Sitting in cars for commuting: Impacts on weight gain among physically-active adults

Authors

Takemi Sugiyama, PhD (Corresponding Author)

Behavioural Epidemiology

Baker IDI Heart and Diabetes Institute

99 Commercial Road, Melbourne, VIC 3004, Australia

Email: takemi.sugiyama@bakeridi.edu.au

Tel: 61 3 8532 1853, Fax: 61 3 8532 1100

Ding Ding, PhD

Department of Family and Preventive Medicine, University of California San Diego, USA

Neville Owen, PhD

Behavioural Epidemiology, Baker IDI Heart and Diabetes Institute, Melbourne, Australia

Word count

Abstract: 248 (max 250)

Text: 1793 (max 1800)

Pages: 10 (text, acknowledgements, references), Tables: 2, Figures: 0

No financial disclosures were reported by the authors of this paper.

Abstract

Background: Prolonged sitting, including time spent sitting in cars, is detrimentally associated with health outcomes.

Purpose: This study examined whether commuting by car was associated with adults' weight gain over four years.

Methods: Among 822 adult residents of Adelaide, Australia, weight change was ascertained from self-reported weight at baseline (2003–04) and at follow-up (2007–08). Using time spent for car commuting and work status at baseline, participants were categorized as non-car commuters, occasional car commuters, and daily car commuters. Multilevel linear regression (conducted in 2012) examined associations of weight change with car-commuting category, adjusting for potential confounding variables, for the whole sample and among those who were physically inactive or active (150+ min/week) in their leisure time.

Results: For the overall sample, adjusted mean weight gain (95% CI) was 1.26 (0.64, 1.89) kg for non-car commuters, 1.53 (0.69, 2.37) kg for occasional car commuters, and 2.18 (1.44, 2.92) kg for daily car commuters (*p* for trend=0.090). A significant association was found for those with sufficient leisure-time physical activity: adjusted mean weight gain was 0.46 (-0.43, 1.35) kg for non-car commuters, 1.38 (0.15, 2.62) kg for occasional car commuters, and 1.98 (1.02, 2.93) kg for daily car commuters (*p* for trend=0.035).

Discussion: Over four years, those who used cars daily for commuting tended to gain more weight than those who did not commute by car. This relationship was pronounced among those who were physically active during leisure time. Reducing sedentary time may prevent weight gain among physically-active adults.

Background

Prolonged sitting – particularly television viewing time – is detrimentally associated with risk biomarkers and health outcomes.[1] This is also the case for sitting while driving or riding in a car. Among adults living in Atlanta, each additional hour per day spent in a car was associated with a 6% greater odds of obesity.[2] A cohort study with 21 years of follow up of 7,700 men found that those reporting more than 10 hours/week riding in a car at baseline had 50% greater cardio-vascular mortality than those who reported less than 4 hours/week.[3] Among the different purposes for car use, commuting is a highly common sedentary behavior for working adults. The proportion of adults who use a car as the main form of transportation to work is 80% in Australia[4] and 86% in the USA.[5] Car commuting is thus a prevalent risk behavior with public health implications. A cross-sectional study in Texas showed road distance to work – a proxy measure of time spent in cars for commuting – to be associated with higher BMI, waist circumference, and metabolic risk score.[6] However, little is known about the long-term impact of commuting by car on weight change. This study examined whether commuting by car was associated with weight gain over four years.

Methods

Study sample. Data were from the PLACE (Physical Activity in Localities and Community Environments) study conducted in Adelaide, Australia (population: 1.1 million). Details of study design and sampling procedures have been reported elsewhere.[7] Briefly, residential addresses were randomly chosen from 32 urban neighborhoods, which were selected from within the Adelaide Statistical Division based on walkability and socioeconomic status criteria. These neighborhoods had a median size of 116 ha (interquartile range: 86–228 ha). An eligible

participant from each address was invited to participate in the study. In 2003–04, 2650 adults completed and returned baseline questionnaires (11.5% of the residential addresses initially identified); in 2007–08, 1098 (41.4% of the baseline participants) completed the follow-up survey. The Behavioural and Social Sciences Ethics Committee of the University of Queensland approved the study.

Measures and instruments. The outcome variable was weight change over four years, calculated from self-reported weight at baseline and at follow-up (positive values: weight gain). The exposure variable was the category of car use for commuting to work. The question used to identify car commuting only asked time spent driving a car for commuting on a typical work day, but not how many days per week. Thus, this item was combined with participant's work status to produce a proxy measure for the frequency of car use. Based on the use of a car for commuting and work status (not working; working part-time; working full-time) at baseline, participants were categorized as non-car commuters (those who did not work and those who worked but did not commute by car), occasional car commuters (part-time working car commuters), and daily car commuters (full-time working car commuters). A potential moderator variable was leisure-time physical activity (LTPA). As LTPA is known to be protective against weight gain,[8, 9] it can be postulated that participants who are active during leisure time and do not use a car for commuting are less likely to gain weight than are those who are inactive and use a car to get to work. The present study addressed this hypothesis by examining associations of car commuting with weight gain, separately for those who were physically active and inactive. LTPA in the past seven days was assessed using the long version of the International Physical Activity Questionnaire (IPAQ).[10] Demographic covariates were age, gender, educational attainment, having child in the

household, marital status, and income category. Behavioral covariates included self-reported time spent sitting while watching TV at home and in cars during leisure time (assessed using the previously-validated questions regarding the number of days and the average daily amount of time spent in each behavior in the last seven days[11]) and occupational and domestic physical activities in the past seven days measured using the IPAQ. Walking for transport, which was also assessed with the IPAQ, was examined as a potential mediator of the relationship between car commuting and weight gain.

Statistical analysis. To account for clustering of study participants, multilevel analyses (individuals nested within neighborhood) were used. Linear regression models with random intercepts examined associations of car-commuting category with weight change, adjusting for age and gender (Model 1), and further adjusting for other demographic variables (those associated with car-commuting category in univariate analysis) and for the behavioral covariates described above (Model 2). Baseline weight was not included in the models as adjusting for baseline weight, which differed between car-commuting categories, could introduce bias in the regression findings.[12] Walking for transport was added separately (after Model 2 was fitted) in order to examine if it attenuated the association between car commuting and weight change. Adjusted mean weight changes were estimated for each commuting category using the covariates set at their mean values. To test for trend, car-commuting category was entered in the regression models as an ordinal variable. Analyses were conducted for the whole sample and for the subgroups stratified by LTPA (insufficient vs. sufficient, using 150 min/week as the cut-off) on an a priori basis. Data were analyzed in 2012 using Stata12. The alpha level was set at 0.05.

Results

The final study sample included 822 adults (age range: 20–66 years at baseline), after excluding those with missing values, those who changed their work status between two survey points, and those with extreme weight change values (over 20 kg increase or decrease). Table 1 shows the sample characteristics by car-commuting categories. In comparison to the adult population in Adelaide based on the 2006 Australian Census,[13] the study sample overrepresented women, older people, people with tertiary education, and those who were working. The overall mean weight gain over four years was 1.6 kg. This is consistent with findings from a large-scale population study on Australian adults (annual weight gain: 0.3 kg for men, 0.5 kg for women).[14]

(TABLE 1 ABOUT HERE)

Table 2 shows the findings (adjusted mean weight change) of two multilevel linear regression models for the whole sample and the subgroups stratified by LTPA. For the whole sample, there was a marginal trend for the associations of car-commuting category with weight gain in both Model 1 and Model 2. Gender was the only covariate associated with weight change (significantly higher weight gain for women). For those with insufficient LTPA, weight gain did not differ significantly between the three car-commuting categories. However, for those who reported sufficient LTPA, there was a statistically-significant association between weight gain and the category of car commuting. Weight gain was significantly greater than zero for all of the subgroups, except among those who did not commute by car and engaged in sufficient levels of LTPA. Further analysis in which walking for transport was added in Model 2 found that walking for transport slightly attenuated the association of car-commuting category with weight change,

but did not substantially change the findings: *p* for trend was 0.11 for the whole sample, 0.68 for the group with insufficient LTPA, and 0.041 for the group with sufficient LTPA (weight gain for non-car commuters still not significantly greater than zero).

(TABLE 2 ABOUT HERE)

Discussion

This study found that adults who commuted by car tended to gain more weight than those who did not, after adjusting for potential demographic and behavioral confounders. The findings are consistent with those of previous studies that showed deleterious associations of prolonged time spent sitting in cars with health outcomes.[2, 3, 6] Although there was a gradient in weight gain across three commuting categories, all showed significant weight gain over four years (ranging from 1.3 to 2.2 kg). This suggests that not using cars for commuting may prevent excessive weight gain, but it alone may not be enough to maintain weight over a long period of time. Stratified analysis found that the association of car-commuting category with weight gain was pronounced among those who were physically active in their leisure time: the weight gain of non-car commuters over four years was, on average, 1.5 kg less than that of daily car commuters (*p* for trend = 0.035, Model 2). It should be noted that the association among physically-active participants remained significant after adjusting for walking for transport, suggesting that the impact of sitting in cars for commuting on weight is independent of transport-related walking. In addition, the adjusted mean weight gain for those who participated in sufficient leisure-time physical activity and who did not commute by car was not significantly greater than zero. This may be interpreted as showing that long-term weight maintenance may be possible through

combining not using cars for commuting and being physically active during leisure time. Annual weight gain is common among adults.[14] Weight maintenance strategies may have to address both reducing sedentary behavior and increasing physical activity.

Strengths of the study include its longitudinal study design tracking participants for four years and its adjustment for many behavioral variables, such as walking for transport, occupational physical activity, TV viewing, and leisure-time car use, which could potentially confound the relationship between commuting modes and weight gain. Limitations to be considered in interpreting the findings include self-reported weight and behavior measures. The exposure category was based on car use for commuting and work status rather than the actual time spent sitting in cars. However, in Adelaide, about three quarters of working adults live within 20 km from their workplace.[4] Since very long commuting time was less likely in the study areas, the category employed can be considered a proxy measure of car use for commuting. Lack of information about participants' diet, which may be different between car commuters and non-car commuters, is another limitation. Data were collected from one Australian city, which may limit the generalizability of the findings. The effect of car commuting may be more serious in larger cities with worse traffic congestion.

Previous studies have shown the health benefits of being regularly active in transport.[15, 16] Influencing commuting behaviors – not only increasing physically active transport but also reducing time spent sitting in cars – is an important public health strategy. Future studies need to examine associations of time spent sitting in cars for commuting with health outcomes, taking into account the established positive health impact of active commuting.[2, 17] The use of

technologies such as GPS, which is now incorporated into mobile phones, could provide accurate information about how long people spend sitting in cars. In addition, research focusing on the health impact of shifting from inactive transport to active transport is of interest. Evidence from such studies can inform future public health, urban planning, and transportation initiatives, which are needed to prevent weight gain through facilitating active transport and leisure-time physical activity, and reducing prolonged sitting time.

Acknowledgements

Sugiyama and Owen are supported in part by the Victorian Government's Operational Infrastructure Support Program. Owen is supported by a Program Grant #569940 and a Senior Principal Fellowship #1003960 from the National Health and Medical Research Council of Australia.

References

1. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: The population health science of sedentary behavior. *Exerc Sport Sci Rev*. 2010;38(3):105-113.
2. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med*. 2004;27(2):87-96.
3. Warren TY, Barry V, Hooker SP, Sui X, Church TS, Blair SN. Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Med Sci Sport Exerc*. 2010;42(5):879-885.
4. Australian Bureau of Statistics. Environmental issues: Waste management and transport use. Canberra: ABS. 2009.
5. McKenzie B, Rapino M. Commuting in the United States: 2009 American Community Survey Reports. Washington, DC.: U.S. Census Bureau. 2011.
6. Hoehner CM, Barlow CE, Allen P, Schootman M. Commuting distance, cardiorespiratory fitness, and metabolic risk. *Am J Prev Med.* 2012;42(6):571-578,
7. Owen N, Cerin E, Leslie E, et al. Neighborhood walkability and the walking behavior of Australian adults *Am J Prev Med*. 2007;33(5):387-395.
8. Waller K, Kaprio J, Kujala UM. Associations between long-term physical activity, waist circumference and weight gain: A 30-year longitudinal twin study. *Int J Obes*. 2008;32(2):353-361.
9. Donnelly JE, Smith B, Jacobsen DJ, et al. The role of exercise for weight loss and maintenance. *Best Pr Res Cl Gastro*. 2004;18(6):1009-1029.
10. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sport Exerc*. 2003;35(8):1381-1395.

11. Salmon J, Owen N, Crawford D, Bauman A, Sallis JF. Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychol*. 2003;22(2):178-188.
12. Glymour MM, Weuve J, Berkman LF, Kawachi I, Robins JM. When is baseline adjustment useful in analyses of change? An example with education and cognitive change. *Am J Epidemiol*. 2005;162(3):267-278.
13. Australian Bureau of Statistics. Census Home: Data and Analysis: Historical Data. Canberra: ABS. 2006. www.abs.gov.au/websitedbs/censushome.nsf/home/historicaldata.
14. Ball K, Crawford D, Ireland P, Hodge A. Patterns and demographic predictors of 5-year weight change in a multi-ethnic cohort of men and women in Australia. *Public Health Nutr*. 2003;6(3):269-281.
15. Ding D, Sugiyama T, Owen N. Habitual active transport, TV viewing and weight gain: A four year follow-up study. *Prev Med*. 2012;54(3-4):201-204.
16. Sugiyama T, Merom D, Reeves M, Leslie E, Owen N. Habitual active transport moderates the association of TV viewing time with body mass index. *J Phys Activ Health*. 2010;1(7):11-16.
17. Hamer M, Chida Y. Active commuting and cardiovascular risk: A meta-analytic review. *Prev Med*. 2008;46(1):9-13.

Table 1. Sample characteristics by car-commuting categories

	Total	Car-commuting category			p[1]
		No	Occasional	Daily	
Number (%)	822	375 (46%)	177 (22%)	270 (33%)	–
Gender, % men	39%	39%	21%	49%	< 0.001
Age, mean (sd)	48.6 (10.2)	52.1 (10.2)	46.3 (9.2)	45.1 (9.1)	< 0.001
Education, % with tertiary education	46%	35%	54%	55%	< 0.001
Work status, % working	66%	27%	100%	100%	< 0.001
Having child in household, % yes	31%	23%	50%	28%	< 0.001
Marital status, % couple	63%	60%	69%	63%	ns
Income, % >$41,600 per annum	54%	33%	57%	83%	< 0.001
TV viewing time in min/day, mean (sd)	103.5 (85.9)	116.9 (99.5)	102.7 (80.1)	85.5 (63.3)	< 0.001
Leisure-time car use in min/day, mean (sd)	33.7 (48.3)	26.7 (35.0)	40.3 (51.5)	39.0 (59.6)	< 0.001
Walking for transport in min/day, mean (sd)	22.3 (33.1)	26.5 (35.5)	17.4 (27.4)	19.3 (32.3)	< 0.01
Leisure-time physical activity in min/day, mean (sd)	36.9 (52.3)	36.8 (50.7)	31.8 (50.6)	40.5 (55.4)	ns
Occupational physical activity in min/day, mean (sd)	70.8 (150.6)	27.3 (87.4)	85.7 (150.8)	121.5 (195.8)	< 0.001
Domestic physical activity in min/day, mean (sd)	94.2 (112.8)	109.4 (128.4)	85.7 (87.8)	78.8 (101.4)	< 0.01
Weight at baseline in kg/m^2, mean (sd)	74.8 (15.9)	75.5 (16.5)	72.3 (14.8)	75.5 (15.5)	ns (0.07)
Weight change in kg/m^2, mean (sd)	1.62 (5.59)	1.14 (5.94)	1.78 (4.97)	2.18 (5.42)	ns (0.06)

All demographic and behavioural variables were measured at baseline.

[1] Difference across car-commuting categories was tested using chi-square for categorical variables and ANOVA for continuous variables.

Table 2. Adjusted mean weight change (95% CI) in kg by car-commuting categories and LTPA levels

Car-commuting category	Total (n=822)	Insufficient LTPA[1] (n=420)	Sufficient LTPA[2] (n=402)
Model 1			
No	1.29 (0.71, 1.86)	1.91 (1.10, 2.72)	0.50 (-0.34, 1.33)
Occasional	1.50 (0.67, 2.33)	1.71 (0.57, 2.85)	1.38 (0.17, 2.59)
Daily	2.17 (1.49, 2.85)	2.46 (1.41, 3.50)	1.93 (1.04, 2.82)
p for trend	0.063	0.48	0.023
Model 2			
No	1.26 (0.64, 1.89)	1.98 (1.09, 2.86)	0.46 (-0.43, 1.35)
Occasional	1.53 (0.69, 2.37)	1.74 (0.57, 2.91)	1.38 (0.15, 2.62)
Daily	2.18 (1.44, 2.92)	2.33 (1.18, 3.49)	1.98 (1.02, 2.93)
p for trend	0.090	0.69	0.035

Model 1 adjusted for age and gender. Model 2 further adjusted for education, having child in household, household income (quartile), TV viewing time, driving/riding a car during leisure time, occupational physical activity, and domestic physical activity. Both models accounted for clustering at the neighborhood level.

[1] Leisure time physical activity < 150 min/week, [2] Leisure time physical activity >= 150 min/week