Journal of Public Health (2023) 31:1867–1874
https://doi.org/10.1007/s10389-022-01752-w

ORIGINAL ARTICLE

Active commuting associations with BMI and self-rated health: a cross-sectional analysis of the Healthy Ireland survey

A. M. Masterson[1] · C. M. Phillips[1]

Received: 28 May 2022 / Accepted: 23 August 2022 / Published online: 8 September 2022

Abstract
Aim Active travel is advised to help meet recommended weekly physical activity levels. However limited research has examined active travel associations with health indicators. The aim of this study is to investigate active commuting associations with BMI and self-rated health (SRH) using data from the Healthy Ireland Survey.
Subjects and methods Cross-sectional analysis of data was conducted from a nationally representative study of the Irish population. Participants who worked or attended education ($n=4038$) provided information regarding their most common travel mode to work or education and demographic, lifestyle and health characteristics during an interview. Following comparative analysis, multivariable logistic regression was used to investigate associations between active commuting modes and overweight, obesity and SRH.
Results Active commuting was associated with decreased likelihood of obesity (AOR 0.69, 95% CI = 0.52, 0.90) relative to non-active commuting. Examination of active commuting mode revealed further reduced obesity risk among cyclists (AOR 0.23, 95% CI = 0.09, 0.56) relative to non-cyclists and among those actively travelling ≥3 km (AOR 0.54, 95% CI = 0.30, 0.98). No associations between active commuting and overweight or SRH were observed.
Conclusion Our findings, which indicate an inverse association between active commuting and obesity, represent a significant contribution to the evidence base supporting promotion of active travel for obesity prevention.

Keywords Active commuting · Obesity · Self-rated health · Cross-sectional · BMI

Introduction

Regular physical activity has many health benefits including contributing to prevention of non-communicable diseases and better health-related quality of life, making it an important part of a healthy lifestyle (World Health Organization 2010; Harvey et al. 2018; Bize et al. 2007). Associations between self-reported health (SRH), which is beneficial for both physical and psychological health, and physical activity have also been reported (Hansen et al. 2013; Marques et al. 2018). The World Health Organization (WHO) recommends at least 150 minutes of moderate intensity or 75 minutes of high intensity aerobic physical activity per week to obtain such health benefits (WHO 2010). However these recommendations are not being met. Globally, physical inactivity levels have remained relatively static in the past two decades with over a quarter of adults classified as insufficiently active in 2016 (Guthold et al. 2018). In Western developed countries physical inactivity levels increased by 5.9% between 2001 and 2016 suggesting that the global target of a relative risk reduction of 10% in physical inactivity by 2025 will not be achieved (Guthold et al. 2018).

In 2018 the WHO launched the Global Action Plan on Physical Activity 2018–2030 which set out objectives to tackle individual and social determinants of physical inactivity while recognising the need for a whole system approach across government and sectors (WHO 2018). Increased sedentary occupations, use of technology and motorised transport in developed countries have contributed to physical inactivity (Guthold et al. 2018). Active travel is a form of transportation which requires a degree of physical exertion such as walking, cycling, skateboarding or using a non-motorized wheelchair (Lake et al. 2010). This form of physical activity can enhance health while being potentially convenient, habitual, cost-effective and purposeful. Active

✉ C. M. Phillips
catherine.phillips@ucd.ie

1 School of Public Health, Physiotherapy and Sports Science, University College Dublin, Belfield, Dublin 4, Ireland

travel is being promoted due to the multiple benefits of physical activity on general health such as obesity prevention. Research to date indicates an inverse association between active commuting and BMI, with cycling more strongly related with lower BMI than walking (Laverty et al. 2013; Millett et al. 2013; Mytton et al. 2016a). Additionally, active commuting has been linked with better SRH (Eriksson et al. 2020; Hansen et al. 2013; Neumeier et al. 2020), although none of these studies were conducted in a nationally representative population. There is a lack of research internationally investigating associations between active commuting, obesity and SRH. Therefore, the aim of this study was to investigate active commuting associations with BMI and SRH in the Irish population using data from the nationally representative Healthy Ireland survey.

Methods

Study population

The Healthy Ireland survey uses a representative sample of the population in the Republic of Ireland and is conducted annually to collect information on health and lifestyle behaviours of the Irish population. Multistage probability sampling was used in the Healthy Ireland survey to ensure a representative distribution of sampling points around the Republic of Ireland. In brief, 686 sampling points were created using electoral divisions stratified by region and demographic characteristics with 21 of the divisions containing more than one sampling point due to larger size (Department of Health 2020). The current cross-sectional study population was derived from Wave 3 of the Healthy Ireland survey 2017 which included 7487 in-person interviews (Department of Health 2017). The sample was restricted to participants who worked or attended education ($n = 4038$). Ethics approval for the parent Healthy Ireland survey was granted by the Research Board at the Royal College of Physicians in Ireland. Ethics exemption for the current study was granted by the Research Ethics Committee, School of Public Health, Physiotherapy and Sports Science, University College Dublin.

Data collection

Specially trained professionals visited the selected households and conducted face-to-face interviews with study participants who completed a questionnaire using computer-assisted personal interviewing to gather information related to lifestyle and health behaviours. In the present study values were recoded as missing data and excluded in cases where participants responded "Do not know" or who refused to answer a question.

SRH was determined by asking participants to rate their health in general with the following question – "How is your health in general?". Responses included – very good, good, fair, bad and very bad. SRH was classified as high (responses were very good or good) or low (responses were fair, bad or very bad). Participants (78%) completed a health assessment involving objective measurement of BMI and waist circumference. BMI was calculated as (weight (kg)/height (m)^2). Standard cut-off points for BMI were used to define underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), obesity (≥30 kg/m^2) (WHO 2021). In total a response rate of 60.4% was achieved for the Healthy Ireland 2017 Wave 3 survey and data was weighted to minimise bias in the dataset generated by non-responses (Department of Health 2020). Regarding commuting mode participants were asked the following – "How do you usually travel from home to your regular place of work or college?", selecting only one mode from the following: travel on foot, travel by bicycle, travel by public transport, travel by car or motorbike. Active travel was defined as travel by bicycle or on foot. Non-active travel included travel by car or motorbike or public transport.

Classification of covariates

Potential confounders and relevant covariates were identified from literature. These were: gender, age (15 to 24 years, 25 to 44 years, 45 to 64 years, 65 years and older), education (primary/post primary or third level), socioeconomic classification using the National Statistics Socio-Economic classification (NS-SEC) (Office of National Statistics 2021), distance from work (less than 3 km travelled or 3 km and longer), residential location (urban/rural), current smoking status (yes/no), presence of a chronic health condition limiting activities of daily living (yes/no), daily fruit consumption (yes/no), daily vegetable consumption (yes/no) and daily consumption of unhealthy food in the form of cakes, muffins, or biscuits (2 categories yes/no).

Statistical analysis

SPSS (IBM Version 24) was used to analyse data from April to June 2021. Descriptive statistics were presented using frequencies and percentages as all variables were categorical. Pearson Chi Square tests were used to compare different commute modes – active commuting (active/inactive). Multivariable logistic regression was used to investigate associations between active commuting and overweight, obesity and high SRH. Two models were run: model 1 adjusted for socio-demographic variables (age, gender, education level, socioeconomic group, urban/rural residential location, distance travelled, and chronic health conditions limiting activities of daily living (yes/no) and SRH or overweight/obesity according to the dependent variable). Model 2 additionally adjusted for lifestyle variables (smoking status, daily consumption of fruit, vegetables and unhealthy food). Further analysis examined active travel mode (cycling, walking) and distance travelled (less than 3 km or at least 3 km to work or place of education). All logistic regression results were presented as odds ratios and 95% CIs. Significant results were determined as a two tailed *p* value of <0.05.

Results

A total of 4038 participants (50% male, aged ≥15 years of age) in the Healthy Ireland 2017 survey attended work or education. Descriptive characteristics of the study population are presented in Table 1. The largest proportion of participants were 25-to-44-years of age (48%) and in the higher managerial and professional socioeconomic group (40%). Approximately 75% travelled at least 3 km to work or place of education and the majority were living in urban areas. More than three quarters of participants used a private motorised vehicle to commute (75.7%), 8.8% used public transport while 15.5% actively commuted (12.5% on foot and 3% used cycling). Regarding BMI, 39% of participants were of normal weight, 40% were classified as overweight, and 20% were classified as obese. Most participants reported their health as very good or good (92%).

Characteristics of active and non-active commuters

Comparative demographic and lifestyle characteristics of active and inactive commuters are presented in Table 1. Active commuters were more likely to be younger (68.6% were less than 45 years of age), have lower educational attainment and socioeconomic status, have a healthy BMI, live in an urban location and have a shorter commuting distance compared to the inactive commuters. Inactive commuters were more likely to be non-smokers and consume vegetables on a daily basis compared to active commuters. No differences were detected in self-rated health or in the percentage with a chronic health condition limiting activities of daily living between commuting groups.

Active commuting associations with BMI

Binary logistic regression analyses were performed to investigate the relationships between active commuting modes and overweight and obesity (Table 2). Those who used any form of active commuting had decreased odds of being obese compared to non-active commuters (AOR 0.69, 95% CI 0.52, 0.90). When active commuter modes were analysed separately, cycling was associated with further decreased odds of obesity relative to those who did not cycle (AOR 0.23, 95% CI 0.09, 0.56). Walking to work or place of education was not associated with obesity (AOR 0.85, 95% CI 0.64, 1.13) relative to those who did not commute on foot. There was no association identified between active commuting (overall or by individual modes) and odds of being overweight.

Active commuting associations with self-rated health

Binary logistic regression analyses were performed to investigate the relationship between active commuting modes and high SRH with adjustment for covariates (Table 3). There were no statistically significant associations between SRH and active commuting overall or when cycling and walking were analysed separately.

Active commuting associations according to distance travelled

When commuters were stratified according to the distance they travelled to work or place of education (i.e. less than 3 km and 3 km or greater using active means) (Table 4) active transport with a journey of at least 3 km was associated with decreased odds of obesity (AOR 0.54, 95% CI 0.30, 0.98) relative to non-active commuters. No association with obesity was observed for a commute distance of less than 3 km nor was active travel associated with overweight or self-rated health at either journey distance.

Discussion

Main finding of this study

In this cross-sectional analysis of a representative sample of the population in the Republic of Ireland we investigated associations between active commuting and weight status and self-rated health. The main findings suggest that active commuting is inversely associated with obesity, with further reduced obesity risk observed among cyclists and those who actively commuted ≥3 km. No associations were observed between active commuting (overall or individual modes) with overweight or SRH.

What is already known on this topic

Our finding, that active commuting is associated with lower likelihood of obesity, is consistent with findings from other studies (Gordon-Larsen et al. 2009; Lindström 2008). A systematic review by Brown and colleagues suggested small but important benefits of active travel for obesity management (Brown et al. 2017). The results

Table 1 Descriptive characteristics of active and non-active commuters

	N	Total	Commuter mode		*p*- value
			Active ($n = 623$)	Inactive ($n = 3415$)	
Age group (years)	4038				
15–24		554 (13.5)	150 (24.1)	394 (11.5)	
25–44		1930 (47.8)	277 (44.5)	1653 (48.4)	0.0001[a]
45–64		1405(34.8)	148 (23.8)	1257 (36.8)	
65 and older		159 (3.9)	48 (7.7)	111 (3.3)	
Gender	4038				
Male		2020 (50.0)	328 (52.6)	1692 (49.5)	0.154[a]
Education level	4038				
Primary/post primary		2125 (52.6)	385 (61.8)	1740 (51.0)	0.0001[a]
Third level		1913 (47.4)	238 (38.2)	1675 (49.0)	
Distance travelled	3770				
<3 km		936 (24.8)	468 (75.1)	468 (14.9)	0.0001[a]
≥3 km		2834 (75.2)	155 (24.9)	2679 (85.1)	
Socioeconomic group	4038				
Managerial, professional		1632 (40.4)	169 (27.1)	1463 (42.8)	
Intermediate profession		1452 (36.0)	226 (36.3)	1226 (35.9)	0.0001[a]
Manual and routine		749 (18.5)	152 (24.4)	597 (17.5)	
Unclassified		205 (5.1)	76 (12.2)	129 (3.8)	
Residential location	4038				
Urban		2533 (62.7)	463 (74.3)	2070 (60.6)	0.0001[a]
Rural		1505 (37.3)	160 (25.7)	1345 (39.4)	
BMI (kg/m^2)	3296				
<18.5		50 (1.5)	9 (1.7)	41 (1.5)	0.659[a]
18.5–24.9		1271 (38.6)	235 (45.3)	1036 (37.3)	0.001[a]
25.0–30.0		1311 39.8)	195 (37.6)	1116 (40.2)	0.264[a]
> 30.0		664 (20.1)	80 (15.4)	584 (21.0)	0.003[a]
SRH	4037				
High[b]		3732 (92.4)	567 (91.2)	3165 (92.7)	0.187[a]
Low[c]		305 (7.6)	55 (8.8)	250 (7.3)	
Chronic health condition limiting ADLs (yes)	4038	460 (11.4)	71 (11.4)	389 (11.4)	0.997[a]
Current smoking status (yes)	4038	845 (20.9)	166 (26.6)	679 (19.9)	0.0001[a]
Daily fruit consumption (yes)	4038	2647 (65.6)	402 (64.5)	2245 (65.7)	0.558[a]
Daily vegetable consumption (yes)	4038	3022 (74.8)	445 (71.4)	2577 (75.5)	0.033[a]
Daily unhealthy food consumption [d] (yes)	4036	721 (17.9)	115 (18.5)	606 (17.7)	0.644[a]

N and % represented. Boldface indicates statistical significance (* $p < 0.05$)

[a]chi square test

[b]very good or good SRH

[c]Fair, bad or very bad SRH

[d]Unhealthy food: cakes, muffins or biscuits

ADL, Activity of daily living; SRH, self-rated health

from the current study support the proposed framework that active travel use results in higher energy expenditure than inactive travel modes which may result in healthy weight maintenance provided no significant increase in energy intake occurs in active travel users (Brown et al. 2017). When cycling and walking were investigated separately, cycling had a strong inverse association with obesity. This was in concordance with findings from other studies (Laverty et al. 2013; Millett et al. 2013; Mytton et al. 2016a; Nordengen et al. 2019a; Rissel et al. 2014; Wen and Rissel 2008). Results from another systematic review indicate that cyclists have lower BMI and decreased cardiovascular disease risk factors than non-cyclists (Nordengen et al. 2019b). Contrary to other

Table 2 Logistic regression models of the relationship between active commuting modes and overweight and obesity

Commuter mode	Overweight		
	Crude OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Active commuting (reference = non-active)	0.90 (0.74–1.09)	0.99 (0.81–1.21)	0.99 (0.81–1.22)
Cycling commuting (reference = not cycling)	0.93 (0.61–1.40)	0.84 (0.55–1.28)	0.84 (0.55–1.28)
Walking commuting (reference = not walking)	0.90 (0.72–1.11)	1.04 (0.87–1.30)	1.04 (0.83–1.31)
	Obesity		
	Crude OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Active commuting (reference = non-active)	0.68 (0.53–0.88)	**0.68 (0.52–0.89)**	**0.69 (0.52–0.90)**
Cycling commuting (reference = not cycling)	**0.20 (0.08–0.50)**	**0.22 (0.09–0.54)**	**0.23 (0.09–0.56)**
Walking commuting (reference = not walking)	0.85 (0.65–1.11)	0.84 (0.63–1.12)	0.85 (0.64–1.13)

Boldface indicates statistical significance (*$p < 0.05$). Model 1 adjusted for age, gender, urban/rural location, socioeconomic group, education level, SRH and chronic health condition affecting activities of daily living. Model 2 adjusted for Model 1 covariates and smoking status, daily consumption of fruit, vegetables and unhealthy food (cakes, biscuits or muffins)

Table 3 Logistic regression models of relationships between active commuting and SRH

Commuter mode	High SRH[a]		
	Crude OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Active commuting (reference = sedentary)	0.81 (0.60–1.11)	0.98 (0.61–1.56)	0.99 (0.62–1.59)
Cycling commuting (reference = not cycling)	1.01 (0.51–2.01)	0.51 (0.23–1.13)	0.50 (0.23–1.13)
Walking commuting (reference = not walking)	0.78 (0.56–1.01)	1.21 (0.73–1.99)	1.23 (0.75–2.04)

Boldface indicates statistical significance (*$p < 0.05$). Model 1 adjusted for age, gender, urban/rural location, distance travelled, socioeconomic group, education level, overweight or obese status and chronic health condition affecting activities of daily living. Model 2 adjusted for Model 1 covariates and smoking status, daily consumption of fruit, vegetables and unhealthy food (cakes, biscuits or muffins)

[a]Very good or good SRH

SRH, self-rated health

Table 4 Adjusted logistic regression models of associations between active commuting and health indicators stratified by distance

	Overweight AOR (95% CI)	Obesity AOR (95% CI)	High SRH[a] AOR (95% CI)
Inactive commuting	Reference	Reference	Reference
Active commuting < 3 km	0.96(0.70–1.32)	0.81(0.54–1.22)	1.43(0.81–2.54)
Active commuting ≥ 3 km	1.05(0.72–1.54)	**0.54(0.30–0.98)**	0.51(0.24–1.1)

Boldface indicates statistical significance (*$p < 0.05$). AOR for age, gender, education level, residential location, chronic health condition limiting activities of daily living, smoking status, daily fruit, vegetable, unhealthy food consumption (cakes, biscuits or muffins), socioeconomic group, self-rated health (for overweight or obesity dependent variable), overweight/obese (for self-rated health dependent variable

[a]Very good or good SRH

SRH, self-rated health

studies which reported associations between active travel on foot and reduced obesity risk (Laverty et al. 2013; Millett et al. 2013; Rissel et al. 2014), we did not find any association between walking and obesity. Of note we used objective BMI measurements whereas some of the previous studies used self-reported BMI data which may affect the accuracy of results (Laverty et al. 2013; Rissel et al. 2014). However, our findings are plausible as cycling is often considered a more intense activity. Oja and colleagues reported that commuting by bicycle was associated with higher cardiorespiratory and metabolic improvements than walking in a 10-week RCT of sedentary commuters (Oja et al. 1991).

There was no association detected between active commute modes and overweight. This is inconsistent with findings from other cross-sectional studies (Barengo et al. 2006; Hu et al. 2002; Mendoza et al. 2011), all of which used objective BMI measurements. Eriksson and colleagues reported lower CVD risk for overweight participants who actively commuted (Eriksson et al. 2020). A possible explanation for the lack of an association between active commuting and overweight in the current study may be that active travel is generally of lower intensity than leisure time physical activity while regular higher intensity physical activity may be needed for prevention of overweight.

Higher SRH is hypothesised to be associated with active travel use, given the established links between physical activity and better health-related quality of life (Bize et al. 2007). No association was found between high SRH and active commute modes. This contrasts with findings from a study of 1196 commuters by Norgenen and colleagues (Nordengen et al. 2019a). It should be noted that in that study 40% of the study population cycled and 88% reported high SRH, whereas in the current study 3% of participants cycled and 92% reported high SRH, which may account for the lack of an association with active commuting. In a longitudinal study by Mytton and colleagues, higher physical well-being was associated with maintenance of cycling commuting in Cambridge, UK, using the Physical Component Summary (PCS-8), which includes an SRH component (Mytton et al. 2016b). It has been suggested that those who participate in healthy lifestyle behaviours can be more negative about their health (Layes et al. 2012). Therefore, it is important to appreciate the complex nature of SRH as a representation of overall health as it can be influenced by many underlying social and individual factors. Residual confounding factors such as job strain and sleep may also affect the association between SRH and active commuting in this study.

Interestingly we report a stronger inverse association with obesity in those who actively travelled at least 3 km which may suggest a dose-response relationship. This is consistent with previous studies which indicated similar exposure-response findings (Laverty et al. 2013; Martin et al. 2015). Those engaging in longer active journeys are more likely to achieve the 30-minute recommended physical activity threshold which is linked to a decreased disease risk (Department of Health and Children, Health Service Executive 2009).

Active travel specifically to work or education accounts for 27% of all trips in Ireland with the largest proportion of all trips taken during the week in Ireland (National Transport Authority 2017). In the present study almost 16% of study participants aged 15 years and older used active commuting. Although this represents an increase from 13% in 2016 (Central Statistics Office 2016) and is similar to that reported in the UK (Laverty et al. 2013; Flint et al. 2014) it is lower than in other European countries, for example in Sweden 38% report actively commuting (Eriksson et al. 2020). These differences may represent different ethnicities, cultural habits and infrastructure availability to the populations in question. Car use is more dominant in Ireland, England and the USA while government policies in other countries such as the Netherlands are more car restrictive in favour of active transport promotion (Pucher and Buehler 2010).

What this study adds

To our knowledge this is the first study in Ireland to investigate associations between active commuting and BMI and SRH. Additionally, our study which uses data from a nationally representative study of the Irish population, contributes to the evidence base regarding active commuting associations with SRH as a single item measure. Interviewers were professionally trained for face-to-face interviews reducing the risk of information bias and error. Objectively measured height and weight data was used for BMI measurement which is more reliable than self-reported data (Maukonen et al. 2018). Information on many potential confounders was collected.

In Ireland only 33% of adults and 12% of adolescents meet the WHO weekly physical activity recommendations (European Commission WHO 2018). Therefore, active travel use is an important lifestyle factor which has the potential to improve health by incorporating physical activity into daily commuting, re-enforcing the benefits of making small behavioural changes. This study, which demonstrated an inverse association between active commuting, particularly among cyclists and those actively commuting ≥3 km, represents a significant contribution to the evidence base regarding active commuting associations with obesity. The findings support the need for further incentives to actively travel. Further research should consider additional confounding factors in this association, in particular environmental factors such as traffic congestion, green space surroundings and public transport availability.

Limitations of this study

However, there are some limitations that should be noted. The cross-sectional study design, which precludes drawing conclusions regarding the temporal direction of relationships, limits inference with respect to causality. Reverse causality is possible; that is that participants who were obese may have been less likely to actively commute. Additionally, self-reported data for active commute use was collected during a face-to-face interview which may be subject to social desirability bias (Adams et al. 2005). Self-selection bias is possible in this study. Healthier people are more inclined to actively commute and have healthier lifestyle habits. Additional data on physical activity levels of participants would help to delineate if the inverse association between active commuting and BMI is related specifically to active travel and not to overall fitness in daily life. This was an Anonymised Microdata File version of the original 2017 Healthy Ireland dataset. Data analysis was limited as a result by the categorised nature of all data which may affect accuracy of results.

Acknowledgements Data collection was carried out by Ipsos MRBI on behalf of the Department of Health between September 2016 and June 2017.

Authors' contributions Both authors contributed significantly to this study. AM created the study objectives and study design, completed the data analysis, and generated the first draft of the manuscript. CMP supervised the study design, data analysis and critically reviewed the draft manuscript for intellectual input. Both AM and CMP drafted the final manuscript for submission.

Data availability The 2017 Healthy Ireland dataset is available for research purposes through an application process by email to the Irish Social Science Data Archive (ISSDA). An Anonymised Microdata File (AMF) for each wave of the Healthy Ireland survey is deposited in the ISSDA and is available for research and teaching purposes.

Code availability Not applicable.

Declarations

Ethical approval Ethics approval for the Healthy Ireland survey was provided by the Research Board at the Royal College of Physicians in Ireland. Ethical exemption for the current study was granted by the Research Ethics Committee, School of Public Health, Physiotherapy and Sports Science, University College Dublin.

Consent to participate Informed consent was gained from participants in the 2017 Healthy Ireland survey before commencing by trained interviewers.

Consent for publication The data and its creators will be cited in all publications for which the data have been used.

Conflict of interest The authors do not have any conflicts of interest to disclose.

References

Adams SA, Matthews CE, Ebbeling CB et al (2005) The effect of social desirability and social approval on self-reports of physical activity [published correction appears in Am J Epidemiol. May 1;161(9):899]. Am J Epidemiol 161(4):389–398. https://doi.org/10.1093/aje/kwi054

Barengo NC, Kastarinen M, Lakka T, Nissinen A, Tuomilehto J (2006) Different forms of physical activity and cardiovascular risk factors among 24-64-year-old men and women in Finland. Eur J Cardiovasc Prev Rehabil 13(1):51–59. https://doi.org/10.1097/00149831-200602000-00008

Bize R, Johnson JA, Plotnikoff RC (2007) Physical activity level and health-related quality of life in the general adult population: a systematic review. Prev Med 45(6):401–415. https://doi.org/10.1016/j.ypmed.2007.07.017

Brown V, Moodie M, Mantilla Herrera AM, Veerman JL, Carter R (2017) Active transport and obesity prevention - a transportation sector obesity impact scoping review and assessment for Melbourne. Australia Prev Med 96:49–66. https://doi.org/10.1016/j.ypmed.2016.12.020

Central Statistics Office (2016) Census of Population 2016-Profile 6 Commuting in Ireland. https://www.cso.ie/en/releasesandpublications/ep/p-cp6ci/p6cii/p6mtw/. Accessed 17 June 2021

Department of Health (2017) Healthy Ireland survey 2017. Summary of findings. https://assets.gov.ie/9542/8aa3c0d3f1d8417c95b025b69bc0c8d3.pdf. Accessed 23 June 2021

Department of Health (2020) Healthy Ireland Survey, 2017 [dataset]. Version 1. Irish Social Science Data Archive. SN: 0021–03. www.ucd.ie/issda/data/healthyireland/. Accessed 20 Jan 2021

Department of Health and Children, Health Service Executive (2009) The National Guidelines on Physical Activity for Ireland. https://www.hse.ie/eng/about/who/healthwellbeing/our-priority-programmes/heal/heal-docs/the-national-guidelines-on-physical-activity-for-ireland.pdf. Published 2009. Accessed 17 June 2021

Eriksson JS, Ekblom B, Kallings LV et al (2020) Active commuting in Swedish workers between 1998 and 2015-trends, characteristics, and cardiovascular disease risk. Scand J Med Sci Sports 30(2):370–379. https://doi.org/10.1111/sms.13581

European Commission WHO (2018) Ireland Physical Activity Factsheet 2018. Brussels: WHO. https://www.euro.who.int/__data/assets/pdf_file/0005/382514/ireland-eng.pdf. Accessed 24 March 2021

Flint E, Cummins S, Sacker A (2014) Associations between active commuting, body fat, and body mass index: population based, cross sectional study in the United Kingdom published correction appears in BMJ. 2015;350:h2056. BMJ 349:g4887. https://doi.org/10.1136/bmj.g4887

Gordon-Larsen P, Boone-Heinonen J, Sidney S, Sternfeld B, Jacobs DR Jr, Lewis CE (2009) Active commuting and cardiovascular disease risk: the CARDIA study. Arch Intern Med 169(13):1216–1223. https://doi.org/10.1001/archinternmed.2009.163

Guthold R, Stevens GA, Riley LM, Bull FC (2018) Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants [published correction appears in Lancet Glob Health 2019 Jan;7(1):e36]. Lancet Glob Health 6(10):e1077–e1086. https://doi.org/10.1016/S2214-109X(18)30357-7

Hansen AW, Beyer N, Flensborg-Madsen T, Grønbæk M, Helge JW (2013) Muscle strength and physical activity are associated with self-rated health in an adult Danish population. Prev Med *57*(6):792–798. https://doi.org/10.1016/j.ypmed.2013.08.029

Harvey SB, Øverland S, Hatch SL, Wessely S, Mykletun A, Hotopf M (2018) Exercise and the Prevention of Depression: Results of the HUNT Cohort Study. Am J Psychiatry 175(1):28–36. https://doi.org/10.1176/appi.ajp.2017.16111223 Epub 2017 Oct 3

Hu G, Pekkarinen H, Hänninen O, Yu Z, Guo Z, Tian H (2002) Commuting, leisure-time physical activity, and cardiovascular risk factors in China. Med Sci Sports Exerc 34(2):234–238. https://doi.org/10.1097/00005768-200202000-00009

Lake AA, Townshend TG, Alvanides S (eds) (2010) Obesogenic environments: complexities, perceptions and objective measures, 1st edn. John Wiley and Sons Ltd, Chichester

Laverty AA, Mindell JS, Webb EA, Millett C (2013) Active travel to work and cardiovascular risk factors in the United Kingdom. Am J Prev Med 45(3):282–288. https://doi.org/10.1016/j.amepre.2013.04.012

Layes A, Asada Y, Kepart G (2012) Whiners and deniers - what does self-rated health measure? Soc Sci Med 75(1):1–9. https://doi.org/10.1016/j.socscimed.2011.10.030

Lindström M (2008) Means of transportation to work and overweight and obesity: a population-based study in southern Sweden. Prev Med 46(1):22–28. https://doi.org/10.1016/j.ypmed.2007.07.012

Marques A, Peralta M, Gouveia ÉR, Chávez FG, Valeiro MG (2018) Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction. J Public Health (Oxf) 40(3):e328–e335. https://doi.org/10.1093/pubmed/fdy012

Martin A, Panter J, Suhrcke M, Ogilvie D (2015) Impact of changes in mode of travel to work on changes in body mass index: evidence from the British household panel survey. J Epidemiol Community Health 69(8):753–761. https://doi.org/10.1136/jech-2014-205211

Maukonen M, Männistö S, Tolonen H (2018) A comparison of measured versus self-reported anthropometrics for assessing obesity in adults: a literature review. Scand J Public Health 46(5):565–579. https://doi.org/10.1177/1403494818761971

Mendoza JA, Watson K, Nguyen N, Cerin E, Baranowski T, Nicklas TA (2011) Active commuting to school and association with physical activity and adiposity among US youth. J Phys Act Health 8(4):488–495. https://doi.org/10.1123/jpah.8.4.488

Millett C, Agrawal S, Sullivan R et al (2013) Associations between active travel to work and overweight, hypertension, and diabetes in India: a cross-sectional study. PLoS Med 10(6):e1001459. https://doi.org/10.1371/journal.pmed.1001459

Mytton OT, Panter J, Ogilvie D (2016a) Longitudinal associations of active commuting with body mass index. Prev Med 90:1–7. https://doi.org/10.1016/j.ypmed.2016.06.014

Mytton OT, Panter J, Ogilvie D (2016b) Longitudinal associations of active commuting with wellbeing and sickness absence. Prev Med 84:19–26. https://doi.org/10.1016/j.ypmed.2015.12.010

National Transport Authority. National Household Survey (2017) Final Report December 2018.https://www.nationaltransport.ie/wp-content/uploads/2020/09/National_Household_Travel_Survey_2017_Report_-_December_2018.pdf *Published 2017. Accessed 22 March 2021*

Neumeier, LM, Loidl, M, Reich, B, Fernandez LA Pente de Battre, MD, Kissel, CK, Templin, C, Schmeid, C, Niebauer, J, Niederseer, D (2020) Effects of active commuting on health-related quality of life and sickness-related absence. Scand J Med Sci Sports 30(Suppl1):31–40. https://doi.org/10.1111/sms.13667

Nordengen S, Ruther DC, Riiser A, Andersen LB, Solbraa A (2019a) Correlates of commuter cycling in three Norwegian counties. Int J Environ Res Public Health 16(22):4372 Published 2019 Nov 8. https://doi.org/10.3390/ijerph16224372

Nordengen S, Andersen LB, Solbraa AK, Riiser A (2019b) Cycling is associated with a lower incidence of cardiovascular diseases and death: part 1 - systematic review of cohort studies with meta-analysis. Br J Sports Med 53(14):870–878. https://doi.org/10.1136/bjsports-2018-099099

Office of National Statistics (2021) The National Statistics Socio-economic classification (NS-SEC) https://www.ons.gov.uk/methodology/classificationsandstandards/otherclassifications/thenationalstatisticssocioeconomicclassificationnssecrebasedonsoc2010. Accessed 17 June 2021

Oja P, Manttari A, Heinonen A, Kukkonen-Harjula K, Laukkanen R, Pasanen M, Vuori I (1991) Physiological effects of walking and cycling to work. Scand J Med Sci Sports 1(3):151–157

Pucher J, Buehler R (2010) Walking and cycling for healthy cities. Built Environ 36(4):391–414

Rissel C, Greenaway M, Bauman A, Wen LM (2014) Active travel to work in New South Wales 2005-2010, individual characteristics and association with body mass index. Aust N Z J Public Health 38(1):25–29. https://doi.org/10.1111/1753-6405.12097

Wen LM, Rissel C (2008) Inverse associations between cycling to work, public transport, and overweight and obesity: findings from a population based study in Australia. Prev Med 46(1):29–32. https://doi.org/10.1016/j.ypmed.2007.08.009

World Health Organization (2010) Global Recommendations on Physical Activity for Health. https://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf. Accessed 18 June 2021

World Health Organization (2018) Global action plan on physical activity 2018–2030: more active people for a healthier world. Geneva: World Health Organization. Available at: https://apps.who.int/iris/bitstream/handle/10665/272722/9789241514187-eng.pdf. Accessed 30 June 2021

World Health Organization (2021) Body Mass Index-BMI. https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi . Accessed 10 June 2021