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The effects of active commuting on cardiovascular disease incidence and mortality - a literature review

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Abstract:
Objective: Cardiovascular disease (CVD) remains a leading cause of death in developed countries, with physical inactivity identified as a major risk factor. Despite widespread promotion of physical activity by health organizations and general awareness of its benefits, inactivity is increasing. Active commuting, such as walking or cycling to replace driving or public transport, offers a practical way to integrate physical activity into daily routines without requiring additional time. This study aims to evaluate the impact of active commuting on reducing CVD incidence and mortality, considering the duration and mode of commuting.
Methods: An extensive literature review was conducted using PubMed, focusing on studies from 2000 to 2023.

Results
The review revealed mixed findings on the effects of active commuting on cardiovascular health. Studies such as Celis-Morales et al., indicated significant reductions in CVD incidence and mortality with longer durations of walking and cycling. Conversely, studies like Barengo et al. and Lopirinzi et al. reported no significant benefits from active commuting alone. Differences in study design, population demographics, and measurement methods likely contribute to these inconsistencies.

Conclusions
Overall, evidence suggests that while active commuting, particularly cycling, can reduce CVD risk, its benefits are influenced by the intensity and duration of activity and individual fitness levels. Active commuting may be most effective when combined with other forms of physical activity. The review highlights the need for more standardized research to accurately quantify the health benefits of active commuting and inform policy development.

Keywords: active commuting, cardiovascular disease, physical activity, walking, cycling

Introduction

Cardiovascular disease (CVD) is a leading cause of death in the developed world [1]. One of the major risk factors for developing a CVD is lack of physical activity. Insufficient physical activity is common among people living in high-income countries [2]. Being physically active is promoted by WHO, medical associations and government agencies, the benefits of physical activity are understood by the general population. However the prevalence of physical inactivity continues to increase, despite the efforts to increase it. Physical activity is commonly associated with leisure time, with increasingly busy lives many people might find it hard to have time for physical activity in their spare time. One of increasingly popular ways to incorporate some physical activity into daily life is active commuting- partially or completely replacing driving or using public transport with walking or cycling. This can significantly increase the amount of physical activity over a typical workweek without the need for extra time [3,4]. This approach seems rational, as even a small increase in physical activity leads to positive health outcomes [5] and decreases CVD risk [6,7,8,9], however the effects of this type of activity on cardiovascular health have not reached a consensus. Studies that examine the association between active commuting and CVD report effects varying from beneficial to none [10,11,12,13]. Our aim was to investigate to which degree active commuting can be beneficial for reducing CVD incidence or mortality and whether its dependent on the amount of time spent commuting [14,15,16] and mode of commuting- walking, cycling or mixed. Accurate quantification of possible benefits that active commuting could provide would be a useful tool for policymakers when proposing new health and transport- related policies [17].

Methods

Literature search extensive was performed using PubMed database with keywords such as “active commuting”, “walking”, “cycling”, “cardiovascular disease” and “CVD”. Relevant studies from years 2000-2023 were included. Studies in languages other than English were excluded.

Current state of literature

The role of active commuting in maintaining a proper level of physical activity is a topic that continues to grow in popularity, despite this there is a modest amount of studies that focuses on investigating the influence of active commuting on CVD incidence and mortality. Some studies that asses the relationship between physical activity and CVD include active commuting as a form of physical activity. We focused on studies that compare active commuters to others, who commute only by public transport and cars. Another type of study that was of our interest were studies comparing other types of physical activity such as leisure- time, work- related to active commuting.

One of the bigger studies on this subject is a study by Celis-Morales et al.[18], which assessed the relationship between active commuting and CVD incidence and mortality. The study found that cycling and walking has positive effect for CVD incidence- HR of 0.54 for cycling and HR of 0.73 for walking. CVD mortality was also lower among those who cycled (HR=0.48) and walked (HR=0.64) to work.

The amount of activity also had an effect- walking and cycling longer distances (above median) reduced CVD incidence (walking: HR= 0.59 CI=0.38- 0.92)(cycling: HR=0.53 CI=0.29- 0.97).

There was no statistically significant reduction in CVD incidence when walking(HR=0.79 CI=0.51-1.22) or cycling(HR= 0.67 CI=0.31-1.45)shorter distances (below median). CVD mortality was also significantly decreased when cycling longer distances(HR=0.48 CI=0.29 to 0.79).No statistically significant outcomes were found between mixed mode commuting and CVD outcomes. This study showed promising outcomes of active commuting on CVD incidence and mortality, especially when it comes to cycling, this difference may be explained by greater exercise intensity of cycling compared to walking[19], it is also important to acknowledge that commuter cyclists in the UK are a smaller and more select group than in more cycling- friendly countries, and are generally fitter than the general population which may be a confounding factor.

Another study using UK Biobank data was a study by Kaiser et al. [20], which assessed the effect of active commuting on CVD- related biomarkers: total cholesterol, direct low density lipoprotein (LDL), high density lipoprotein (HDL), triglycerides, apolipoprotein A and B, Creactive protein, and lipoprotein (a) as a measure of health outcomes. This study also used data from UK Biobank. This study found positive effect of walking on 2 of 8 of the biomarkers-s (HDL and apolipoprotein A) and a positive effect of cycling on 5 of 8 of the biomarkers- (HDL, triglycerides, apolipoprotein A and B, and C-reactive protein). Distance cycled had no statistically significant effect on the different biomarkers. Walking distance was only positively connected to better triglicerydes. Association between using public transport and CVD- related biomarkers was statistically insignificant albeit mostly positive. Again, cycling provided more positive effects, however it is worth noting that no dose- dependent effect was observed for cycling, unlike the Celis-Morales study.

Different large study on this subject was a study by Salier Eriksson et al. [21], which used data from the Health Profile Assessment (HPA) database evaluated relationship between different profiles of active commuters in Sweden and their risk of first-time CVD event. Participants were divided into “passive commuters” (<5 min/day) “low dose commuters” (5-19 min/day) and “high dose commuters” (≥20 min/day).There was no discerning between modes of active commuting (walking, cycling etc.) This study found that active commuting was beneficial regardless of amount for those with light physical work or who don’t exercise or exercise irregularly. Active commuting in lower amounts (5-19 min a day)was also beneficial for overweight(BMI 25-30 m2/kg) or obese (BMI >30m2/kg) individuals and those with low estimated VO2 max (<32ml/min/kg). (fig.1).No positive effect of active commuting were observed in groups with partly strenuous or strenuous physical work situation, that exercised regularly (≥1/week),with high estimated VO2 max (>32ml/min/kg) regardless of dose . Results of this study partially stand in contrast with previous studies, especially Celis-Morales study, which has not shown positive effects of walking or cycling shorter distances, this may be caused by the differences in the design of these studies, where one grouped participants activity by time and other by distance, which makes comparing the results more difficult.

It is also important to notice that groups which are physically active in other ways (work, exercise) and are physically fit (high VO2 max) have not achieved any significant benefits from AC, thus we might conclude that AC does not have the same benefits for people that are more physically active in other areas of life (work, leisure time).

	Light physcial work	Irregular/ lack of exercise	Overweight (BMI 25-30 m2/kg)	Obese (BMI >30m2/kg)	Low estimated VO2 max (<32ml/min/kg)
„low dose" AC	0.85(0.78-0.94)	0.84(0.76-0.94)	0.89(0.80-0.98)	0.83(0.71-0.98)	0.84(0.76-0.94)
„high dose" AC	0.89(0.79-0.99)	0.85(0.74-0.98)	0.89(0.78-1.00)	1.04(0.85-1.27)	0.93(0.81-1.06)

Fig. 1 Hazard ratio (95% CI) for first-time CVD event in relation to active commuting habits in different lifestyle- related subgroups included in the study.

A study by Mengyu Fan et al. [22] examined the association between active commuting and CVD incidence in China using the Kadoorie Biobank. This study divided participants into 5 groups of commuting behaviour – 1. Walking 2. Cycling 3. Motorcycle/moped 4. Car/bus/ferry/train 5.Working from home. Walking and cycling groups were further divided by commuting time- <15min, 15-29 min, 30-59 min, ≤60 min. CVDs examined in this study were ischemic heart disease, ischemic stroke and haemorrhagic stroke The study found that working from home(HR, 0.90; 95% CI, 0.82–0.99), walking(HR, 0.90; 95% CI, 0.84–0.96) and cycling (HR, 0.81; 95% CI, 0.74–0.88) was associated with lower incidence of ischemic heart disease than nonactive commuting. For Ischemic Stroke, only cycling (HR, 0.92; 95% CI, 0.84–1.00) was associated with decreased incidence. Moreover, there was no significant association for work at/near home, walking, or cycling for haemorrhagic stroke. Active commuting had a dose- response trends for ischemic heart disease incidence (fig 2.). There was no dose- specific response between active commuting time and ischemic stroke and haemorrhagic stroke incidence. This study shows a similar trend to previously mentioned studies where there is a clear dose- response relationship between activity time and CVD incidence, in this study limited to IHD. Again, as in the Celis-Morales study, cycling as the more physically intense activity showed more a greater risk reduction. Similarly to the Salier Eriksson study, even low doses of activity had a noticeable effect.

	Walking	Cycling
<15 min	1.00 (95% CI, 0.87–1.15)	0.85 (95% CI, 0.68–1.07)
15-29min	0.95 (95% CI, 0.85–1.06)	0.73 (95% CI, 0.63–0.86)
30-59min	0.87 (95% CI, 0.79–0.95)	0.82 (95% CI, 0.73–0.92)
≤60min	0.82 (95% CI, 0.71–0.95)	0.79 (95% CI, 0.67–0.92)

Fig. 2 Hazard ratio (95% CI) of ischemic heart disease incidence in groups of walkers and cyclists in relation to commuting time.

GISMO [23] study aimed to assess the effects of daily active commuting on exercise capacity. Participants were divided into intervention and control groups. Intervention group was further divided into a public transport group and cycling group. Both intervention groups were prompted to reach the WHO recommendation of 150 minutes of moderate intensity PA per week during their commute for 12 months. The CG was asked not to change their passive mode of commuting. Relevant data was collected at the beginning and the end of the study. The main indicator of exercise capacity were ergometry results. Changes in exercise capacity were significant between intervention (14 W [95% CI: 6, 22]) and control (−8 W [95% CI: −19, 3]) groups. At the end of the study exercise capacity of control group was (202 W [95% CI: 175, 229]) and the intervention group (239 W [95% CI: 213, 264]. There was also a difference between cycling (262 W [95% CI: 220, 305] and public transport (216 W [95% CI: 186, 247] intervention groups at the end of the study. All of these differences were statistically significant (p=<0.05). Change in commuting habits has shown an increase in participants exercise capacity, which is one of the best prognostic factors for cardiovascular risk[24]. One of the main strengths of this study is that it is a prospective study, and that data collection regarding mobility was collected with GPS- equipped fitness watches, which substantially increases the validity of the data compared to self- reporting. The fitness data of participants was also accurately measured during ergometry. Other data collected during this study was used in Mahdi Sareban et al. study [25]; which derived data from the GISMO study and investigated how introducing active commuting to daily routine has changed the participants CVD risk factor profile and body composition over a time span of 12 months. Relevant anthropometric data, systolic and diastolic blood pressure, BMI , skinfold thickness, Fasting glucose, HbA1c, total cholesterol (CHOL), high-density lipoprotein cholesterol (HDL), and triglycerides (TRI), Low-density lipoprotein cholesterol (LDL) were collected at the beginning and the end of the study. This study found that changes in body composition variables did not differ between groups, there were also no statistically significant differences in blood pressure, glycemic control and in lipid profile. The only significant difference was a decrease in LDL cholesterol by 13% in group which cycled and by 8% in group which used a mix of public transport and active commuting. HbA1c levels decreased by 0,2% in the public transport group and by 0,1% in control group, this difference however was not statistically different between groups.

This study is one of very few prospective studies on the subject, the results suggest that active commuting impacts lipid profiles and considering the well-established and direct link between dyslipedemia and CVD [26], managing lipid profiles is considered to be one of the most important aspects of preventive cardiovascular medicine. [27] . Previously mentioned studies are generally suggesting that active commuting has a positive effect on CVD incidence and mortality, that there is a dose- response relationship and that using a mode of transport that demands a higher intensity of physical activity (eg. cycling) yields greater benefits than less physically demanding ways (eg. Walking). Not all research on this subject is suggesting similar conclusions. Studies examining and comparing effects of different types of PA on CVD incidence and mortality provide different results.

Comparing different types of physical activity

Barengo et al. [28] examined the influence of leisure time, occupational and commuting physical activity on CVD and all- cause mortality. The study used data from six independent cross-sectional surveys that were carried out at five-year intervals from 1977 to 1992 in Finland. The participants were asked about the amount of physical activity over their typical week in 3 areas: 1.leisure, 2.work, 3.commuting. Each area of physical activity was divided into 3 intensity groups: 1- low, 2- moderate, 3- high. For commuting this meant: low= <15 min a day of exercise, moderate= 15-30 min a day of exercise, high= >30 min a day of exercise. A decrease in all- cause and CVD mortality was observed in men and women who were classified as high or moderately active in leisure time The risk reduction in all-cause mortality was 9% (95% confidence interval [CI] 2–16%) among men who had moderate leisure time physical activity and 21% (95% CI 10–30%) who reported high leisure time physical activity. CVD mortality decreased respectively 9% (95% CI 0–18%) and 17% (95% CI 1–31%) for men with moderate and high levels of leisure- time physical activity. Similar results were observed among women- RR of all-cause mortality was 0.89 (moderate leisure time physical activity, 95% CI 0.81–0.98) and 0.98 (high leisure time physical activity; 95% CI 0.83–1.16) compared to women who were inactive in their leisure time. CVD mortality among women was also decreased (HR 0.83; 95% CI 0.71–0.96 and 0.89; 95% CI 0.68–1.18, respectively) than those with low leisure time physical activity. Occupational physical activity also had a significant effect on all-cause and CVD mortality, even greater than high leisure-time activity.

	Men	Women
Moderate physical activity	0.75 (0.68–0.83)	0.79 (0.70–0.89)
High physical activity	0.77 (0.71–0.84)	0.78 (0.70–0.87)

Table 1: Relative Risk of all- cause mortality in moderately and highly physically active men and women regarding occupational activity.

	Men	Women
Moderate physical activity	0.75 (0.64–0.87)	0.73 (0.60–0.88)
High physical activity	0.77 (0.69–0.87)	0.77 (0.65–0.91)

Table 2: Relative Risk of CVD mortality in moderately and highly physically active men and women regarding occupational activity.

Interestingly, the positive effects of physical activity are not observed among men and women who had been engaged in active commuting. Regarding commuting activity there was a decrease in all- cause and CVD mortality in women who had >15 min of exercise a day, however after adjustment for occupational physical activity and leisure time physical activity, the association was no longer statistically significant. No statistically significant effect of active commuting on all-cause mortality or CVD mortality was found in men. Such results are in contradiction with previously mentioned studies, however they support the basic premise of reducing CVD risk by achieving adequate amount of physical activity, in this case, in other areas of life. We can only speculate why active commuters have not achieved any significant difference in CVD mortality, the duration of data acquisition was long enough for effects of physical activity to take place.

It may be that this group simply did not achieve enough amount of physical activity by commuting alone, it's important to remember that other studies accounted for other types of physical activity and yet have shown benefits of active commuting, other types of physical activity is still an important confounding factor that might have impacted previous, more positive research on this subject.

Another similar study on this subject is a study by Lopirinzi et al. [29], which examined individual, combined, and isolated effects of movement-based behaviors (MBB) on all-cause mortality and CVD-specific mortality. The study used data from 1999-2004 National Health & Nutrition Examination Survey (US), with follow-up data through December 31, 2006. In this study participants self-reported engagement in 4 distinct movement- based behaviors (MBBs) (moderate-intensity exercise, vigorous-intensity exercise, muscular strength activities, and active transport) and the outcome measures were all- cause mortality and CVD mortality. The findings of this study were that individually a single MBB had no significant effect on mortality when it comes to muscular strength activities and active commuting, however when it comes to moderate-intensity and vigorous-intensity exercises, there was an inverse association with all- cause and CVD mortality. The authors admit however that regarding active commuting they were not able to differentiate between different modes of commuting(cycling, walking, public transport) and that might explain why it had a null finding. Engaging in multiple forms of MBB have also provided an inverse association with all- cause and CVD mortality, suggesting that the amount of physical activity has a greater effect than the type of activity. When it comes to engaging only in a single activity vigorous-intensity exercise had an inverse effect on all- cause mortality, but not on CVD mortality. Other MBBs in isolation had no statistically significant effects. This study draws similar conclusions to Barengo et al. study, engaging in more physical activity is a more certain way to achieve benefits, engaging in more physical activity can be done by doing it in different domains of life (leisure, commuting, work). This study does not show benefits of active commuting directly, however it shows that it can be beneficial as a way to add extra physical activity to one's day.

Besson et al. [30] assessed the relationship between overall and domain- specific physical activity and all-cause, CVD mortality. The study used data from EPIC- Norfolk prospective cohort study, 14903 participants were included. Physical activity was assessed using self-

completed questionnaire, and was divided into 4 domains: around the home, occupational, commuting to work and recreational.

Participants were also divided into 4 levels of activity based on the approximated energy expenditure derived from the questions in the questionnaire. For the commuting domain walking and cycling was also examined separately. Total physical activity was significantly inversely related to all-cause and cardiovascular mortality. Physical activity at home and recreational physical activity was also inversely related to all- cause and CVD mortality. Like total physical activity, recreational PA had a statistically significant effect on CVD and all-cause mortality in almost every intensity group, while PA at home had a statistically significant effect only on CVD mortality in the active group. Neither cycling nor walking for transportation, analyzed separately and together, nor activity at work was significantly associated with all-cause and cardiovascular mortality. The findings of this study point at the intensity of the physical activity as more important reason for reduction in mortality.

Matthews et al. [31] investigated the effects of different types of physical activity on mortality in Chinese women.

The study used data from Shanghai Women's Health Study (1997–2004). Total number of participants was 67,143. Information about exercise participation, household activities, walking and cycling for transportation, and occupational type was assessed by interview. The participants were divided into 4 groups based on the amount of activity in standard metabolic equivalents (METs) as MET-hours/day. This study found an inverse relation between all-cause mortality and overall physical activity for every intensity group. Reduction in CVD mortality however was only statistically significant for the most active women who had ≥18.1 MET-hours/day of activity. Exercise activity and nonexercise activities (eg. Housework) had an inverse relation between all- cause and CVD mortality, however this trend was weaker regarding CVD mortality than all-cause mortality, and was statistically insignificant between nonexercise activity and CVD mortality ($p=0.063$). Walking and cycling was also inversely related to both all- cause and CVD mortality, but walking had much weaker association and the association was statistically insignificant for both all-cause($p=0.071$). and CVD mortality ($p=0.072$). The findings of this study suggest that physical activity, regardless of circumstances can provide health benefits, as long as the activity is intense enough. Studies comparing effects of different types of physical activity and CVD incidence and mortality do not show such a positive view of active commuting. With the exception of Matthews study, groups which had active commutes have not achieved any significant benefits. This may be due to differences in study design, different ways of measuring physical activity or other, unknown confounding factors. One finding is consistent and that is increased physical activity is inversely related to CVD incidence and mortality.

Conclusions

Many studies show that active commuting is associated with reduced CVD risk: Several studies, including Celis-Morales, Kaiser, Salier Eriksson, and Mengyu Fan, indicate that active commuting, particularly cycling and walking, is associated with lower CVD incidence and mortality. The Celis-Morales study found significant reductions in CVD incidence and mortality among individuals who cycled or walked to work, especially for longer distances.

Studies consistently show a dose-response relationship between the duration or intensity of active commuting and CVD risk reduction.

Longer durations of cycling or walking are associated with greater benefits in terms of CVD outcomes. Cycling yields greater benefits than walking, research suggests that cycling, being a more intense form of physical activity, yields greater benefits compared to walking in terms of reducing CVD risk. The benefits of active commuting may vary depending on other factors such as the individual's physical fitness, BMI, and level of physical activity in other areas of life. For instance, active commuting may not provide significant benefits for individuals who are already physically active in other aspects of their lives. Engaging in multiple forms of physical activity, including active commuting, moderate-intensity, and vigorous-intensity exercise, may have a greater impact on reducing all-cause and CVD mortality compared to engaging in a single type of activity. The intensity of physical activity appears to be an important factor in reducing mortality rates. Studies like Besson and Matthews suggest that higher intensity activities, such as vigorous-intensity exercise, may have a more significant impact on reducing mortality compared to lower intensity activities like walking.

While many studies support the positive association between active commuting and reduced CVD risk, some studies, like Barengo and Lopirinzi, found null or contradictory results. These inconsistencies may be due to various factors such as differences in study design, population demographics, and methods of measuring physical activity. Overall, the evidence suggests that active commuting, especially cycling, can be an effective strategy for reducing CVD risk, but its benefits may vary depending on factors such as duration, intensity, and individual characteristics. On its own it may not be enough yield significant benefits, it may be a good way to incorporate more physical activity into daily routine. Our review also shows that there is a need of more research on this subject, as the inconsistencies we found can be attributed to varying study designs and general inconsistency and lack of standardization between them. The definition of “active commuting” was inconsistent between studies as well as measurement of exposure- some studies used distance travelled and some time spent on activity, not every study differentiated between walking and cycling, Most studies use self-reporting which is susceptible to recall bias. This may result in an over- or underestimation of the absolute level of active commuting. In some studies active commuters were a small and select group, which favoured them in comparison with other groups. Future studies need a better definition of active commuting in terms of type, duration, intensity and frequency, better standardization of the methods used to evaluate active commuting, and an appropriate consideration of several confounding factors.

Author's contribution

Conceptualization KM, KK, HP, KP, MP, MK, KKu, UK, PK; methodology KM, KK, HP, KP, MP, MK, KKu, UK, PK; software KM, KK, HP, KP, MP, MK, KKu, UK, PK; check KM, KK, HP, KP, MP, MK, KKu, UK, PK; formal analysis KM, KK, HP, KP, MP, MK, KKu, UK, PK; investigation KM, KK, HP, KP, MP, MK, KKu, UK, PK; resources KM, KK, HP, KP, MP, MK, KKu, UK, PK; data curation KM, KK, HP, KP, MP, MK, KKu, UK, PK; writing – rough preparation KM, KK, HP, KP, MP, MK, KKu, UK, PK; writing – review and editing KM, KK, HP, KP, MP, MK, KKu, UK, PK; visualization KM, KK, HP, KP, MP, MK, KKu,

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References:

1. Woodcock J, Franco OH, Orsini N, Roberts I. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. Int J Epidemiol. 2011;40(1):121-138. doi:10.1093/ije/dyq104.
2. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet. 2012;380(9838):247-257. doi:10.1016/S0140-6736(12)60646-1.
3. Besser LM, Dannenberg AL. Walking to public transit: steps to help meet physical activity recommendations. Am J Prev Med. 2005;29(4):273-280. doi:10.1016/j.amepre.2005.06.010
4. Costa S, Ogilvie D, Dalton A, Westgate K, Brage S, Panter J. Quantifying the physical activity energy expenditure of commuters using a combination of global positioning system and combined heart rate and movement sensors. Prev Med. 2015;81:339-344. doi:10.1016/j.ypmed.2015.09.022
5. Wen CP, Wai JP, Tsai MK, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet. 2011;378(9798):1244-1253. doi:10.1016/S0140-6736(11)60749-6
6. Lee IM, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet. 2012;380(9838):219-229. doi:10.1016/S0140-6736(12)61031-9
7. Adams V, Reich B, Uhlemann M, Niebauer J. Molecular effects of exercise training in patients with cardiovascular disease: focus on skeletal muscle, endothelium, and myocardium. Am J Physiol Heart Circ Physiol. 2017;313(1):H72-H88. doi:10.1152/ajpheart.00470.2016
8. Clausen JSR, Marott JL, Holtermann A, Gyntelberg F, Jensen MT. Midlife Cardiorespiratory Fitness and the Long-Term Risk of Mortality: 46 Years of Follow-Up. J Am Coll Cardiol. 2018;72(9):987-995. doi:10.1016/j.jacc.2018.06.045

9. Mandsager K, Harb S, Cremer P, Phelan D, Nissen SE, Jaber W. Association of Cardiorespiratory Fitness With Long-term Mortality Among Adults Undergoing Exercise Treadmill Testing. JAMA Netw Open. 2018;1(6):e183605. Published 2018 Oct 5. doi:10.1001/jamanetworkopen.2018.3605
10. Andersen LB, Schnohr P, Schroll M, Hein HO. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med. 2000;160(11):1621-1628. doi:10.1001/archinte.160.11.1621
11. Crespo CJ, Palmieri MR, Perdomo RP, et al. The relationship of physical activity and body weight with all-cause mortality: results from the Puerto Rico Heart Health Program. Ann Epidemiol. 2002;12(8):543-552. doi:10.1016/s1047-2797(01)00296-4
12. Eaton CB, Medalie JH, Flocke SA, Zyzanski SJ, Yaari S, Goldbourt U. Self-reported physical activity predicts long-term coronary heart disease and all-cause mortalities. Twenty-one-year follow-up of the Israeli Ischemic Heart Disease Study. Arch Fam Med. 1995;4(4):323-329. doi:10.1001/archfami.4.4.323
13. Rosengren A, Wilhelmsen L. Physical activity protects against coronary death and deaths from all causes in middle-aged men. Evidence from a 20-year follow-up of the primary prevention study in Göteborg. Ann Epidemiol. 1997;7(1):69-75. doi:10.1016/s1047-2797(96)00106-8
14. Bauman AE. Updating the evidence that physical activity is good for health: an epidemiological review 2000-2003. J Sci Med Sport. 2004;7(1 Suppl):6-19. doi:10.1016/s1440-2440(04)80273-1
15. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc. 2007;39(8):1423-1434. doi:10.1249/mss.0b013e3180616b27
16. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. CMAJ. 2006;174(6):801-809. doi:10.1503/cmaj.051351
17. Woodcock J, Givoni M, Morgan AS. Health impact modelling of active travel visions for England and Wales using an Integrated Transport and Health Impact Modelling Tool (ITHIM). PLoS One. 2013;8(1):e51462. doi:10.1371/journal.pone.0051462
18. Celis-Morales C A, Lyall D M, Welsh P, Anderson J, Steell L, Guo Y et al. Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study BMJ 2017; 357 :j1456 doi:10.1136/bmj.j1456
19. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc. 2011;43(8):1575-1581. doi:10.1249/MSS.0b013e31821ece12
20. Kaiser M, Bauer JM, Otterbach S, Reisch LA, Sousa-Poza A. The association between commuting and cardiovascular disease: A biomarker-based analysis of cross-sectional cohort data from the UK Biobank. Prev Med. 2023;172:107521. doi:10.1016/j.ypmed.2023.107521

21. Eriksson JS, Ekblom B, Kallings LV, et al. Active commuting in Swedish workers between 1998 and 2015-Trends, characteristics, and cardiovascular disease risk. Scand J Med Sci Sports. 2020;30(2):370-379. doi:10.1111/sms.13581
22. Fan M, Lv J, Yu C, et al. Association Between Active Commuting and Incident Cardiovascular Diseases in Chinese: A Prospective Cohort Study. J Am Heart Assoc. 2019;8(20):e012556. doi:10.1161/JAHA.119.012556
23. Reich B, Niederseer D, Loidl M, et al. Effects of active commuting on cardiovascular risk factors: GISMO-a randomized controlled feasibility study. Scand J Med Sci Sports. 2020;30 Suppl 1(Suppl 1):15-23. doi:10.1111/sms.13697
24. Leeper NJ, Myers J, Zhou M, et al. Exercise capacity is the strongest predictor of mortality in patients with peripheral arterial disease. J Vasc Surg. 2013;57(3):728-733. doi:10.1016/j.jvs.2012.07.051
25. Sareban M, Fernandez La Puente de Battre MD, Reich B, et al. Effects of active commuting to work for 12 months on cardiovascular risk factors and body composition. Scand J Med Sci Sports. 2020;30 Suppl 1(Suppl 1):24-30. doi:10.1111/sms.13695
26. Lloyd-Jones DM, Wilson PW, Larson MG, et al. Framingham risk score and prediction of lifetime risk for coronary heart disease. Am J Cardiol. 2004;94(1):20-24. doi:10.1016/j.amjcard.2004.03.023
27. Piepoli MF, Hoes AW, Agewall S, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts)Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur Heart J. 2016;37(29):2315-2381. doi:10.1093/eurheartj/ehw106
28. Barengo NC, Hu G, Lakka TA, Pekkarinen H, Nissinen A, Tuomilehto J. Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland. *Eur Heart J*. 2004;25(24):2204-2211. doi:10.1016/j.ehj.2004.10.009
29. Loprinzi PD, Davis RE. Effects of individual, combined, and isolated physical activity behaviors on all-cause mortality and CVD-specific mortality: Prospective cohort study among U.S. adults. *Physiol Behav*. 2015;151:355-359. doi:10.1016/j.physbeh.2015.07.032
30. Besson H, Ekelund U, Brage S, et al. Relationship between subdomains of total physical activity and mortality. Med Sci Sports Exerc. 2008;40(11):1909-1915. doi:10.1249/MSS.0b013e318180bcad
31. Matthews CE, Jurj AL, Shu XO, et al. Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. Am J Epidemiol. 2007;165(12):1343-1350. doi:10.1093/aje/kwm088