ACTIVE COMMUTING IS ASSOCIATED WITH A LOWER RISK OF OBESITY, DIABETES AND METABOLIC SYNDROME IN CHILEAN ADULTS

Short title: Active commuting, obesity and diabetes

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ABSTRACT

Background - There is a limited evidence on how active commuting is associated with health benefits in developing countries. The aim of this study therefore was to investigate the associations between active commuting and makers of adiposity and cardiometabolic risk in the Chilean adult population

Methods - 5,157 participants from the Chilean National Health Survey 2009-2010 were included in this cross-sectional study. Active commuting was measured using the Global Physical Activity Questionnaire (GPAQ v2). Body mass index (BMI) and waist circumference (WC) were measured and used to define obesity and central obesity. Type 2 diabetes (T2D) and metabolic syndrome was determined using WHO and update ATPIII-NCEP criteria, respectively. .

Results - The main finding of this study revealed that 30 minutes increase in active commuting was associated with lower odds for BMI >25.0kg.m^{-2} (0.93 [95% CI: 0.88 a 0.98, p=0.010]). Similarly the odds for central obesity was 0.87 [0.82 a 0.92, p<0.0001]. Similar associations were found for T2D (0.81 [0.75 to 0.88]) and metabolic syndrome (OR: 0.86 [0.80 to 0.92]).

Conclusion - Our findings shown that active commuting is associated with a lower adiposity and a healthier metabolic profile including lower risk for obesity, diabetes and metabolic syndrome.

Keywords – active commuting; obesity; diabetes, metabolic syndrome

INTRODUCTION

Despite the known protective effects of increased physical activity (PA) against morbidity and mortality, approximately one third of the world's population remains physically inactive (1, 2). Recently, physical inactivity was cited as the fourth leading cause of non-communicable disease (NCD) mortality, attributable for 5.3 million deaths per year (3). Global trends, however, indicate prevalence of physical inactivity continues to increase, particularly among low and middle income countries (2).

In southern Latin American countries, sustained periods of economic growth accompanied by rapid urbanisation of previously rural populations have resulted in paradigm shifts in lifestyle behaviours (4, 5). Increased access to household appliances, televisions, and motorised transportation has been paralleled by decreases in overall levels of PA and increased sedentary behaviour (5). Subsequently, burden of NCDs has increased in this region, and cardiovascular disease has been the leading cause of mortality over the last two decades (6).

Declines in active commuting are suggested to be at least partially responsible for overall declines in population PA, as urban population growth has outpaced infrastructure development and people have shifted to more personalised modes of motorised transport (i.e. driving cars) (7). In 1960 a 60% of the total population in Chile use to live in urban setting, however in 2015 more than 90% is currently living in urban cities (8). This growth in urbanization has been more rapidly than in some major developed countries such as United States and United Kingdom, which increased urbanization approximately from 78% to 83% during these years (8). Along with this changes the numbers of cars in Chile has increased from 2 million in 1998 to more than

4.6 million in 2015, while the number of bicycles have increased from 1.1 million to 1.9 million (9).

Active commuting is recommended as a simple way of increasing PA, and recent research has continually reported the health benefits (10). Investigations into the effects of active commuting on markers of adiposity and cardiometabolic health have reported improved cardiovascular risk profiles and lower prevalence of obesity in whose who actively commute (11-14). A recent study (n>250,000) reported that active commuters (cycling and walking) is associated with reduce risk of all-cause mortality, CVD and cancer incidence and mortality (10).

Population level observations of active commuting trends are predominantly available in high income countries (2), and any observed associations may not be generalizable to other regions. While there is limited evidence of the effects of active commuting in low to middle-income countries (15, 16), associations between active commuting and prospective health outcomes in southern Latin American countries remain largely unestablished. The aim of this study was therefore to investigate the associations between active commuting and markers of adiposity and cardiometabolic risk in the Chilean adult population.

METHODS

Study Population

This cross-sectional study was based on data from participants aged ≥15 years from the 2009-2010 Chilean National Health Survey (CNHS). The CNHS is a large, nationally representative population-based study of risk factors, dietary status and health

conducted every 6 years in Chile. Complex random stratified sampling was used to cover a nationally representative sample based on statistics from the 2002 Chilean National Census, which included strata from administrative regions (county) and urban/rural locations, as described in detail elsewhere .

Response rate from the eligible population to the CNHS was 85%. A total 5,276 (97%) provided data on PA behaviours collected with the Global Physical Activity Questionnaire (GPAQ), version 2. Participants aged <18 years (n=224) were excluded from the current analysis (results will be reported elsewhere). In addition, 121 participants (3%) with PA data were excluded based on the GPAQ protocol for outlier detection (48% women). Complete data was available for 5,155 participants for the present analysis (17).

Measurements

Socio-demographics

To ensure quality of data collection, standardised protocols were used and nurses and technicians underwent joint training sessions prior to the survey (17). Socio-demographic data was collected for all participants, including age, gender, education level (primary or <8 years, secondary or between 8-12 years, and beyond secondary or >12 years of schooling), and smoking status (non-smoker, ex-smoker or smoker). Dietary intake was measured using a dietary intake questionnaire, which include questions regarding frequency and quantity of consumption of fruit and vegetables, alcohol and salt intake.

Anthropometrics

Height was measured to the nearest 0.1 cm using a portable stadiometer and weight was measured to the nearest 0.1 kg using a digital scale (Tanita HD313) with participants removing their shoes and wearing light clothing. Body mass index was calculated as [weight/height^2] and classified using the World Health Organization (WHO) criteria (<18.5 kg.m^{-2} – underweight, 18.5 to 24.9 kg.m^{-2} – normal, 25.0 to 29.9 kg.m^{-2} – overweight and ≥30 kg.m^{-2} – obese) (18). Central obesity was defined using waist circumference (>88cm for women and >102cm for men).

Metabolic outcomes

Fasting glucose and haemoglobin A1c (HbA1c) were measured from whole blood collected by trained nurses after an eight hour overnight fast. Analysis of samples was conducted in a certified laboratory facility and has been described in detail elsewhere (17) . T2D was determined via the WHO criteria (fasting plasma glucose ≥ 126mg.dl-1) (19) and/or by self-report of a pre-existing medical diagnosis and/or in those who reported using glucose lowering medication. Metabolic syndrome was determine according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) as the presence of 3 or more of the following: waist >102 cm in men, >88 cm in women; triglycerides ≥ 1.70 mmol/l (150 mg/dL); high density lipoprotein cholesterol (HDL-C) <1.03 mmol/l (40 mg/dL) in men, <1.29 mmol/l (50 mg/dL) in women; blood pressure ≥ 130/85 mm Hg; and fasting plasma glucose ≥ 6.11 mmol/l (110 mg/dL) or self-reported diabetes (20).

Physical activity

The GPAQ (version 2) was used to measure PA and sedentary behaviour in the CNHS. Developed by the WHO to measure population-level PA behaviours, the GPAQ uses

standardised protocols shown to be valid and reliable and adaptable to incorporate cultural and other differences (21, 22). The GPAQ assesses sedentary behaviour (total time spent sitting) and time spent on active-commuting (PA from travel). For active commuting domain participants were ask the following question a) Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places? (Yes, No); b) In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?; and c) How much time do you spend walking or bicycling for travel on a typical day?. These questions were used to derive time spent on active commuting in minutes per day. Total PA was reported as metabolic-equivalent value (MET) using recommendations made by the GPAQ protocol (4-METs was used for transport-related activities and moderate intensity physical activities, whereas 8-METs was used for Vigorous intensity physical activities) (23). The GPAQ uses algorithms to categorize weekly PA into two categories: inactive individuals (<600 MET.min.week^{-1}) and active individuals (≥ 600 MET.min.week^{-1}) (23). Sedentary behaviour was derived using the following question: How much time do you usually spend sitting or reclining on a typical day? (23).

Statistical Analysis

Survey-weighted descriptive characteristics are presented as adjusted means with standard deviation (SD) for quantitative variables or as a proportion for categorical variables. Quantitative data was checked for normality using skewness and kurtosis normality tests. For statistical analysis, active commuting was stratified into 4 categories based on self-reported time spent on active commuting (0: participants who reported not doing active commuting; >30 minutes a day; 30 to 60 minutes a day and >60 minutes a day).

To investigate the association of active commuting with adiposity and metabolic markers, linear regression analysis were performed. Active commuting was fitted into the model as an ordinal variable variable (0= non-active commuters, 1= >30; 2= 30 to 60, and 3= >60 minutes a day). The association of active commuting categories with obesity, central obesity, T2D and metabolic syndrome were investigated using logistic regression analyses. All models were adjusted for age, sex, education, smoking, leisure PA, sitting time, fruit and vegetable, salt and alcohol intake. Metabolic markers were additionally adjusted for BMI.

To account for the differential probability of selection, all outcome estimates (deltas and odds ratio) were weighted using the sample weights provided by CNHS(17). Statistical analyses were conducted using STATA 14 (StataCorp; College Station, TX). A two-sided α-level of 0.05 was used and all analyses accounted for the complex sample design of CNHS data.

RESULTS

The main characteristics of the participants by active commuting are summarised in Table 1. In summary, individuals who actively commuted were more likely to have high levels of education and household income, and had a slightly higher prevalence of smokers and had a lower prevalence of obesity and physical inactivity compared to the non-active commuting group. Active commuters had a lower BMI and waist circumference, and had higher levels of total physical activity in comparison to those reporting no active commuting (Table 1). No major differences were found on time spent on sedentary behaviour and dietary intake patterns between active and non-active commuters.

Overall, there was a significant association of active commuting time with obesity and metabolic markers (Figure 2). Body mass index and WC were -0.56 $kg.m^{-2}$ and -01.12 cm lower in individuals who accumulate between 1-30 minutes of active commuting per day compare to non-active commuters. Larger differences were observed on WC for those who accumulate between 30-60 or >60 $minutes.week^{-1}$ (-1.90 and -2.23 cm, respectively) but not for BMI (-0.63 and -0.62 $kg.m^{-2}$, respectively) compare to non-active commuters. . Fasting glucose concentration were significantly lower on those achieving 30-60 and >60 $min.day^{-1}$ compare to non-active commuters (-0.12 and -0.22 $mmol.l^{-1}$, respectively). No significant differences were found for those accumulating <30 $min.day^{-1}$compare to non-active commuters (-0.09 $mmol.l^{-1}$). Whereas, systolic blood pressure compare to non-active commuters was significantly lower in those accumulating <30, 30-60 and >60 $min.day^{-1}$ (-2.3, -2.72 and -3.8 mmHg, respectively). No differences were found for total cholesterol, HDL cholesterol, triglycerides and diastolic blood pressure between active commuting groups (Fig 1). These associations were independent of socio-demographics, smoking, sedentary behaviour, dietary behaviour and BMI (when glucose was used as main outcome). However, no association were found for active commuting and lipids profile (total cholesterol, HDL-cholesterol and triglycerides) and diastolic blood pressure (Fig 1).

When the association of active commuting time with obesity, T2D and metabolic syndrome was investigated we found a significant trend to reduce the odds for all these risk factors with increasing active commuting time in comparison to those who report not doing active commuting (Figure 2). The odds for overall obesity (BMI >30.0 $kg.m^{-2}$) was 25%, 26% and 33% lower on those who accumulate <30, 30-60 and >60 $min.day^{-1}$ compare to non-active commuters. Similar results were found for central obesity (20%, 21% and 31), but higher reduction in the odds were found for T2D (26%, 27% and 48%))

and metabolic syndrome (33%, 34% and 63%) for those who accumulate <30, 30-60 and >60 min.day^{-1}, respectively, compare to those who did not reporting any active commuting. These results were independent of socio-demographics, smoking, sedentary behaviour, dietary behaviour and BMI (this last one was added when T2D and metabolic syndrome were used as outcomes) (Figure 2). No significant differences were found between active commuting groups (<30, 30-60 and >60 min.day^{-1}) for any of the health outcomes (P>0.05).

DISCUSSION

Main finding of this study

The main findings of this study were that active commuting was significantly associated with markers of adiposity and metabolic disease, and incidence of obesity, T2D and metabolic syndrome. The higher the time spent on active commuting the larger were the benefits for T2D, waist circumference and systolic blood pressure. Our results revealed that these associations were independent of age, sex, education, leisure time PA, sedentary behaviour, dietary intakes and BMI (when adiposity markers were not the outcome). As active commuting has been reported to contribute to overall PA (24, 25), these results may have important public health implications. Improved provisions for active commuting may facilitate population level health benefits, as it is an inexpensive mode of increasing PA.

What is already known on this topic

The extensive evidence of associations with health for both overall and leisure-time physical activity (26, 27) contrasts with limited evidence of the effects of non-leisure time

physical activity, such as active commuting, on prospective health outcomes. Previous observational studies have reported similar findings to our own in that active commuting may be associated with lower adiposity and reduced likelihood of obesity (11, 12, 14). A large cross sectional analysis of ~150,000 people from the UK Biobank cohort reported that mixed-mode commuters (i.e. public transport and active commuters)(men: β coefficient -1.00 $kg.m^2$ [95% CI: -1.14 to -0.87], p<0.0001; women: -0.67 $kg.m^2$ [-0.86 to -0.47], p<0.0001) had favourable adiposity profiles compared to car-only commuters, however the greatest protective benefits of active commuting were observed in those who reported some cycling during their commute (i.e. cycling or walking and cycling)(men: β coefficient -1.71 $kg.m^2$ [95% CI: -1.86 to -1.56], p<0.0001; women: -1.65 $kg.m^2$ [-1.92 to -1.38], p<0.0001) (11). Our data was limited to stratify the analysis by type of active commuting (walking or cycling), as the questionnaire used to collect such information does not include separate question for cycling and walking. However our study provides some evidence that even relatively low levels of active commuting (<30 $mins.day^{-1}$) may be beneficial for markers of adiposity, compared to people who do not actively commute.

The association between active commuting and incidence of T2D has been previously reported, but remains equivocal. In Finnish adults, >30 mins per day active commuting (defined as walking or cycling) reduced risk of T2D by 36% (HR: 0.64 [0.45 to 0.92]) compared to non-active commuters; and >21 minutes of walking to work per day reduced the likelihood of T2D in Japanese men by 27% (OR: 0.73 [0.58 to 0.92])(28, 29). Despite this, another study of Japanese men reported that walking to work was not associated with incidence of T2D, regardless of how many $mins.day^{-1}$ were reported (13). Our data provides novel evidence of the associations between active commuting and prevalent T2D in a Latin American cohort, and suggests that even low levels of active commuting

may be protective against T2D and metabolic syndrome in this population. Other studies conducted in low to middle-income countries (China, India, Mexico, Ghana, Russia and South Africa) (15, 16), have reported that use of active travel for ≥150 min per week is more common in lower socio-economic groups and appears to confer similar health benefits (lower BMI and systolic blood pressure) to those identified in high-income settings (15, 16).

Interestingly, we did not found an association of active commuting with HDL-cholesterol and diastolic blood pressure, which is in disagreement with a previous study were active commuters have shown favourable metabolic health compare to non-active commuters (14). However, a study conducted in Chinese population found no association between active commuting time and diastolic blood pressure or HDL-cholesterol in men although the association was significant for women (30, 31). Up to date, there are limited numbers of studies, which have reported the metabolic benefits of active commuting, most of them up to date have focus on obesity and mortality outcomes (10, 29, 32-36). Due to our study did not collected information about the intensity or type of the active commuting; we cannot discard a potential confounding effect of these variables. Moreover, our analysis were not stratified by sex, therefore we do not know whether the lack of association could by driven my men, as previous studies have reported. However, our analysis did not found a significant commuting*sex interaction, so no major differences should be expected within sex.

What this study adds

Data from the 2010 Chilean National Health Survey showed that >60% of the population participated in some form of active commuting. Active commuting may have important contributions to overall PA in this cohort, as 100% of those who reported >30 mins.day^{-}

[1] of active commuting were meeting the physical activity guidelines. This was compared to only 47.8% of those who reported no active commuting. Policies and infrastructure designed to increase population level active commuting presents major opportunities for preventive public health measures in terms of obesity and cardiometabolic risk.

Limitations of this study

The CNHS offer an opportunity to test our research question in a nationally representative sample of the adult Chilean population. Moreover, the inclusion of a wide range of health, demographic and behavioural variables in the dataset allowed for comprehensive adjustment for the effect of confounding factors. However, a key limitation of this study, in common with much of the literature on active commuting and health, is the somewhat crudely quantified exposure. The CNHS participants were asked to give their time spent on transport-related physical activity, meaning mixed-mode journeys were not captured. It is therefore likely that the people who reported using a form of public transport as their main mode were highly heterogeneous in terms of the levels of physical activity their commutes entailed. The cross-sectional nature of this study provides further limitation. As is the case with any observational study, there is the possibility of reverse causation and residual confounding. While we have attempted to minimise residual confounding through adjustment for multiple confounding lifestyle factors, our results do not imply a causative relationship, and further well controlled studies are required to investigate this.

In conclusion, the present data shows a clear association between active commuting and lower adiposity and odds for cardiovascular risk factors, independent of major potential confounding factors. Thus, interventions to increase active commuting could be

considered as part of strategies to increase physical activity levels in the population and therefore reduce the population burden of cardiometabolic disorders.

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Competing interests

None

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446 Table 1. Cohort characteristic by active commuting categories.

	Active commuting (min.day^{-1})			
	None	**<30**	**30-60**	**>60**
Socio-demographics				
n	1794	1469	770	1260
Women, n (%)	1.110 (61.8)	896 (60.9)	446 (57.9)	691 (54.8)
Age (years) mean (SD)	49.4 (19.3)	45.7 (18.9)	44.8 (17.)	43.7 (17.6)
Education, n (%)				
< 8 years	547 (30.6)	393 (26.9)	175 (22.7)	293 (23.3)
8 to 12 years	956 (53.5)	760 (52.1)	442 (57.4)	725 (57.6)
>12 years	284 (15.9)	304 (20.9)	153 (19.9)	241 (19.1)
Anthropometric				
Weight (kg), mean (SD)	72.2 (14.8)	71.1 (14.9)	71.4 (14.9)	71.8 (14.6)
BMI (kg.m^{-2}), mean (SD)	28.2 (5.3)	27.6 (5.3)	27.6 (5.5)	27.6 (5.3)
BMI categories, n (%)				
<18.5 kg.m^{-2}	22 (1.4)	20 (1.5)	13 (1.9)	26 (2.3)
18.5–24.9 kg.m^{-2}	430 (26.6)	402 (30.0)	213 (30.8)	347 (30.1)
25.0–29.9 kg.m^{-2}	636 (39.3)	551 (41.1)	287 (41.5)	455 (39.5)
≥30.0 kg.m^{-2}	529 (32.7)	369 (27.5)	179 (25.9)	325 (28.2)
Waist circumference (cm), mean (SD)	97.4 (12.8)	96.3 (12.7)	95.5 (11.9)	95.2 (12.1)
Central obesity, n (%)	1211 (74.0)	935 (69.4)	456 (65.5)	761 (65.7)
Lifestyle				

Total PA (METs.h^{-1}.week^{-1}), mean (SD)	73.1 (128.7)	104.8 (131.4)	143.5 (154.3)	189.6 (146.4)
Active commuting (min.day^{-1}), mean (SD)	0 (0)	17.5 (8.4)	49.4 (9.5)	167.8 (116.4)
Moderate PA (min.day^{-1}), mean (SD)	78.2 (142.9)	112.2 (148.2)	123.9 (153.3)	119.4 (152.2)
Vigorous PA (min.day^{-1}), mean (SD)	39.2 (111.6)	47.4 (118.2)	67.1 (141.1)	59.5 (124.9)
Sitting time (h.day^{-1}), mean (SD)	3.65 (2.5)	3.47 (2.9)	2.97 (2.3)	3.24 (2.5)
Physical inactivity, n (%)	948 (52.8)	286 (19.5)	0 (0)	0 (0)
Smoking, n (%)				
Never	783 (43.7)	590 (40.6)	313 (40.7)	493 (39.1)
Ex-smoker	428 (23.9)	351 (24.1)	187 (24.3)	302 (23.7)
Smoker	582 (32.5)	513 (35.3)	270 (35.1)	465 (36.9)
Fruit and vegetable (g.day^{-1}), mean (SD)	213.5 (138.6)	214.4 (136.1)	210.9 (132.9)	219.9 (142.1)
Alcohol intake (g.day^{-1}), mean (SD)	55.1 (110.2)	52.9 (88.4)	47.2 (50.5)	56.7 (89.2)
Salt intake, (g.day^{-1}), mean (SD)	9.75 (3.1)	9.82 (3.1)	9.73 (2.8)	9.67 (2.6)
Metabolic and health outcomes				
Systolic Blood pressure (mmHg), mean (SD)	129.4 (23.5)	127.1 (23.1)	126.7 (21.8)	125.6 (20.7)
Diastolic Blood pressure (mmHg), mean (SD)	76.1 (11.2)	75.8 (11.2)	75.9 (10.9)	76.1 (11.3)
Glucose (mmol.l^{-1}), mean (SD)	5.43 (1.8)	5.34 (1.8)	5.36 (1.7)	5.22 (1.4)

Total Cholesterol ($mmol.l^{-1}$), mean (SD)	5.08 (1.1)	5.03 (1.1)	5.01 (1.1)	4.97 (1.11)
HDL-cholesterol ($mmol.l^{-1}$), mean (SD)	1.23 (0.3)	1.22 (0.3)	1.22 (0.3)	1.21 (0.3)
Triglycerides ($mmol.l^{-1}$), mean (SD)	1.71 (1.3)	1.69 (1.2)	1.58 (1.2)	1.70 (1.5)
T2D, n (%)	230 (14.3)	142 (11.0)	75 (11.1)	91 (8.0)
Metabolic Syndrome, n (%)	375 (42.4)	236 (33.1)	206 (32.8)	111 (29.9)
Hypertension, n (%)	593 (35.5)	442 (32.4)	218 (30.6)	334 (28.8)

447 SD: standard deviation, n: numbers, MET: metabolic equivalent task. Data is presented
448 as mean and SD for continuous variables and number and % for categorical variables.
449 Physical inactivity was defined as <600 $METS.min.week^{-1}$ of moderate-equivalent
450 physical activity.

451

FIGURE LEGENDS

Figure 1 . Association of active commuting time with anthropometric and metabolic markers.

Data is presented as delta and their 95% CI. Non-active commuters are used as reference group. Analyses were adjusted for age, sex, education, smoking, leisure PA, sitting time, fruit and vegetable, salt and alcohol intake. Metabolic markers were additionally adjusted for BMI.

Figure 2. Association of active commuting with obesity, diabetes and metabolic syndrome.

Data is presented as odds ratio and their 95% CI. Non-active commuters are used as reference group. Analyses were adjusted for age, sex, education, smoking, leisure PA, sitting time, fruit and vegetable, salt and alcohol intake. Analysis for T2D and metabolic syndrome were additionally adjusted for BMI.