup>32</sup> was recently developed to allow international comparisons, but the long form (which measures all physical activity domains) has not yet been widely adopted.

One final limitation is that we used aggregate data on transportation and obesity that were obtained from national surveys, rather than individual level data. Thus, we did not show that individuals who engage in active transportation have a reduced likelihood of being obese. However, studies conducted in Sweden, the United States, and Australia have found that individuals who perform active transportation have a decreased odds ratio of obesity.<sup>6, 33, 34</sup> Thus, when considering all of these studies together, the relationship between active commuting and obesity appears to be quite strong.

Summary. Walking and bicycling are much more common in European nations than in the United States, Canada, and Australia. The present study shows that there is an inverse association between active transportation and obesity rates in these countries. These results do not necessarily indicate a causal relationship. However, given the fact that physically active individuals gain less weight over time,<sup>28</sup> it is possible that active transportation is one of the factors responsible for international differences in obesity rates. Future research should analyze to what extent walking and cycling infrastructure

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improvements, combined with expanded public transit systems, actually increase travel and thus provide additional physical activity that would help reduce obesity rates.

## ACKNOWLEDGEMENTS

The assistance of Pamela Andrews, Richard Burke, and Sebastian Brueckner in locating and translating reference materials for this article, and Megan Simmons in compiling data tables, is gratefully acknowledged.

## REFERENCES

1. Pucher J, Dijkstra L. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. *Am J Public Health*. 2003;93:1509-1516.
2. Greenberg M, Lane R, Zupan J, Renne J. Physical activity and use of suburban train stations: an exploratory analysis. *J. Public Transportation*. 2005;8:89-116.
3. Transportation Research Board. *Making Transit Work: Insight from Western Europe, Canada, and the United States*. Washington, DC: National Academy of Sciences Press; 2001.
4. Pucher J. Transportation Trends, Problems, and Policies: An International Perspective. *Transportation Research Part A-Policy and Practice*. 1999;33:494-503.
5. Bell AC, Ge K, Popkin BM. The road to obesity or the path to prevention: motorized transportation and obesity in China. *Obes Res*. 2002;10:277-283.

## Travel Modes and Obesity

6. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med.* 2004;27:87-96.
7. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc.* 2000;32:S498-S516.
8. U.S. Department of Health and Human Services. *The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity.* Rockville, MD: US Department of Health and Human Services, Public Health Service; 2001.
9. Bouchard C, Shepard RJ, Stephens T, Sutton JR, McPherson BD. *Exercise, Fitness, and Health: A Consensus of Current Knowledge.* Champaign, IL: Human Kinetics; 1990.
10. Maddison A. *The World Economy: Historical Statistics.* Paris, France: Organization for Economic Co-operation and Development (OECD) Publications Service; 2003.
11. Food and Agriculture Organization of the United Nations. *Summary of Food and Agricultural Statistics, 2004.* Rome: p. 75; 2004.
12. Eurostat. Short distance passenger mobility in Europe. *Statistics in Focus: Transport.* May 2005:1-7.
13. Kunert U, Kloas J, Kuhfeld H. Design characteristics of national travel surveys: International comparison for 10 countries. *Transportation Research Record 1804.* Washington, DC: Transportation Research Board, National Research Council; 2002:107-116.

## Travel Modes and Obesity

14. Schafer A. Regularities in travel demand: an international perspective. *J. Transportation and Statistics*. 2000;December:1-31.
15. Verma V. Comparability in International Survey Statistics. Paper presented at: International Conference on Improving Surveys; August 25-28, 2002; Copenhagen.
16. International Association for the Study of Obesity. Adult Overweight and Obesity in European Union (EU 27). Available at: <http://www.ietf.org/database/index.asp>. Accessed February 12, 2007.
17. Organization for Economic Co-operation and Development. *Health at a Glance: OECD Indicators 2007*. Paris, France: OECD Publications Service; 2007.
18. Gorber SC, Tremblay M, Moher D, Gorber B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev*. 2007;8:307-326.
19. Visscher TLS, Viet AL, Kroesbergen HT, Seidell JD. Underreporting of BMI in adults and its effect on obesity prevalence estimations in the period 1998 to 2001. *Obesity*. 2006;14:2054-2063.
20. Crespo CJ, Keteyian SJ, Heath GW, Sempos CT. Leisure-time physical activity among US adults. *Arch Intern Med*. 1996;156:93-98.
21. De Almeida MDV, Graca P, Afonso C, Amleto DA, Lappalainen R, Damkjaer S. Physical activity levels and body weight in a nationally representative sample in the European Union. *Public Health Nutr*. 1999;2:105-113.

## Travel Modes and Obesity

22. Department for Transport. *Focus on Personal Travel (including the Report of the National Travel Survey 2002/2003)*: Great Britain National Travel Survey Unit, Statistics Travel; 2005.
23. Ewing R, Pendall R, Chen D. Measuring sprawl and its impact. Available at: [www.smartgrowthamerica.org](http://www.smartgrowthamerica.org). Accessed July 28, 2005.
24. Ewing R, Schmid T, Killingsworth R, Zlot A, Raudenbush S. Relationship between urban sprawl and physical activity, obesity, and morbidity. *Am J Health Promot.* 2003;18:47-57.
25. Saelens B, Sallis J, Black J, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health.* 2003;93:1552-1558.
26. European Commission. Energy and Transport in Figures- Statistical pocket book 2003. *Statistical Office of the European Communities (Eurostat)*. Available at: [http://europa.eu.int/comm/dgs/energy\\_transport/figures/pocketbook/2003\\_en.htm](http://europa.eu.int/comm/dgs/energy_transport/figures/pocketbook/2003_en.htm). Accessed July 21, 2004.
27. International Obesity Task Force, European Association for the Study of Obesity. Obesity in Europe; the case for action. Available at: [www.iotf.org/media/euobesity.pdf](http://www.iotf.org/media/euobesity.pdf). Accessed September 8, 2004.
28. DiPietro L. Physical activity in the prevention of obesity: current evidence and research issues. *Med Sci Sports Exerc.* 1999;313:S542-546.
29. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*. Geneva: World Health Organization; 1998.



## Travel Modes and Obesity

30. Beer-Bost S, Hercberg S, Morabia A, et al. Dietary patterns in six European populations: results from EURALIM, a collaborative European data harmonization and information campaign. *Eur J Clin Nutr.* 2000;54:253-262.
31. Rozin P, Kabnick K, Pete E, Fischler C, Shields C. The ecology of eating: smaller portion sizes in France than in the United States can help explain the French paradox. *Psychol Sci.* 2003;14:450-454.
32. Craig CL, Marshall AL, Sjostrom M, et al. International Physical Activity Questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35:1381-1395.
33. Lindstrom M. Means of transportation to work and overweight and obesity: a population-based study in southern Sweden. *Prev. Med.* 2008;46:22-28.
34. Wen LM, Rissel C. Inverse associations between cycling to work, public transport, and overweight and obesity: findings from a population based study in Australia. *Prev. Med.* 2008;46:29-32.
35. Australian Bureau of Statistics. Method of Travel to Work. *2006 Census of Population and Housing.* Available at:  
<http://www.censusdata.abs.gov.au/ABSNavigation/prenav/ViewData?breadcrumb=-LPTD&method=Place%20of%20Usual%20Residence&subaction=-1&issue=2006&producttype=Census%20Tables&documentproductno=0&textversion=false&documenttype=Details&collection=census&javascript=true&topic=Transport%20Access%20%26%20Use&action=404&productlabel=Method%20of%20Travel%20to%20Work%20by%20Sex&order=1&period=2006&tabname=Details&areacode=0&navmapdisplayed=true&>. Accessed February 10, 2008.

## Travel Modes and Obesity

36. Austrian Federal Ministry of Transport, Innovation and Technology. [Transport in Figures]. Available at:  
<http://www.bmvit.gv.at/verkehr/gesamtverkehr/statistik/viz07/kap7.html>. Accessed February 8, 2008.
37. Statistics Canada. Where Canadians Work and How They Get There. Available at:  
<http://www12.statcan.ca/english/census01/Products/Analytic/companion/pow/contents.cfm>. Accessed February 11, 2008.
38. Danish Ministry of Transport. [Number of Trips per person per day] website in Danish. Available at:  
<http://www.dtu.dk/upload/df/modelcenter/tu/standard%20tabeller/transportmiddel/alder.html>. Accessed February 10, 2008.
39. Ministry of Transport and Communications, Finland. The National Travel Survey 2004-2005. Available at: <http://www.hlt.fi/english/modes.htm>. Accessed February 9, 2008.
40. Federal Ministry of Transport, Germany FSO. [Travel in Germany 2002: Results at a Glance] Report in German. Available at: [http://www.mobilitaet-in-deutschland.de/03\\_kontiv2002/pdf/ergebnistelegramm\\_mobilitaet\\_in\\_deutschland\\_2002.pdf](http://www.mobilitaet-in-deutschland.de/03_kontiv2002/pdf/ergebnistelegramm_mobilitaet_in_deutschland_2002.pdf). Accessed February 10, 2008.
41. Central Statistics Office, Government of Ireland. Volume 12- Travel to Work, School and College. Available at:  
[http://www.cso.ie/census/census2006results/volume\\_12/volume\\_12.pdf](http://www.cso.ie/census/census2006results/volume_12/volume_12.pdf). Accessed February 9, 2008.

## Travel Modes and Obesity

42. Statistics Netherlands. [National Travel Survey] website in Dutch. Available at:  
[http://www.swov.nl/cognos/cgi-bin/ppdscgi.exe?DC=Q&E=/English/Mobility/National%20Travel%20Survey%20\(NTS\)&LA=de&LO=de&BACK=%2Fcognos%2Fcgi-bin%2Fppdscgi.exe%3Ftoc%3D%252FEnglish%252FMobility%26LA%3Dde%26LO%3Dde](http://www.swov.nl/cognos/cgi-bin/ppdscgi.exe?DC=Q&E=/English/Mobility/National%20Travel%20Survey%20(NTS)&LA=de&LO=de&BACK=%2Fcognos%2Fcgi-bin%2Fppdscgi.exe%3Ftoc%3D%252FEnglish%252FMobility%26LA%3Dde%26LO%3Dde). Accessed February 11, 2008.
43. Swedish Institute for Transport and Communications Analysis, SIKa. The National Travel Survey. Available at: [http://www.sika-institute.se/Doclib/2007/SikaStatistik/ss\\_2007\\_19\\_eng.pdf](http://www.sika-institute.se/Doclib/2007/SikaStatistik/ss_2007_19_eng.pdf). Accessed 10 February, 2008.
44. Federal Office for Spatial Development and Federal Statistical Office, Switzerland. [Micro Census/ Travel Behavior 2005] website in German. Available at:  
<http://www.bfs.admin.ch/bfs/portal/de/index/themen/11/07/01/02/01.html>. Accessed February 8, 2008.
45. Department for Transport, United Kingdom. National Travel Survey. Available at:  
<http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/mainresults/nts2006/>. Accessed February 10, 2008.
46. US Department of Transportation. National Household Travel Survey- Version 4.0. Available at: <http://nhts.ornl.gov/download.shtml#2001>. Accessed February 12, 2008.
47. Brown A, Siahpush M. Risk factors for overweight and obesity: results from the 2001 National Health Survey. *Public Health*. 2007;121:603-613.

## Travel Modes and Obesity

48. Vanasse A, Demers M, Hemiari A, Courteau J. Obesity in Canada: where and how many? *Int J Obes*. 2006;30:677-683.
49. Bendixen H, Holst C, Sorensen TIA, Raben A, Bartels EM, Astrup A. Major increase in prevalence of overweight and obesity between 1987 and 2001 among Danish adults. *Obes Res*. 2004;12:1464-1472.
50. Tikkinen KAO, Auvinen A, Huhtala H, Tammela TLJ. Nocturia and obesity: a population based study in Finland. *Am J Epidemiol*. 2006;163:1003-1011.
51. INSERM (Intitute Nationale de la Sante Et de la Recherche Medicale). [*ObEpi, Obesity and Overweight in France: epidemiologic survey performed in a representative sample of the French adult population*] report in French. Neuilly-sur-Seine: Institute Roche de L'Obesite, Sofres; 2003.
52. Federal Statistical Office- Germany. [Body measures of the population by age groups, results from the micro-census in April 1999] website in German. Available at: <http://www.destatis.de/cgi-bin/printview.pl>. Accessed June 14, 2007.
53. Gallus S, Colombo P, Scarpino V, et al. Overweight and obesity in Italian adults 2004, and an overview of trends since 1983. *Eur J Clin Nutr*. 2006;60:1174-1179.
54. McCarthy SN, Gibney MJ, Flynn A, Livingstone MBE. Overweight, obesity, and physical activity levels in Irish adults: evidence from the North/South Ireland Food Consumption Survey. *Proc Nutr Soc*. 2002;61:3-7.
55. Schokker DF, Visscher TLS, Nooyens ACJ, van Baak MA, Seidell JC. Prevalence of overweight and obesity in the Netherlands. *Obes Rev*. 2006;8:101-107.
56. Martinez JA, Moreno B, Martinez-Gonzalez MA. Prevalence of obesity in Spain. *Obes Rev*. 2004;5:171-172.

## Travel Modes and Obesity

57. Sundquist K, Qvist J, Johansson S-E, Sundquist J. Increasing trends of obesity in Sweden between 1996/97 and 2000/01. *Int J Obes*. 2004;28:254-261.
58. Eichholzer M, Bernasconi F, Jordan P, Gutzwiller F. [Nutrition in Switzerland 2002--results of the Swiss Health Survey]. *Schweiz Rundsch Med Prax*. 2005;94:1713-1721.
59. Ni H, Schiller J, Hao C, Cohen RA, Barnes P. Early release of selected estimates based on data from the 2002 National Health Interview Survey. *National Center for Health Statistics*. Available at: [www.cdc.gov/nchs/nhis.htm](http://www.cdc.gov/nchs/nhis.htm). Accessed February 13, 2008.
60. Dalton M, Cameron AJ, Zimmet PZ, Shaw JE, Jolley D, Dunstan DW. Waist circumference, waist-hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. *J Intern Med*. 2003;254:555-563.
61. Luo W, Morrison H, deGroh M, et al. The burden of adult obesity in Canada. *Chronic Diseases in Canada*. 2007;27:135-144.
62. Rennie KL, Jebb SA. Prevalence of obesity in Great Britain. *Obes Rev*. 2005;6:11-12.
63. Pomerleau J, Pudule I, Grinberga D, et al. Patterns of body weight in the Baltic Republics. *Public Health Nutr*. 2000;3:3-10.
64. Anderssen SA, Engeland A, Sogaard AJ, Nystad W, Graff-Iversen S, Holme I. Changes in physical activity behavior and the development of body mass index during the last 30 years in Norway. *Scand J Med Sci Sports*. 2007;Jul 23 [Epub ahead of print] PMID:17645730.

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- 65.** Ogden CL, Carroll MD, McDowell MA, Flegal KM. *Obesity among adults in the United States- no change since 2003-04*. Hyattsville, MD: National Center for Health Statistics; 2007.

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Table 1. Characteristics of national travel surveys in Europe, North America, and Australia.

Country	Agency responsible for the survey	Survey	Period of data collection	Age Range (yr)	Sample Size	Source
Australia	Australian Bureau of Statistics	Census of Population *	2006	15+	20,000,000 persons	Australian Bureau of Statistics <sup>35</sup>
Austria	Austrian Ministry of Transport, Innovation and Technology	National Travel Survey	2005	6+	12,400 households	Austrian Ministry of Transport <sup>36</sup>
Belgium	Federal Office for Academic, Technical and Cultural Affairs	National Travel Survey	1998-99	6+	9,459 households	Eurostat <sup>12</sup>
Canada	Statistics Canada	Census of Population *	2001	employed persons	census of population	Statistics Canada <sup>37</sup>
Denmark	Danish Ministry of Transport	National Travel Survey	2003	10-84	25,000 persons	Danish Ministry of Transport <sup>38</sup>
Finland	Ministry of Transport and Communications Finland, Finnish National Road Administration	National Travel Survey	2004-05	6+	18,250 persons	Ministry of Transport and Communications Finland <sup>39</sup>
France	INSEE	National Travel & Communication Survey	1993-94	6+	20,002 households	Eurostat <sup>12</sup>
Germany	Federal Ministry of Transport and Spatial Development	National Travel Survey	2001-02	all ages	25,000 households, 62,000 persons	Federal Ministry of Transport and Spatial Development <sup>40</sup>
Ireland	Central Statistics Office	Census of Population *	2006	15+	census of population	Central Statistics Office <sup>41</sup>
Latvia	Central Statistical	National Travel	2003	6+	2,476 households,	Eurostat <sup>12</sup>

## Travel Modes and Obesity

Netherlands	Bureau of Latvia Ministry of Transport, Public Works, and Water Management	Survey- short trips National Travel Survey	2006	all ages	6,208 persons 34,454 households, 77,317 persons	Statistics Netherlands <sup>42</sup>
Norway	Institute for Transportation Research	National Travel Survey	2001-02	13+	20,752 persons	Eurostat <sup>12</sup>
Spain	Ministry for Public Works and Economy	National Travel Survey- short trips	2000	All ages	24,000 households, 39,981 persons	Eurostat <sup>12</sup>
Sweden	Swedish Institute for Transport and Communications Analysis (SIKA)	National Travel Survey	2005-06	6-84	41,000 persons	SIKA <sup>43</sup>
Switzerland	Federal Office for Spatial Development and Federal Statistical Office	Micro Census/Travel Behavior #	2005	6+	31,950 households, 33,930 persons	Federal Office for Spatial Development and Federal Statistical Office <sup>44</sup>
United Kingdom	Department for Transport	National Travel Survey	2006	All ages	8,300 households, 19,350 persons	Department for Transport <sup>45</sup>
United States	Federal Highway Administration	National Travel Survey	2000-01	All ages	26,083 households	US Department of Transportation <sup>46</sup>

\* work trips only, overestimates trips by public transportation and underestimates trips by bike and on foot

# special focus on short trips (any trip of 25 meters or more is included); this overestimates walk trips



Travel Modes and Obesity

Table 2. Obesity (BMI ≥ 30 kg·m<sup>-2</sup>) prevalence determined from National Health Interview Surveys where body mass index (BMI) was computed from self-reported height and weight.

Country	Reference	Survey	Years of Data Collection	Sample Size (men/women)	Age Range (yr)	Obesity Prevalence in men (%)	Obesity Prevalence in women (%)	Obesity Prevalence combined (%)
Australia	Brown et al. <sup>47</sup>	2001 National Health Survey	2001	7600/8646	18+	16.6	15.8	(16.2)
Canada	Vanasse et al. <sup>48</sup>	2003 Canadian Community Health Survey	2003	130,000 total	20+	NA	NA	15.2
Denmark	Bendixen et al. <sup>49</sup>	Trends in Food Habits in Denmark, Nutrition Council	2001	10,094/9,897	16-98	11.8	12.5	(12.2)
Finland	Tikkinen et al. <sup>50</sup>	Danish Prostatic Symptom Score Questionnaire	2003-04	1663/1897	18-79	13.5	13.2	(13.3)
France	INSERM <sup>51</sup>	ObEpi 2003	2003	25,770 total	15+	NA	NA	11
Germany	Federal Statistical Office, Germany <sup>52</sup>	Telephone Survey	2005	25,873 total	18+	NA	NA	12.1
Italy	Gallus et al. <sup>53</sup>	National Multipurpose	2004	1407/1525	18+	7.4	8.9	8.2

## Travel Modes and Obesity

Surveys								
Ireland	McCarthy et al. <sup>54</sup>	North/South Ireland Food Consumption Survey	1997-99	1379 total	18-64	20	16	(18)
Netherlands	Schokker et al. <sup>55</sup>	Health Interview Survey	2001	1809/1882	20-59	8.5	7.7	(8.1)
Spain	Martinez et al. <sup>56</sup>	National Health Survey (ENS)	2001	21,120 total	>16	11.9	13.6	12.8
Sweden	Sundquist et al. <sup>57</sup>	Swedish Annual Level of Living Survey (SALLS)	2000-01	5515/5838	16-84	9.6	9.3	(9.4)
Switzerland	Eicholzer et al. <sup>58</sup>	Swiss Health Survey	2002	19,706 total	15+	NA	NA	8
United States	Ni et al. <sup>59</sup>	National Health Interview Survey (NHIS)	2002	31,044 adults	20+	NA	NA	23.9

Note: obesity rates in parentheses were calculated from a weighted average of the published obesity rates for men and women  
 NA = not available

Travel Modes and Obesity

Table 3. Obesity (BMI  $\geq 30$  kg·m<sup>-2</sup>) prevalence determined from National Health Examination Surveys where body mass index (BMI) was computed from measured height and weight.

Country	Reference	Survey	Years of Data Collection	Sample Size (men/women)	Age Range (years)	Obesity Prevalence in men (%)	Obesity Prevalence in women (%)	Obesity Prevalence combined (%)
Australia	Dalton et al. <sup>60</sup>	The Australian Diabetes, Obesity, and Lifestyle Study	2000	11,247	25+	19.3	22.2	20.8
Canada	Luo et al. <sup>61</sup>	Canadian Community Health Survey, 2.2,	2004	18,668	20+	22.9	22.5	22.7
Great Britain	Rennie and Jebb <sup>62</sup>	Health Survey for England	2002	Not specified		23	25	(24)
Latvia	Pomerleau et al. <sup>63</sup>	Not specified	1997	1062/1230	19-64	9.5	17.4	(13.7)
Netherlands	Visscher et al. <sup>19</sup>	Health Interview Survey & Health Examination Survey of the Risk Factors and Health (REGENBOOG)	1998-2002	1809/1882	20-59	11.5	11.0	(11.2)
Norway	Anderssen et al. <sup>64</sup>	National Health Screening Service Survey	1995-2002	10,690/12654	20-70	15.4	13.3	(14.3)
United States	Ogden et al. <sup>65</sup>	National Health and Nutrition Examination	2005-2006	U.S Census Bureau	20+	33.3	35.3	(34.3)

## Travel Modes and Obesity

Survey  
(NHANES)

Note: obesity rates in parentheses were calculated from a weighted average of the published obesity rates for men and women  
NA = not available

## Travel Modes and Obesity

## FIGURE CAPTIONS

Figure 1. Percentage of trips taken by walking, bicycling, and public transit, in countries of Europe, North America, and Australia. For data sources, see Table 1.

\* Work trips only, \*\* Walk and bike trips combined for Spain, \*\*\* special focus on short trips (any trip of 25 m or more is included)

Figure 2. Obesity ( $\text{BMI} \geq 30 \text{ kg m}^{-2}$ ) prevalence and rates of active transportation (defined as the combined percentage of trips taken by walking, bicycling, and public transit) in countries of Europe, North America, and Australia. BMI was computed from self-reported height and weight. Data were obtained from national surveys of travel behavior and health indicators conducted between 1994 and 2006 (see text for details).

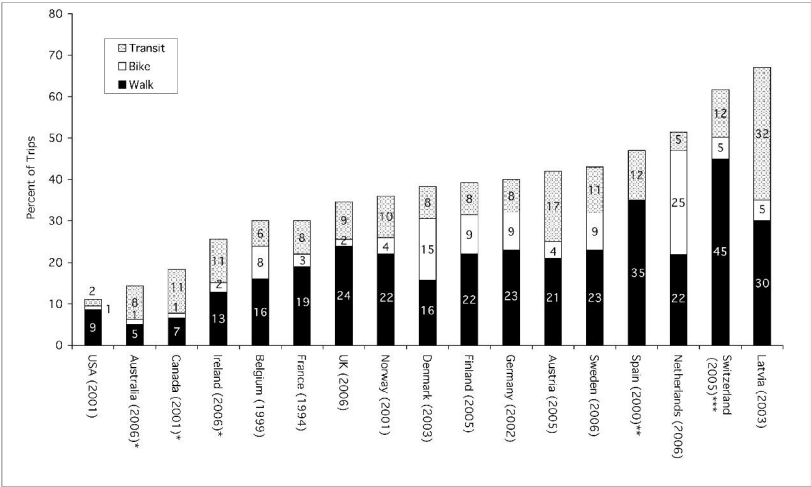
Figure 3. Obesity ( $\text{BMI} \geq 30 \text{ kg m}^{-2}$ ) prevalence and rates of active transportation (defined as the combined percentage of trips taken by walking, bicycling, and public transit) in countries of Europe, North America, and Australia. BMI was computed from measured height and weight. Data were obtained from national surveys of travel behavior and health indicators conducted between 1997 and 2006 (see text for details).

Figure 4. Walking and cycling distances in selected European countries and the United States, expressed in kilometers traveled per person per year in 2000. Source:

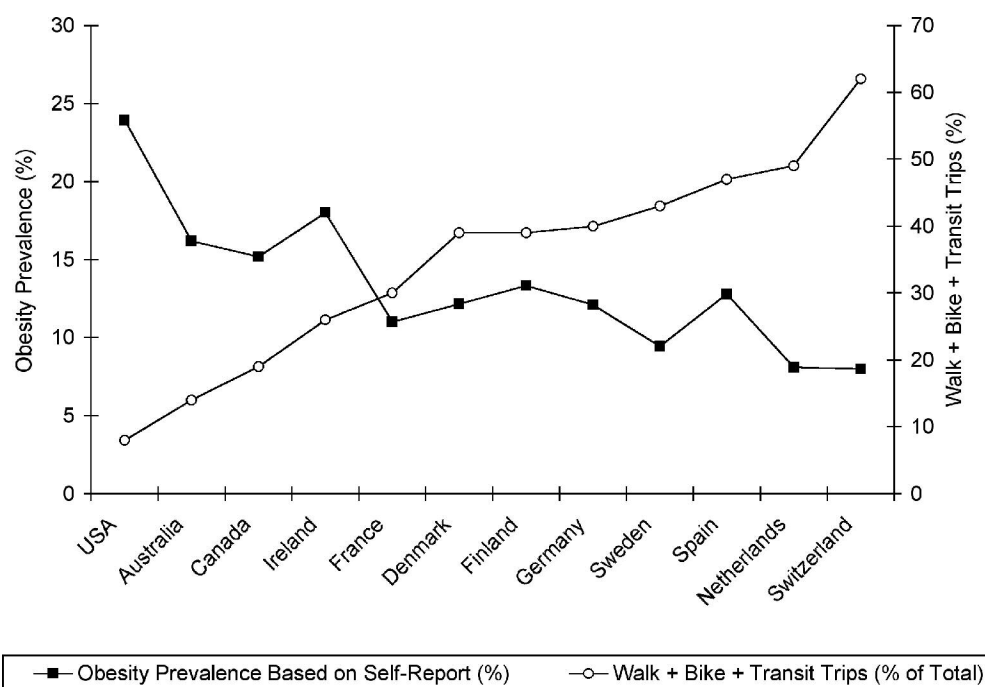
## Travel Modes and Obesity

European Commission's Directorate-General for Energy and Transport,<sup>26</sup> the Danish Ministry of Transport, and United States Department of Transportation.<sup>46</sup>

Figure 5. Estimated energy expenditure by transportation-related walking and cycling in selected European countries and the United States in 2000, expressed as Calories burned per person per day.



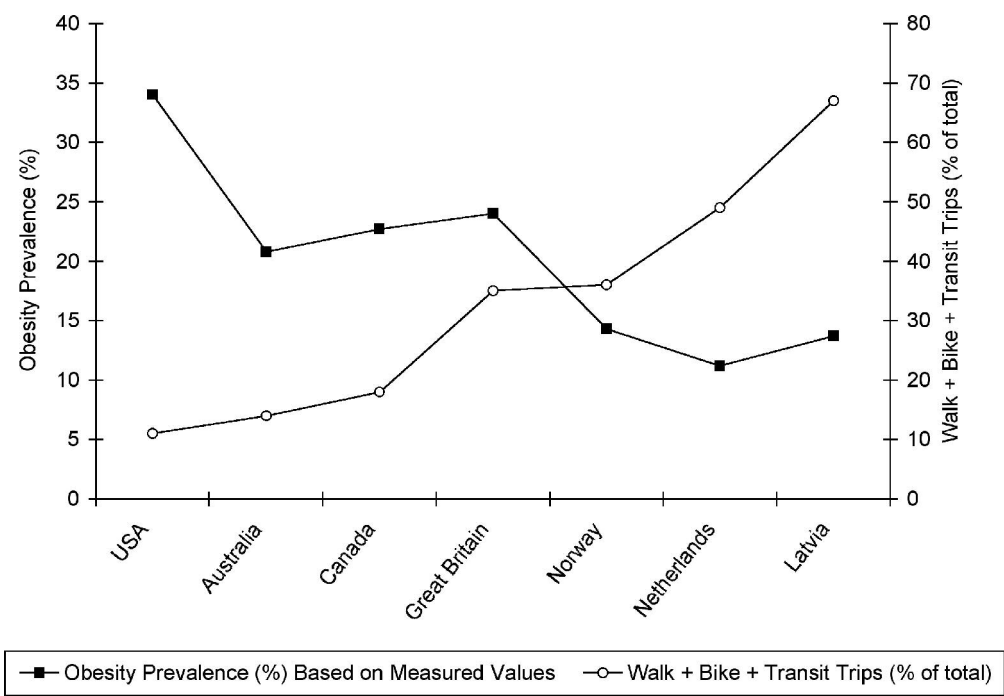
**Percentage of trips taken by walking, bicycling, and public transit, in developed countries in Europe, North America, and Australia. For data sources, see Table 1.**  
279x215mm (300 x 300 DPI)



**Obesity prevalence and levels of active transportation (defined as the combined percentage of trips taken by walking, bicycling, and public transit) in countries of Europe, North America, and Australia. BMI was computed from self-reported height and weight. Data were obtained from national surveys of travel behavior and health indicators conducted between 1994 and 2006 (see text for details).**

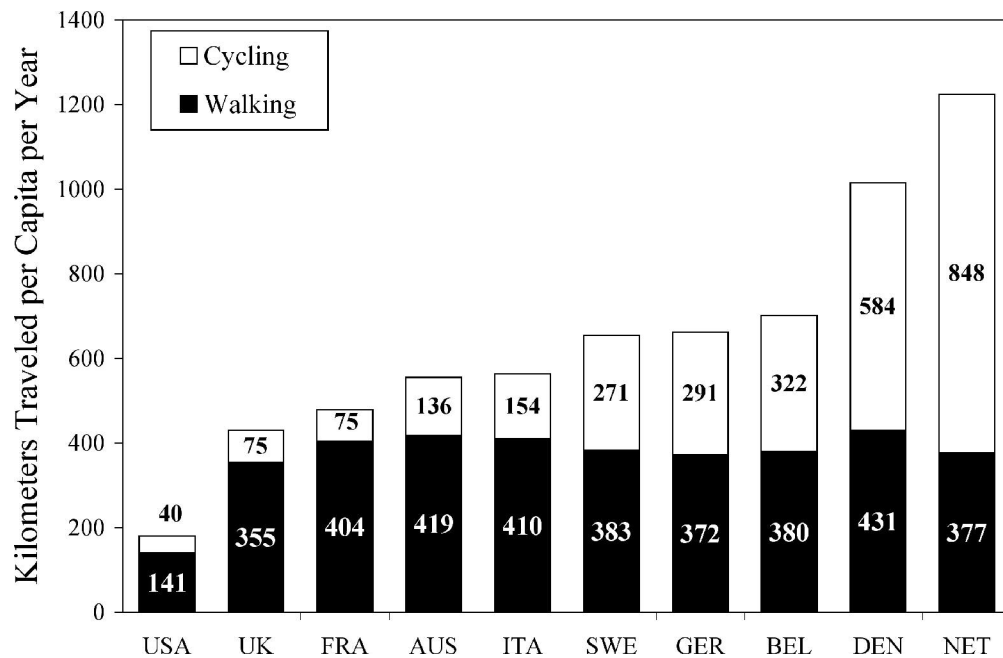
213x143mm (300 x 300 DPI)





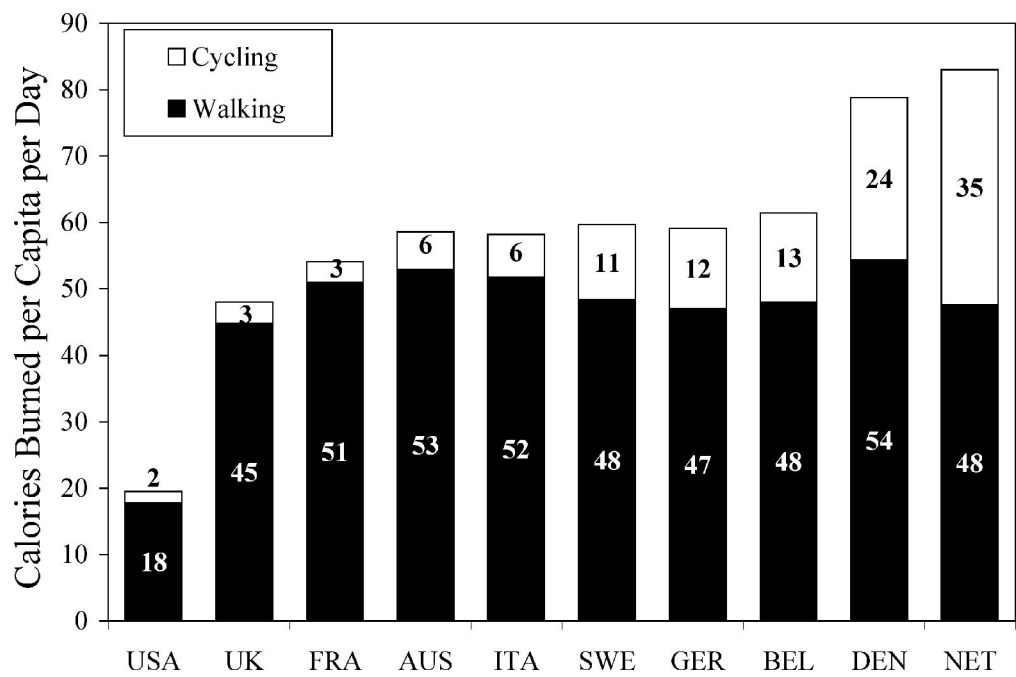
**Obesity prevalence and rates of active transportation (defined as the combined percentage of trips taken by walking, bicycling, and public transit) in countries of Europe, North America, and Australia. BMI was computed from measured height and weight. Data were obtained from national surveys of travel behavior and health indicators conducted between 1997 and 2006 (see text for details).**

213x145mm (300 x 300 DPI)



**Walking and cycling distances in selected European countries and the United States, expressed in kilometers traveled per person per year in 2000. Source: European Commission's Directorate-General for Energy and Transport,<sup>26</sup> the Danish Ministry of Transport, and United States Department of Transportation.<sup>44</sup>**

234x150mm (300 x 300 DPI)



**Estimated energy expenditure by transportation-related walking and cycling in selected European countries and the United States in 2000, expressed as Calories burned per person per day.**  
232x152mm (300 x 300 DPI)