Is active transport and leisure time physical activity associated with inflammatory markers in US adults:

Cross-sectional analyses from NHANES

Smith, L[a*]., Stubbs, B[bcd]., Hu, L[e]., Veronese, N[f]., Vancampfort, D[g]., Williams, G[h]., Vicinanza, D[i]., Jackson S E.,[j] Ying, L[k]., López-Sánchez, G. F.,[l] Yang, L[m].

[a]The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge

[b]Physiotherapy Department, South London and Maudsley NHS Foundation Trust, Denmark Hill, London SE5 8AZ, United Kingdom

[c] Health Service and Population Research Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, De Crespigny Park, London Box SE5 8AF, United Kingdom

[d] Faculty of Health, Social Care and Education, Anglia Ruskin University, Chelmsford, United Kingdom

[e]Department of Sport Science, Zhejiang University, Hangzhou, China

[f]Consiglio Nazionale delleRicerche Area della Ricerca di Padova, Neuroscience Institut

[g] University Psychiatric Centre Catholic University Leuven, Kortenberg, Belgium

[h]School of Sport and Health Sciences, University of Exeter, UK

[i]Department of Computing and Technology, Anglia Ruskin University, Cambridge, UK

[j]Dept of Behavioural Science and Health, UCL

[k]Department of Health Management, The Third Xiangya Hospital, Central South University, Changsha, Hunan Province, China

[l]Faculty of Sports Sciences, University of Murcia, Spain

[M]Department of epidemiology, Center for Public Health, Kinderspitalgasse 15, 1st floor, Vienna, 1090, Austria.

*Corresponding author: Lee Smith; The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge; lee.smith@anglia.ac.uk.

1

ABSTRACT

Background: To investigate the association between levels of active transport and levels of leisure time physical activity (LTPA) with C-reactive protein (CRP), white blood cell count (WBC), body mass index (BMI),waist circumference (WC), and lipids, in a large representative sample of adults residing in the US.

Methods: Cross-sectional data fromthe National Health and Nutrition Examination Survey (NHANES). Adjusted multinomial logistic regressions were carried out to quantify associations between levels of self-reported active transport (or LTPA) and quintiles of anthropometric measures and serum markers.

Results: 3,248 adults were included. For serum inflammatory biomarkers, we observed a lower likelihood of being in the top quintile groups of circulating CRP (aOR: 0.60, 95%CI: 0.40 to 0.90) and WBC (aOR: 0.65, 95%CI: 0.44 to 0.95) with engaging in low to medium levels active transport, but not with higher levels of active transport. Higher levels of LTPA were associated with lower likelihood of having high levels of serum inflammatory biomarkers (aOR: 0.60, 95%CI: 0.42 to 0.86 in the top CRP group; aOR: 0.58, 95%CI: 0.39 to 0.87 in top WBC group).

Conclusions: Promoting active transport and/or LTPA may be a beneficial strategy to improving some, but not all, cardio-metabolic health outcomes.

Key words: Active transport; adult; cross-sectional; inflammatory markers.

Introduction

Regular and sustained participation in physical activity aids in the prevention of non-communicable diseases and associated risk factors[1-2]. Adults can achieve adequate levels of physical activity (30 minutes

2

a day on 5 days a week at at least moderate intensity) through a variety of domains. Two key domains include leisure time physical activity (LTPA) and active travel (i.e. walking and cycling). While there is sufficient evidence to show that overall physical activity is beneficial for physical health[1-2], domain specific benefits are known to a lesser extent.

Overall physical activity may have beneficial anti-inflammatory effects as evidence from epidemiological studies has consistently demonstrated an inverse association between physical activity and markers of low grade systemic inflammation[3-5]. The anti-inflammatory effects of exercise may partly explain the well-documented cardio-protective effects of physical activity[6-8]. An important and well-studied inflammatory marker is C-Reactive Protein (CRP), a protein found in blood plasma. The level of CRP, which can be measured in your blood, increases when there's inflammation in your body. Importantly, CRP has been shown to be inversely associated with physical activity[9]and it has been shown to predict, independently of conventional risk factors, coronary heart disease (CHD) and cardiovascular disease (CVD) mortality in the general population and also in patients with type 2 diabetes[10, 11]. Another important and studied inflammatory marker is total white blood cell count (WBC). A low WBC (leukopenia) is a decrease in disease-fighting cells (leukocytes) in the blood.WBC has been shown to have an inverse association with overall physical activity and to be independently associated withnon-communicable diseases, such as CHD (e.g. see [12]).

A recent systematic review [13] on the associations between active transport and health (including a total of 24 studies from 12 countries, 15 of which included adult samples)concluded that active transport may have positive effects on health outcomes. However, the review identified just one study investigating the association between active transport and lipid levels and showingan increase in HDL cholesterol but no changes in serum total cholesterol or triglyceride concentrations[14]. Further research is required to confirm or refute these findings. Another systematic review investigated the association between active transport and adiposity in adults and the review concluded that there is limited evidence that active transport is

associated with more physical activity as well as lower body weight[15]. However, study heterogeneity and crude measures for active transport and physical activity impede quantitative conclusions[15]. Interestingly, to our knowledge, few studies have investigated associations between active transport and the inflammatory markers CRP and WBC. With regard to associations between LTPA and health, one systematicreview[16] was identified exploring associations between LTPA and incident metabolic syndrome. This review included 16 articles and found that any amount of LTPA is better than none and that LTPA substantially exceeding the current physical activity guidelines is associated with an additional reduction in metabolic syndrome risk[16]. However, few studies have investigated such associations of LTPA with inflammatory biomarkers WBC and CRP.

Considering the current gaps in the literature, the present study asked the question: what are the relationships between active transport and levels of LTPA with inflammatory markers in US adults? The aim of the present study was to investigate the association between levels of active transport and levels of LTPA with CRP, WBC, body mass index (BMI), waist circumference(WC), and lipids, in a large representative sample of adults residing in the US. We hypothesized that lower levels of active travel or lower levels ofLTPA would be associated with unfavourable cardiometabolic risk factor outcomes.

METHODS

Study Population

Cross-sectional analyses using data from the National Health and Nutrition Examination Survey (NHANES) were carried out. The National Health and Nutrition Examination Survey (NHANES) was designed to provide cross-sectional estimates on the prevalence of health, nutrition, and potential risk factors among the civilian non-institutionalized U.S. population up to 85 years of age[17]. In brief, NHANES surveys a nationally representative complex, stratified, multistage, probability clustered sample of about 5,000

participants each year in 15 counties across the country. Survey participants were asked to attend a physical examination in a mobile examination centre (MEC) or in the participants' home. The NHANES obtained ethical approval from the National Centre for Health Statistics Research Ethics Review Board and participants provided written informed consent.

We extracted demographic information, employment status, measures of adiposity, drinking and smoking history, self-reported LTPA, self-reported walking and cycling for travel, and inflammatory and lipid biomarkers and combined them into a single dataset for each data collection wave. We created a single dataset for each wave of data from NHANES 2007-2008 and 2009-2010, and excluded those who were younger than 20 years old or were pregnant, or unable to walk for a quarter mile.

Active transport

Participants self-reported their active transport behaviour in the 2007-2008 and 2009-2010 waves. Participants were asked if they walk or use a bicycle for at least 10 minutes continuously to get to and from places (to work, for shopping, to school). Participants who answered "no" to this question were classified as non-active transporters (zero minutes/week active transport). For those who answered "yes", they were further asked about activity frequency ("In a typical week, on who many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?"), and duration ("How many times do you spend walking or bicycling for travel on a typical day?"). Levels of active transport were calculated as the weekly minutes that participants reported participating in walking or cycling by multiplying the number of days participants walked or bicycled by their daily duration. Travel mode was defined as non-active transport (zero minutes/week active transport)[18], low level of active transport (<150 minutes/week), and high level of active transport (≥ 150 minutes/week).

Anthropometry

Weight and height were measured at the time of physical examinations at the MEC. The measurements followed standard procedures and were carried out by trained technicians using standardized equipment. BMI was calculated as weight in kg/(height in meters)^2. We categorized study participants into standard BMI categories: underweight (<18.5kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0 – 29.9 kg/m^2), and obese (≥30.0 kg/m^2). For analytic purposes, we combined underweight and normal weight participants (≤25 kg/m^2)[19]. Waist circumference was measured according to the WHO procedures in centimetres.

Serum inflammatory biomarkers and lipid markers

The process of blood collection is detailed in the NHANES Laboratory/Medical Technologist Procedures Manual[20]. Circulating CRP was quantified by latex-enhanced nephelometry with a Behring Nephelometer Analyzer System. CRP levels were categorized to low (<1.0 mg/L), moderate (1.0 –3.0 mg/L), and high (>3.0 mg/L)[21]. Individuals with CRP levels ≥10 mg/L were excluded since this may represent an acute infective episode.WBC were counted with Coulter HMX Hematology Analyzer, a quantitative, automated hematology analyzer and leukocyte differential cell counter for In Vitro diagnostic use in clinical laboratories. Serum high-density lipoprotein cholesterol (HDL-C), total cholesterol and triglycerides were determined enzymatically on Roche Modular P chemistry analyzer (Roche Diagnostics, 9115 Hague Road, Indianapolis, IN 46250). Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula by subtracting HDL-C and triglycerides/5 from total cholesterol, which restricted the sample to triglycerides values less or equal to 400/mg/dL for validity[22].

Socio-demographic characteristics

Socio-demographic characteristics including age, gender, race and ethnicity, education, marital status, smoking and drinking behaviour, ratio of family income to poverty, employment status, and chronic illness were extracted. Based on self-reported race and ethnicity, participants were classified into one of the

three racial/ethnic groups: Non-Hispanic White, Non-Hispanic Black, and Hispanic and others. Education levels were classified into four groups: less than 12th grade, high school, some college, and college graduate or above. Participants' marital status were summarized into two groups: live with someone (married, and living with partner), and live alone (widowed, divorced, separated, never married). Based on self-reported occupation, we created a binary variable for employed (working at a job or business, with a job or business but not at work) and unemployed (looking for work, not working at a job or business). Ratio of family income to poverty was used as an indicator of socioeconomic status was categorized to six groups (<1, 1-1.9, 2-2.9, 3-3.9, 4-4.9, 5 and above). Alcohol consumption was classified into never drinker, one or more drink per week, and more than one drink per week. Finally, we classified participants into three groups: never smokers (did not smoke 100 cigarettes and do not smoke now), former smokers (smoked 100 cigarettes in life and do not smoke now), and current smokers (smoked 100 cigarettes in life and smoke now).

Self-reported leisure-time physical activity (LTPA)

Participants self-reported their daily activities and leisure time activities using questions based on the Global Physical Activity Questionnaire (GPAQ)[23]. Levels of LTPA were calculated as the minutes per week that participants reported participating in moderate-to-vigorous-intensity physical activity (MVPA). Participants reported the number of days and minutes spent in moderate recreational and vigorous recreational activities in a typical week, by answering questions "In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational activities?", "Minutes vigorous recreational activities", "In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational activities?", and "Minutes moderate recreational activities". We summarized the total number of minutes for both activities, where the number of minutes spent in vigorous-intensity physical activity were doubled and added to the number of minutes of moderate-intensity physical activity to approximately equivalent the MET value[24]. Participants were classified as inactive (zero min/week MVPA),

insufficiently active (<150 min/week MVPA), and sufficiently active (≥150 min/week MVPA) based on the

WHO physical activity guidelines[25].

STATISTICAL ANALYSIS

Survey analysis procedures were used to account for the sample weights (MEC exam weight), stratification, and clustering of the complex sampling design to ensure nationally representative estimates. We included participants with completed information on active transport behaviour, socio-demographic characteristics, self-reported LTPA, anthropometric measures and serum markers. A total of 3,248 adults provided sufficient data for analyses. We calculated the descriptive statistics for participants' characteristics, LTPA categories,anthropometric measures and serum markers by their active transport status. We summarized weighted means and standard errors for continuous variables, and weighted proportions for categorical variables.

Multinomial logistic regressions were carried out to quantify associations between levels of self-reported active transport (or LTPA)and quintiles of anthropometric measures and serum markers. The multivariable models were adjusted for age, gender, race and ethnicity, education level, marital status, smoking and drinking status, ratio of family income to poverty, employment status, chronic illnesses and self-reported LTPA (or active transport) for anthropometric measures, and additionally adjusted for BMI for serum inflammatory and lipid makers. Results from the logistic regression models are presented as odds ratios (ORs) with 95% confidence intervals (95%CIs). Further sensitivity analyses were carried out using multivariable linear regression treating anthropometric measures and serum makers as continuous variables. All statistical significance was set at $p<0.05$. All statistical analyses were performed using Stata version 14.0 (STATA Corp., College Station, Texas, USA).

RESULTS

A total of 3,248 adults aged 20 years or older (mean age 46 years (SE 0.45)) had sufficient data on travel behaviour, LTPA, anthropometry measure, serum inflammatory biomarker and lipid markers, and covariates. Of these, we excluded participants who were pregnant or with physical function limitation by reporting "unable to do" to the question "walking for a quarter mile difficulty". Our study population consisted of 3,139 adults with completed data. The majority of the study population did not engage in active transport (74.7%). Our analyzed sample are middle aged adults (mean age 46.0±0.4 years), and overweight (mean BMI 27.7±0.1 kg/m^2). We observed statistically significant differences between non-active travellers and active traveller for most characteristics, except for smoking behaviour, employment status, and serum LDL cholesterol, total cholesterol and triglycerides levels (Table 1).

<u>Associations of active transport with anthropometry measures, serum inflammatory biomarkers and lipid markers</u>

Tables 2 to 4 summarize both the adjusted association of levels of active transport and LTPA with anthropometry measures, serum inflammatory biomarkers and lipid makers. For anthropometry measures, engaging in high levels of active transport (≥150 minutes/week) had lower likelihood of being in the top quintile of BMI (aOR: 0.62, 95%CI: 0.41 to 0.91) and waist circumference (aOR: 0.51, 95% CI: 0.31 to 0.83) groups. These associations were also seen by engaging in higher LTPA (≥150 minutes/week), yet with slightly stronger effects (aOR: 0.42, 95%CI: 0.28 to 0.63) in the top BMI group; aOR: 0.37, 95% CI: 0.25 to 0.61 in top waist circumference group). For serum inflammatory biomarkers, we observed a lower likelihood of being in the top quintile groups of circulating CRP (aOR: 0.60, 95%CI: 0.40 to 0.90) and WBC count (aOR: 0.65, 95%CI: 0.44 to 0.95) with engaging in 1-149 min/week active transport, but not with higher levels of active transport. Higher levels of LTPA (≥150 minutes/week) were associated with lower likelihood of having high levels of serum inflammatory biomarkers (aOR: 0.60, 95%CI: 0.42 to 0.86 in the top CRP group; aOR: 0.58, 95% CI: 0.39 to 0.87 in top WBC group). With respect to lipids markers, no association was seen for levels of active transport orLTPA. Sensitivity analyses using multivariable linear regression models with anthropometric measures and serum markers as continuous variables showed same results (supplementary tables 1-3).

Discussion

In this large representative sample of US adults, we found thathigher levels of active transport and higher levels of LTPA were associated with lower levels of adiposity, lower levels of CRP, and lower levels of WBC, after adjustment for important confounding variables. Interestingly, no associations were found with lipids. These findings support and add to previous literature demonstrating that

overallphysical activity is associated with the positive health outcomes,lower levels of adiposity and lower levels of inflammatory biomarkers[3-5].

The relationship between physical activity and adiposity is one that is known intimately and a key mechanism driving the association is the increase in daily energy expenditure[26]. Importantly, present findings show that both active transport and LTPA are associated with a reduction in WC. WC in particular has been shown to have a strong association with Type II diabetes and metabolic syndrome[12].Our results support those by others that suggest a reduction in adiposity can be achieved by an increase in active transport or an increase in LTPA[13-16]. Mechanisms resulting in lower levels of WBC and CRP from sustained participation in physical activity are not well understood, and further work in this area is required. However, epidemiologic data suggest that better fitness is associated with reduced total WBC due to lower counts in all WBC subclasses[27, 28]. Additionally, lower BMI has been shown to be associated with reduced total WBC and, in particular, neutrophil, lymphocyte, monocyte, and basophil counts[29]. Physical activity is related to several confounders that are independently associated with lower CRP levels. For example, physical activity is inversely related to age, smoking, hypertension, BMI, and waist-to-hip ratio, total and non-high-density lipoprotein cholesterol, triglycerides, and apolipoprotein B concentrations, whereas these factors are directly related to CRP concentrations[30]. Targeting LTPA and/ or active transport may be effective strategies in lowering levels of inflammatory biomarkers, as well as adiposity.

Interestingly, the present study showed that those engaging in 1-149 min/week active transport had lower levels of serum inflammatory biomarkers but not those engaging in the highest levels of active transport. The exact rationale behind this is not known and a plausible explanation is elusive. However, it may be that those who are participating in exceptionally high levels of active transport are experiencing the negative effects of exercise stress on increasing inflammatory markers. Further research is required to test this hypothesis.

In the present study no associations were found between active transport and markers of lipids. It may be that the activity domains LTPA and active transport arenot sufficient to yield a favourable lipid profile and indeed an increase in overall physical activity is required. However, an improvement in HDL has been observed in relation to higher levels of active transport and LTPA in previous studies[13,16]. Further research in other populations, using longitudinal designs, to understand differences observed between studies is warranted.

Key strengths of this study are the large sample representative of the U.S. adult population, objective measures of physical activity and assessment of active transport for any purpose rather than just for commuting. However, the study is not without limitations. The cross-sectional design prohibits attributing causality to the associations between active transport,LTPA and health outcomes. Further investigation using a prospective or experimental study design is needed to refute/confirm our results. Since outcomes were based on self-report, reporting biases may exist. It is for example known that self-reported walking and cycling might be subject to recall and social desirability biases, a limitation compounded by the use ofquestions that are potentially cognitively challenging.Future research should utilize objective measures of time spent walking or cycling for travel purposes or time spent physically active during leisure time. The measure of travel mode was relatively crude and did not allow multi-modal trips or the daily breakdown of travel behaviour to be ascertained. Public transport use was not measured and travelling by public transport usually includes some walking (e.g. walking to the bus station or waking from the train station to one's destination).

The present study in a large representative sample of US adults suggests that promoting active transport and/ or LTPA may be a beneficial strategy to improving some, but not all, cardiometabolic health outcomes. Specifically, higher levels of active transport and higher levels of LTPA were associated with lower levels of adiposity, lower levels of CRP, and lower levels of WBC. However, no associations with lipids were found.

References

1.Ekelund U, Franks PW, Sharp S, Brage S, Wareham NJ. Increase in physical activity energy expenditure is associated with reduced metabolic risk independent of change in fatness and fitness. *Diabetes Care*.2007;30:2101–2106.

2. Manini TM, Everhart JE, Patel KV, et al. Daily activity energy expenditure and mortality among older adults. *JAMA*.2006;296:171–179.

3. Gleeson M, Bishop NC, Stensel DJ, Lindley MR, Mastana SS, Nimmo MA. The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. *Nat. Rev. Immunol*. 2011;11:607-615

4. Hamer M. The relative influence of fitness and fatness on inflammatory factors. *Prev. Med*.2007;44:3-11.

5. Hamer M, Sabia S, Batty GD, Shipley MJ, Tabák AG, Singh-Manoux A, Kivimaki M. Physical activity and inflammatory markers over 10 years: follow-up in men and women from the Whitehall II cohort study. *Circulation*.2012;126:928-933.

6. Hamer M, Stamatakis E. Physical activity and risk of cardiovascular disease events events: inflammatory and metabolic mechanisms. *Med. Sci. Sports Exerc*.2009;41:1206-1211.

7. Mora S, Cook N, Buring JE, Ridker PM, Lee IM. Physical activity and reduced risk of cardiovascular events: potential mediating mechanisms. *Circulation*.2007;116:2110-2118.

8. Rana JS, Arsenault BJ, Després JP, et al. Inflammatory biomarkers, physical activity, waist circumference, and risk of future coronary heart disease in healthy men and women. *Eur. Heart J*.2011;32:336-344.

9. Kasapis C, Thompson P. The effects of physical activity on serum C-reactive protein and inflammatory markers: A systemative Review. *JACC*.2005;45:1563-1569.

10. Ridker P, Cushman M, Stampfer MJ, Tracy RP, Hennekens CH. Inflammation, asprin, and the risk of cardiovascular disease in apparently healthy men. *N Engl J Med*.1997;336:973-979.

11. Soinio M, Marniemi J, Laasko M, Lehto S, Ronnemaa T. High-sensitivity C-reactive protein and coronary heart disease mortality in patients with type 2 diabetes: a 7-year follow-up study. *Diabetes Care*.2006;29:329-333.

12. Twig G, Afek A, Shamiss A, Derazne E, Tzur D, Gordon B, Tirosh A. White blood cell count and the risk of coronary heart disease in young adults. *Plos One*.2012;7:e47183.

13. Saunders L, Green J, Petitcrew M, Steinbach R, Roberts H. What are the health benefits of active travel? A systematic review of trials and cohort studies. *Plos One*.2013;8:e69912.

14. Oja P, Vuori I, Paronen O. Daily walking and cycling to work: their utility as health enhancing physical activity. *PEC*.1998;33:87-94.

15. Wanner M, Gotschi T, Martin-Diener E, Kahlmeier S, Martin B. Active transport, physical activity, and body weight in adults. *AJPM*.2012;42:493-502.

16. Zhang D, Liu X, Liu Y, et al. Leisure-time physical activity incident metabolic syndrome: a systematic review and dose-response meta-analysis of cohort studies. *Metab. Clin. Exp*.2017;75:36-44.

17. Centers for Disesae Control and Prevention. *National Health and Nutrition Examination Survey*. http://www.cdc.gov/nchs/nhanes.htm. Accessed June 21, 2016.

18. Furie GL, Desai MM. Active transportation and cardiovascular disease risk factors in U.S. adults. *Am J Prev Med*.2012;43:621-628.

19. World Health Organization. *Obesity: preventing and managing the global epidemic. Report of a WHO consultation.* World Health Organization technical report series 2000;894:i-xii,1-253.

20. Centers for Disesae Control and Prevention. *NHANES Laboratory/Medical Technologists Procedures Manua* -https://www.cdc.gov/nchs/data/nhanes/nhanes_09_10/lab.pdf

21. Myers GL, Rifai N, Tracy RP,et al. CDC/AHA Workshop on Markers of Inflammation and Cardiovascular Disease: Application to Clinical and Public Health Practice: report from the laboratory science discussion group. *Circulation*. 2004;110:e545-9.

22. Nilsson G, Hedberg P, Ohrvik J. Inflammation and the metabolic syndrome: clustering and impact on survival in a Swedish community-based cohort of 75 year olds. *MetabSyndrRelatDisord*.2013;11:92-101.

23. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*.2012;380:247-257.

24. Zhao G, Li C, Ford ES, et al. Leisure-time aerobic physical activity, muscle-strengthening activity and mortality risks among US adults: the NHANES linked mortality study. *Br J Sports Med*.2014;48:244-249.

25. World Health Organization. *Global recommendations on physical activity for health*. 2010.

26. Smith L, Ekelund U, Hamer M. The potential yield of non-exercise physical activity energy expenditure in public health. *Sports Medicine*.2015;45:449-452.

27. Johannsen NM, Priest EL, Dixit VD,et al. Association of white blood cell subfraction concentration with fitness and fatness. *Br J Sports Med*.2010;44:588–593.

28. Church TS, Finley CE, Earnest CP,et al. Relative associations of fitness and fatness to fibrinogen, white blood cell count, uric acid and metabolic syndrome. *Int J Obes (Lond)*.2002;26:805–813.

29. Kakanis MW, Peake J,Brenu EW,et al. The open window of susceptibility to infection after acute exercise in healthy young male elite athletes. *Exerc Immunol Rev*. 2010;16:119–137.

30. Ford ES. Does exercise reduce inflammation? Physical activity and C-reactive protein among U.S. adults. *Epidemiology*. 2002;13:561-568.

Table 1. Socio-demographic characteristics and physical activity levels of adults (20 years or older) from the NHANES (207–2010), by travel behaviour		Zero Active Travel	Lower Level Active Travel (<150 min/week)	High Level Active Travel (≥150 minutes/week)	p-value
	N	2,344	351	444	
	Weighted Nᵃ	111,450,154	15,443,711	19,385,234	
Age (year)	Mean (s.e.)	47.2 (0.5)	42.8 (1.3)	41.7 (1.0)	<.001
Gender					0.002
Men	%	49.0	51.8	59.5	
Women	%	51.0	48.2	40.5	
BMI					0.05
<24.9	%	33.9	35.9	42.0	
25.0 – 29.9	%	35.7	34.6	35.7	
≥ 30	%	30.4	29.5	22.3	
Race					0.02
Non-Hispanic White	%	73.2	66.3	65.8	
Non-Hispanic Black	%	9.5	14.5	12.8	
Hispanic and other	%	17.3	19.2	21.4	
Education					<.001
Less than 12th grade	%	16.1	11.5	34.9	
High School	%	24.4	21.3	13.8	
Some college	%	29.2	28.5	34.4	
College graduate or above	%	30.3	38.7	27.9	
Marital status					0.02
Live with someone	%	65.7	57.7	57.9	
Live alone	%	34.3	42.3	42.1	
Smoking					0.77
Never smoker	%	55.9	59.6	56.8	

Former smoker	%	24.6	22.4	22.6	
Current smoker	%	19.5	18.0	20.6	
Alcohol consumption					0.07
Never	%	26.1	22.9	18.8	
≤1 drink per week	%	44.0	40.9	44.6	
>1 drink per week	%	29.9	37.2	36.6	
Ratio of family income to poverty					0.02
<1	%	10.8	16.2	20.1	
1-1.9	%	18.2	20.4	19.4	
2-2.9	%	17.3	10.5	18.5	
3-3.9	%	13.8	15.0	10.5	
4-4.9	%	11.9	12.3	7.6	
≥ 5	%	28.0	25.6	23.9	
Employment status					0.21
Employed	%	68.4	62.3	67.7	
Unemployed	%	31.6	37.7	32.3	
Chronic illness					0.001
Yes	%	36.3	29.7	24.1	
No	%	63.7	70.3	75.9	
Leisure time physical activity (LTPA)					0.009
Inactive	%	44.4	35.8	44.3	
Insufficiently Active	%	17.2	21.9	10.6	
Sufficiently Active	%	38.4	42.3	45.1	
Waist circumference (cm)	Mean (s.e.)	96.7 (0.4)	95.6 (1.1)	94.1 (0.9)	0.01
Circulating CRP (mg/L)	Mean (s.e.)	2.20 (0.05)	1.97 (0.1)	1.91 (0.1)	0.02
White Blood cell count (1000 cells/uL)	Mean (s.e.)	6.54 (0.1)	6.16 (0.1)	6.25 (0.1)	0.008
HDL cholesterol (mg/dL)	Mean (s.e.)	117.0 (0.9)	111.7 (2.3)	115.7 (2.6)	0.40
LDL cholesterol (mg/dL)	Mean (s.e.)	54.5 (0.5)	55.0 (1.5)	54.7 (0.9)	0.75
Total cholesterol (mg/dL)	Mean (s.e.)	197.0 (1.1)	190.8 (2.5)	194.7 (2.8)	0.25

| Triglycerides (mg/dL) | Mean (s.e.) | 129.4 (2.5) | 122.3 (5.4) | 126.3 (5.5) | 0.45 |

[a]Weighted sample size to account for the complex survey design (including oversampling), survey non-response, and post-stratification in the NHANES study.

Table 2: Adjusted odds ratios of being in the top quintile of anthropometric measures associated with time spend in active travel and leisure time physical activity (LTPA)

	Body mass index	Waist circumference
Time spent in active travel		
Zero min/wk		
1-149 min/wk	1.04 (0.63 to 1.71)	1.05 (0.62 to 1.78)
>-150 min/wk	0.62 (0.41 to 0.91)	0.51 (0.31 to 0.83)
LTPA		
Zero min/wk		
1-149 min/wk	0.69 (0.44 to 1.06)	0.70 (0.38 to 1.28)
>-150 min/wk	0.42 (0.28 to 0.63)	0.39 (0.25 to 0.61)
Adjusted for age, gender, race and ethnic group, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).		

Table 3: Adjusted odds ratios of being in the top quintile of serum inflammation biomarkers associated with time spend in active travel and leisure time physical activity (LTPA)

	Circulating CRP	White Blood cell count
Time spent in active travel		
Zero min/wk		
1-149 min/wk	0.60 (0.40 to 0.90)	0.65 (0.44 to 0.95)
>-150 min/wk	0.79 (0.49 to 1.27)	0.64 (0.39 to 1.04)
LTPA		
Zero min/wk		
1-149 min/wk	0.86 (0.56 to 1.32)	0.72 (0.44 to 1.17)
>-150 min/wk	0.60 (0.42 to 0.86)	0.58 (0.39 to 0.87)
Adjusted for age, gender, race and ethnic group, BMI, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).		

20

Table 4Adjusted odds ratios of being in the top quintile of lipids markers associated with time spend in active travel and physical activity

	HDL cholesterol	LDL cholesterol	Total cholesterol	Triglycerides
Time spent in active travel				
Zero min/wk				
1-149 min/wk	1.03 (0.63 to 1.66)	0.60 (0.32 to 1.13)	0.78 (0.45 to 1.36)	1.09 (0.65 to 1.82)
>-150 min/wk	0.99 (0.59 to 1.65)	0.95 (0.56 to 1.60)	1.03 (0.67 to 1.59)	0.92 (0.58 to 1.45)
LTPA				
Zero min/wk				
1-149 min/wk	0.98 (0.58 to 1.65)	0.97 (0.66 to 1.44)	0.78 (0.45 to 1.36)	0.95 (0.58 to 1.57)
>-150 min/wk	1.46 (0.97 to 2.20)	0.97 (0.63 to 1.48)	1.03 (0.57 to 1.46)	0.86 (0.59 to 1.24)
Adjusted for age, gender, race and ethnic group, BMI, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).				

Supplementary table 1: Adjusted beta-coefficients of anthropometric measures associated with time spend in active travel and leisure time physical activity (LTPA)

	Body mass index	Waist circumference
Time spent in active travel		
Zero min/wk		
1-149 min/wk	-0.12 (-0.91 to 0.87)	-0.20 (-2.54 to 2.14)
>-150 min/wk	-0.86 (-1.55 to -0.16)	-2.03 (-3.84 to -0.22)
LTPA		
Zero min/wk		
1-149 min/wk	-0.97 (-1.81 to -0.13)	-1.97 (-4.19 to 0.25)
>-150 min/wk	-1.71 (-2.39 to -1.02)	-4.45 (-6.01 to -2.88)
Adjusted for age, gender, race and ethnic group, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).		

Supplementary table 2: Adjusted beta-coefficients of serum inflammation biomarkers associated with time spend in active travel and leisure time physical activity (LTPA)

	Circulating CRP	White Blood cell count
Time spent in active travel		
Zero min/wk		
1-149 min/wk	-0.15 (-0.39 to 0.08)	-0.31 (-0.51 to -0.11)
>-150 min/wk	-0.05 (-0.30 to 0.20)	-0.27 (-0.49 to -0.05)
LTPA		
Zero min/wk		
1-149 min/wk	0.03 (-0.25 to 0.32)	-0.13 (-0.34 to 0.08)
>-150 min/wk	-0.22 (-0.39 to -0.05)	-0.214 (-0.40 to -0.02)
Adjusted for age, gender, race and ethnic group, BMI, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).		

Supplementary table 3: Adjusted beta-coefficients of lipids markers associated with time spend in active travel and physical activity

	HDL cholesterol	LDL cholesterol	Total cholesterol	Triglycerides
Time spent in active travel				
Zero min/wk				
1-149 min/wk	0.22 (-1.86 to 2.31)	-3.09 (-8.35 to 2.17)	-3.37 (-9.01 to 2.27)	-2.31 (-9.86 to 5.23)
>-150 min/wk	0.43 (-1.16 to 2.01)	-0.05 (-5.49 to 5.39)	0.95 (-5.25 to 7.15)	2.72 (-6.32 to 11.76)
LTPA				
Zero min/wk				
1-149 min/wk	-0.25 (-1.97 to 1.47)	1.04 (-3.09 to 5.17)	0.85 (-3.88 to 5.58)	0.27 (-7.67 to 8.21)
>-150 min/wk	1.24 (-0.28 to 2.76)	-0.16 (-5.21 to 4.88)	0.48 (-5.09 to 6.05)	-2.96 (-9.18 to 3.26)
Adjusted for age, gender, race and ethnic group, BMI, education level, marital status, smoking status, drinking behavior, ratio of family income to poverty, employment status, chronic illness condition, and leisure time physical activity (or active transport).				