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Maintaining health in daily life—is active travel the solution?

A scoping review

Introduction

Physical inactivity is a major public health challenge. In high-income countries, noncommunicable diseases (NCD), e.g., ischemic heart disease and diabetes, are the leading causes of mortality and morbidity. For physical activity (PA) recommendations (WHO, 2020), minimum PA levels for achieving health-promoting and disease-preventing effects have been formulated based on scientific evidence. Accordingly, adults (≥ 18 years) should engage in at least 150–300 min of moderate-intensity aerobic PA or 75–150 min of vigorous-intensity aerobic PA or an equivalent combination of moderate- and vigorous-intensity PA throughout the week (MVPA), for substantial health benefits, and at least 2 days/week of muscle-strengthening exercise (MSE) for additional health benefits. However, the health-promoting potential of exercise (Warburton & Bredin, 2017) is not yet fully exploited in societies. Approximately two-thirds of adults meet the MVPA guidelines globally (Garcia-Hermoso et al., 2022). A higher and continuously increasing prevalence of insufficient MVPA exists in high-income countries (37%: Guthold, Stevens, Riley, & Bull, 2018; specifically for Germany reaching almost 55%: Bennie, de Cocker, & Tittlbach, 2021). PA cannot "only" represent a healthy behavior but plays a significant role in building a healthy and sustainable lifestyle (Nigg & Nigg, 2021). When discussing PA promotion, different dimensions of PA are analyzed: leisure-time PA (LTPA), sports, occupational PA, and active travel (AT). This paper will focus on the latter due to the mobility turnaround toward more sustainable and healthier behaviors, and subsequent increase in the popularity of cycling and walking as AT (Hoor, 2023).

AT, meaning muscle powered and non-motorized locomotion, such as walking, cycling, inline skating, or scootering, is further defined as travel in which the sustained physical exertion of the traveler directly contributes to their motion (Cook, Stevenson, Aldred, Kendall, & Cohen, 2022). Human-powered locomotion can increase health parameters, e.g., heart rate and blood pressure (Larouche, Faulkner, & Tremblay, 2016), activate the whole musculoskeletal system to enhance physical performance (Henriques-Neto et al., 2020), and challenges cognitive parameters (Phansikar & Mullen, 2019). Consequently, a sustainable and active lifestyle comes together in AT (Fröberg & Lundvall, 2021; Maltese, Gatta, & Marcucci, 2021; Nigg & Nigg, 2021; Ribeiro & Fonseca, 2022).

In a review of previous literature examining the associations between AT and health outcomes, it becomes obvious that there is a strong focus on children and youth (e.g., Lubans, Boreham, Kelly, & Foster, 2011; Voulgaris, Smart, & Taylor, 2019). When examining adults, selected physical health outcomes, in the sense of disease prevention, are the main focus (e.g., cardiovascular disease [CVD] mortality) (Hamer & Chida, 2008). Research in adults reports potential positive health effects, but also still inconsistent findings on whether AT contributes robustly to better and comprehensive health outcomes (Dinu, Pagliai, Macchi, & Sofi, 2019). In addition, there is a lack of thorough examination of subjective and mental health measures in terms of holistic health. The importance of health promotion factors, i.e., subjective health assessment as well as mental health, are highlighted from a salutogenic health perspective (Keyes, 2014). Comprehensive reviews on the associations between AT and health promoting factors, respectively mental health, cannot be found.

Increased PA is identified as the most important determinant of health benefits of AT in adults (Mueller et al., 2015). Until recently, it was not completely clear whether AT contributes to increasing PA levels or whether other forms of LTPA may be substituted (Saunders, Green, Petticrew, Steinbach, & Roberts, 2013). The systematic review of Wanjau et al. (2023) has shown that the vast majority of studies reveal no displacement of PA in other domains. Rarely (if at all) could small amounts of compensatory reduction in PA in other domains be found. This means that AT can positively increase overall levels of PA. Dual-mode travelers (walking + cycling) especially met, or were close to meeting, the recommended PA levels of at least 150 min/week, while 'cyclists only' met the guidelines only during spring–fall period (Stigell & Schantz, 2015). Also, combining AT with the use of public transport (PT) can help to meet the PA recommendations (Rissel, Curac, Greenaway, & Bauman, 2012; Lachapelle, Frank, Saelens, Sallis, & Conway, 2011).

Oriented to the research gaps listed, and due to the fact that published re-

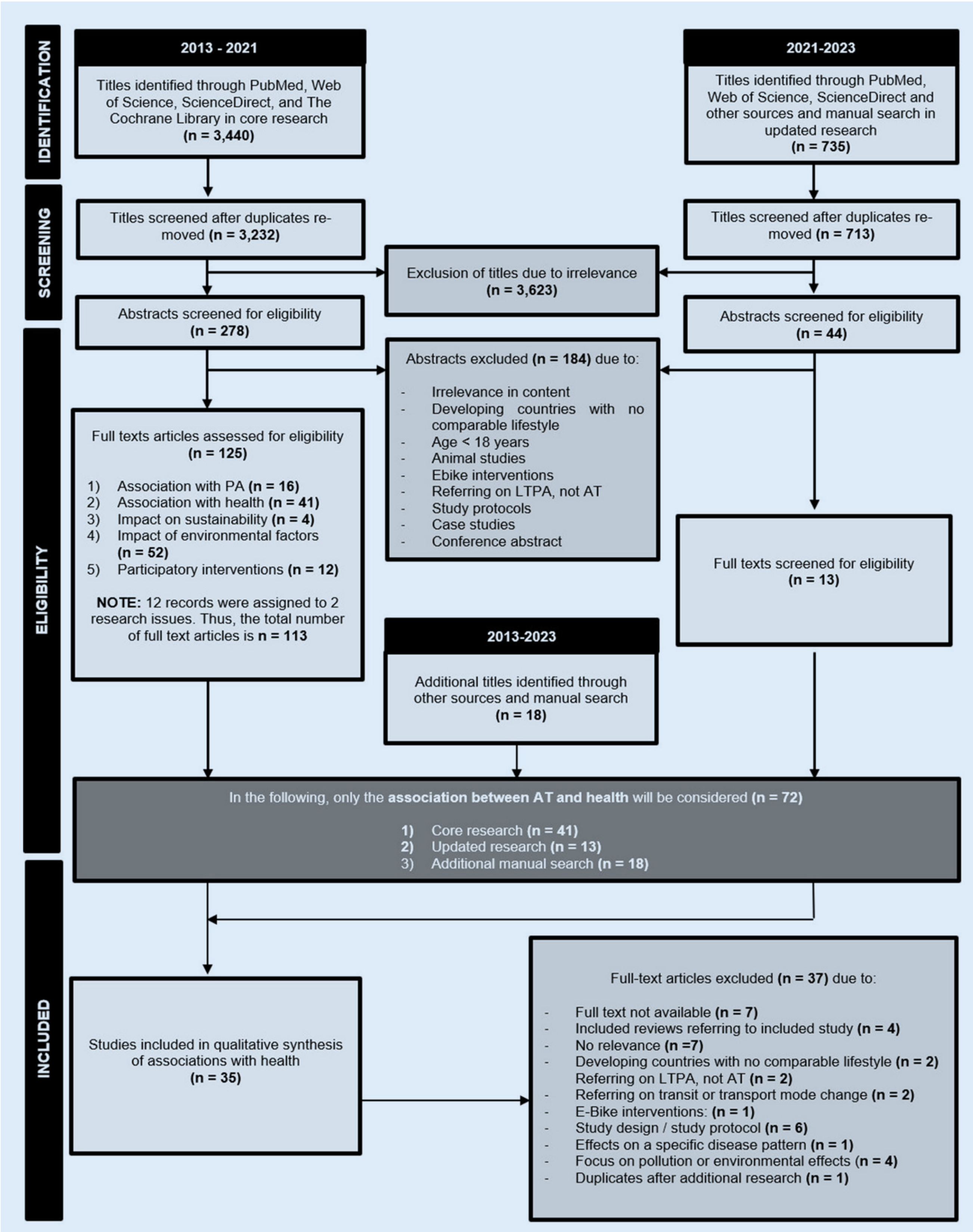

Fig. 1 ▲ Flowchart of the identified studies investigating associations of active travel (AT) and health

search on AT has been growing during the last decade, this scoping review aimed to update and summarize the existing evidence to answer the question whether AT is associated with positive—objective and subjective—health parameters.

Methods

A literature search following the Extension for Scoping Reviews of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-ScR) guidelines (Tricco et al., 2018) was carried out to answer the research questions.

Inclusion and exclusion criteria

The inclusion criteria for eligibility were as follows:

1. Study design: cross-sectional and longitudinal epidemiological studies or reviews,
2. Considered modes of AT: Covering distances necessary in everyday life through cycling, walking, scootering or inline-skating,
3. Outcome: any health aspects (e.g., obesity, mortality, physical fitness, mental health),
4. Data analysis: analysis of the association between AT behavior and health,
5. Sample: male and female adults (≥ 18 years) in Western industrialized countries with urban infrastructure and lifestyles comparable to Europe, to limit the potential of unknown cultural influences on activity behavior,
6. Language: published in English or German, and
7. Publication date: The importance of research into AT has risen sharply and has been intensively researched in the last few years. Therefore, the publication dates for this review have been restricted to the previous decade, hence, 2013 until 2023.

Exclusion criteria were as follows:

8. Papers not meeting all the inclusion criteria (1)–(7),
9. Study sample $n < 100$,
10. Analysis of impact on health solely through air pollution caused by traffic,
11. Studies dealing exclusively with people aged ≥ 80 years of age, and
12. Exclusive focus on e-biking.

The last search update was on 1 September 2023.

Search strategy

The review was embedded in an extensive literature review with several research questions, namely on the associations of AT with health and PA, AT's environmental effects, its socioecological determinants, and participatory intervention options for increasing AT behavior. Therefore, the initial search strategy refers to all of these aspects (see steps identification, screening, and eligibility in **Fig. 1**). However, in this paper, the review presents results for only the associations of AT with health.

The electronic databases PubMed, Web of Science, ScienceDirect, and The Cochrane Library were searched using predefined combinations of keywords sought in the title and abstracts of the papers. See Appendix (**Tables 3, 4, 5 and 6**) for the detailed listing of all search terms. The research was complemented by a manual search (snowball system).

The review protocol was registered in Open Science Framework (OSF; https://doi.org/10.17605/OSF.IO/2NPRM).

Internal validity

To avoid potential bias and reduce the risk of excluding studies that met inclusion criteria, three investigators independently screened titles, abstracts (S.T., A.B., S.K.), and full texts (S.T., S.K.) for eligibility. Disagreements were resolved by consensus.

Results

Search results and study characteristics

Figure 1 provides a flowchart summarizing the included and excluded papers. The literature search resulted in 35 papers including 4,857,918 individuals. The 16 cross-sectional and 12 longitudinal studies were performed in the US (8), the UK (7), Sweden (2), Finland (3), China (2), the Netherlands (2), and several European cities (Denmark, Norway, Switzerland, Ireland; each 1). In seven of the found papers, three reviews included cross-sectional and longitudinal studies, two included longitudinal studies only, and two included cross-sectional stud-

Abstract

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Maintaining health in daily life—is active travel the solution? A scoping review

Abstract
Physical inactivity is a global public health challenge. At the same time, the societal transformation toward a sustainable and active lifestyle can be observed. Active travel (AT) is one physical activity (PA) domain and combines healthy and sustainable daily behavior. However, it is still unclear whether assumed associations between AT and health are resilient for objective and subjective health outcomes. Since published research on AT has been growing during the last decade, this scoping review aimed to update and summarize the existing evidence. Therefore, a scoping review was conducted in PubMed, Web of Science, ScienceDirect, and Cochrane Library, following PRISMA guidelines. In all, 35 papers including 4,857,918 individuals (age range: 18–93 years old) were included. AT is strongly associated with health dimensions with a great body of knowledge showing strong associations between AT and reduced risks for noncommunicable diseases (NCD), especially in comparison to non-AT. Thus, AT can play an important role to prevent the increasing prevalence of NCD. There is a limited amount of research available on health-promoting factors and subjective health. Extracted studies suggest positive connections with AT. Mostly, cycling as a form of AT seems to have a more significant positive association with health compared to walking. Longitudinal studies further support and reinforce these findings.

Keywords
Active commuting · Walking · Cycling · Physical activity · Health

Table 1 Characteristics of the epidemiological studies

No.	Author	Year	Study design	Country	Sample	AT measure	Health measure	Main findings
1	Avila-Palencia et al.	2018	Cross-sectional and longitudinal (2014–2016)	Switzerland	Baseline/Follow-up $n = 8802/3567$, M: 38/41 years, 53% females	Walking, Cycling; PASTA project questionnaire	Self-reported SF-36, short version PSS-4 and MHI-5	+ Positive associations between cycling and good SRH, fewer feelings of loneliness + Positive associations between walking and good SRH, higher vitality, contact with friends/family
2	Barajas & Braun	2021	Cross-sectional	USA	$n = 91{,}541$, 46 ± 0.1 years, 52% females	Walking, Cycling; self-reported in NHTS	Self-reported health	+ Cycling and walking are positively associated with SRH
3	Berger et al.	2018	Cross-sectional	USA	$n = 1450$, aged 20–64 (37.6 ± 12.32) years, 45% females	Cycling; self-reported in TCCS	Self-reported BMI, obesity, hypertension, blood lipids, diabetes	+ Cycling frequency is associated with lower odds of prevalent obesity, hypertension, high triglycerides + Three cycling trips per week are associated with 20% fewer cardiometabolic risk factors
4	Berglund et al.	2016	Cross-sectional	Sweden	$n = 1786$, aged 45–75 (61.8 ± 8.5) years, 54% females	Walking, Cycling; self-reported	Self-reported health, BMI	+ Inactive traveling associated with poor SRH, a greater risk of obesity
5	Bopp et al.	2013	Cross-sectional	USA	$n = 1175$, 43.5 ± 11.4 years, 68% females	Walking, Cycling; self-reported	Self-reported cardiovascular/pulmonary, metabolic/musculoskeletal disease, depression, BMI	+ AT is associated with fewer disease risks and better SRH
6	Bopp et al.	2015	Cross-sectional	USA	$n = 299$, 21.5 ± 1.6 years, 44% females	Walking, Cycling; self-reported	Laboratory-based fitness assessment (endurance, strength, flexibility, body composition)	+ Positive associations of AT and greater cardiovascular fitness + AT associated with lower systolic blood pressure
7	de Haas et al.	2021	Longitudinal (2017–2019)	Netherlands	$n = 4511$, aged 18–65+ years, 52% females	Walking, Cycling; self-reported in MPN	Self-reported health, BMI	+ Higher BMI and lower SRH are associated with less walking/cycling + Positive effect of cycling distance on SRH + Negative effect of walking distance on BMI ○ No relationship between BMI and AT for obese people
8	Echeverría et al.	2023	Longitudinal (2014–2016)	USA	$n = 7515$, aged 21–65 (41.5 ± 12.4), 43% females	Walking, Cycling; self-reported from Eating and Health Module in ATUS	Self-reported general health status, BMI	+ Longer cycling commutes are related to higher levels of SRH and lower BMI + Walking only weakly related to SRH and BMI
9	Eriksson et al.	2020	Longitudinal (1998–2015)	Sweden	$n = 318{,}309$, aged 18–74 years, 47% females	Walking, Cycling; self-reported	Anthropometry, blood pressure, submaximal cycle test	+ Low- and moderate/high-dose active commuters have decreased risks for first time CVD during follow-up

Table 1 (Continued)

No.	Author	Year	Study design	Country	Sample	AT measure	Health measure	Main findings
10	Fan et al.	2019	Longitudinal (2004–2008)	China	*n* = 104,170, aged 35–74 (M 45.9) years, 49% females	Walking, Cycling; self-reported	Weight, height, blood pressure, blood composition	+ Walking/cycling are associated with lower risk of ischemic heart disease, cycling with lower risk of ischemic stroke than nonactive travel + Association of commuting mode with cardiovascular disease
11	Kaiser et al.	2023	Cross-sectional	UK	*n* = 208,893, aged 40–69	Walking, Cycling; self-reported from UK Biobank	Self-reported lifestyle indicators + measures (body fat, grip strength, blood, urine and salvia)	+ Cycling and walking positively associated with biomarkers
12	Kalliolahti et al.	2023	Cross-Sectional	Finland	*n* = 38,223, aged 46.0 ± 11.0, 78% females	Walking, Cycling; self-reported from Finnish Public Sector Study survey	Self-reported health status	+ Passive commuting was associated with higher risk of suboptimal SRH + More frequent/longer distance walking and cycling was positively associated with SRH
13	Kroesen & de Vos	2020	Longitudinal (2007–2017)	Netherlands	*n* = 1548, aged 15–65+ years, 49% females	Walking; self-reported from Longitudinal Internet Studies for the Social sciences panel	Self-reported, BMI, 5-item Mental Health Inventory	+ AT does not affect later BMI levels, but BMI does negatively influence later levels of AT + Effect of AT on mental health, but not reversely
14	Liao et al.	2016	Cross-sectional	Taiwan	*n* = 51,949, aged 20–65 (M 38.1) years, 51% females	Walking, Cycling; self-reported AT time National Adult Fitness Survey Taiwan	Objectively measured BMI	+ Lower risk of being overweight compared with motorized travel
15	Martin et al.	2014	Longitudinal (1991–2008)	UK	*n* = 17,985, aged 18–65 (38.39 ± 12.38) years, 58.9% females	Walking, Cycling; self-reported in BHPS	Self-reported in GHQ12	+ Associations between overall psychological wellbeing and AT, PT + AT is associated with reductions of experiencing psychological symptoms
16	Masterson & Phillips	2022	Cross-sectional	Ireland	*n* = 4038, aged 15–65 + years, 50% females	Walking, Cycling; interviews, questionnaire	Self-rated health, objectively measured BMI, waist circumference	+ AT is associated with decreased likelihood of obesity relative to non-AT + Reduced obesity risk among cyclists relative to non-cyclists ◯ No associations between AT and being overweight or SRH
17	Mytton et al.	2018	Cross-sectional	UK	*n* = 7680, aged 29–65 (M 48.3) years, 51% females	Walking, Cycling; self-reported in RPAQ	Objectively measured body fat, visceral adipose tissue	+ Cycling to work is associated with reduced adiposity relative to exclusive car-use + Walking or cycling are associated with reduced adiposity

Table 1 (Continued)

No.	Author	Year	Study design	Country	Sample	AT measure	Health measure	Main findings
18	Mytton et al.	2016b	Longitudinal (2009–2012)	UK	*n* = 801; aged 16–60 + (M 43) years, 69.7% females	Walking, Cycling; self-reported	Self-reported PCS-8, MCS-8, SF-8	+ Cycling is associated with lower sickness absence, higher mental health ○ Cycling is not associated with physical health and changes in cycling are not associated with changes in wellbeing ○ No significant associations between walking and health measures
19	Mytton et al.	2016a	Longitudinal (2009–2012)	UK	*n* = 809; aged 16–60 + (M 43) years, 69.6% females	Walking, Cycling; self-reported	Self-reported BMI	+ Cycling for AT is associated with lower BMI at one year follow up + Only increase in walking is associated with reduction in BMI compared with non-active modes
20	Østergaard et al.	2018	Longitudinal (1993/1997–2013)	Denmark	*n* = 28,204 (15,272 at follow-up), aged 50–65 (M 60.5) years, 51% females	Cycling; self-reported in The Diet, Cancer, and Health study	Mortality via Civil Registration System	+ Cycling up to 60 min/week is associated with lower risk of all-cause mortality compared with non-cycling
21	Panter et al.	2018	Longitudinal (2006/2010–2015)	UK	*n* = 358,799, aged 37–73, 52% females	Walking, Cycling; self-reported from UK Biobank	Self-reported	+ Regular commuters with more active patterns of travel have a lower risk of incident and fatal CVD, and nonregular commuters have a lower risk of all-cause mortality
22	Patterson et al.	2020	Longitudinal (Census data 1991–2016)	UK	*n* = 394,746, aged 16–60 + years, 47% females	Walking, Cycling; self-reported in ONS-LS	Mortality, cancer incidence via census data	+ Cycling for AT is associated with a 20% reduced rate of all-cause mortality, 24% decreased rate of CVD mortality, 16% lower rate of cancer mortality, and 11% reduced rate of incident cancer (compared to private motorized travel) + Walking for AT is associated with 7% lower cancer incidence
23	Peterman et al.	2021	Cross-sectional	USA	*n* = 1,560,000 (adult population, no age details available)	Walking, Cycling; self-reported in ACS	Self-reported CVD risk factors in BRFSS questionnaire	+ Associations between AT and CVD rates + Negative associations between AT and coronary heart disease, myocardial infarction, stroke
24	Riiser et al.	2018	Cross-sectional	Norway	*n* = 2445, aged 30–67 (48 ± 9.8) years, 54% females	Walking, Cycling; self-reported in IPAQ-L	Self-reported diabetes, objectively measured height, weight, blood pressure, blood composition	+ Diabetes, high-density lipoprotein cholesterol level and obesity are inversely associated with cycling for AT + High blood pressure is inversely associated with walking for AT
25	Schauder & Foley	2015	Cross-sectional	USA	*n* = 1498, aged 18–80 (48.32 ± 18.5) years, 51% females	Walking, Cycling, self-reported in NHANES	Objectively measured BMI, blood pressure, blood lipids, self-reported health	+ AT contributes to reductions in cholesterol levels and the probability of being overweight
26	Tamminen et al.	2020	Cross-sectional	Finland	*n* = 5090, aged 18–70 + (M 55.5) years, 56% females	Walking, Cycling; self-reported in FinHealth survey	Self-reported and clinical measured PMH from WEMWBS	+ AT is associated with high PMH

Table 1 (Continued)

No.	Author	Year	Study design	Country	Sample	AT measure	Health measure	Main findings
27	Vaara et al.	2020	Cross-sectional	Finland	*n* = 776, 26 ± 7.2 years, only men	Walking, Cycling; self-reported	Objectively measured BMI, waist circumference, physical fitness (VO_2max, strength) cardiometabolic risk factors (blood pressure, blood composition)	+ Cycling is positively associated with cardiorespiratory fitness
								+ Cycling is inversely associated with body composition
								+ Walking is inversely associated with clustered cardiometabolic risks
								○ Walking is not associated with physical fitness, body composition
28	Zwald et al.	2018	Cross-sectional	USA	*n* = 13,343, aged 20–65+ years, 50% females	Walking, Cycling; self-reported in NHANES	Self-reported, objectively measured blood pressure, blood composition	+ High AT levels are associated with decreased odds of CVD risk factor assessed, compared to non-AT
								+ Low AT (versus non-AT) is associated with decreased odds of hypertension, diabetes

ACS American community survey, *ATUS* American Time Use Survey, *BHPS* British Household Panel Survey, *BMI* body mass index, *BRFSS* behavioral risk factor surveillance system, *CVD* cardiovascular disease, *GHQ12* 12-item General Health Questionnaire, *M* mean, *MCS-8* Mental Component Summary, *MHI-5* 5-item mental health scale of SF-36, *MPN* Netherlands mobility panel, *NHANES* national health and nutrition examination survey, *NHTS* US national household travel survey, *ONS-LS* UK office for national statistics longitudinal study of England and Wales, *PASTA* physical activity through sustainable transport approaches, *PCS-8* Physical Component Summary, *PMH* Positive mental health, *PSS-4* perceived stress scale, *RPAQ* recent physical activity questionnaire, *SF-8* Medical Outcomes Study Short Form questionnaire, *SF-36* the medical outcome study short form, *SRH* self-rated health, *TCCS* Twin Cities cyclist survey, *WEMWBS* Warwick Edinburgh mental well-being scale, *No.* number
+ positive associations, – negative associations with health parameters, ○ neutral associations

ies only. The studies included in these reviews were conducted mainly in Europe, Australia, China, Japan, Canada, and the US. Participants of the included studies are mostly 18+ years old, with some starting at 16 years old. Except for one study (men only, Vaara, Vasankari, Fogelholm, Koski, & Kyröläinen, 2020), all studies investigated male and female adults. Investigated modes of travel were walking and cycling (30 papers), walking only (2), or cycling only (3) in comparison to non-active travel modes. In addition, 16 of the 28 single studies and five of the reviews compared AT to car travel or motorized private transport, respectively, or made specific comparisons to PT. In the other papers, it is not clear to what extent AT is differentiated from other mobility modes. Besides walking and cycling, there were no other ways of AT investigated in the eligible papers.

The main characteristics of the studies are presented in **Tables 1 and 2** and summarized below.

The associations between AT and health parameters have been intensively researched. However, there was not a balanced distribution between objective and subjective health parameters. Nineteen studies and seven reviews assessed associations with objective parameters, i.e., cardiovascular respectively cardiometabolic diseases and diabetes (3, 6, 9, 10, 23–25, 27, 28, 30, 32–34)[1], obesity and body composition (3, 4, 5, 7, 14, 16, 17, 19, 24, 25, 27, 29, 31, 35), mortality (20, 22), cancer (22, 30), chronic diseases in general (5), and physical fitness (6, 27, 31). Only eight studies and one review assessed subjective health parameters, e.g., mental and self-rated health (1, 2, 7, 13, 15, 16, 18, 26, 33).

Associations of AT and disease-preventing parameters

In general, positive associations could be found between AT and chronic diseases (5). When looking at specific disease-preventing parameters, strong associa-

[1] The numbers in parentheses in the following text correspond to the numbering of the papers from **Tables 1 and 2**.

Table 2 Characteristics of the reviews

No.	Author	Year	Study design of integrated studies	Country	Sample	AT measure	Health measure	Main results
29	Brown et al.	2017	Cross-sectional and longitudinal	Australia, France, Netherlands, New Zealand, Norway, Poland, Spain, Sweden, Switzerland, UK, USA	*n* = 430,440 (5 reviews, 18 studies), aged 15–75 years	Walking, Cycling; self-reported	BMI, waist circumference, body composition	◯ Evidence of an obesity effect of AT behavior is inconclusive and potential BMI effect is relatively small
30	Dinu et al.	2019	Longitudinal	China, Denmark, Finland, France, Germany, Ireland, Japan, Switzerland, UK, USA	*n* = 531,333, aged 15–93 years (23 studies)	Walking, Cycling; self-reported	All-cause mortality, CVD mortality, diabetes, Cancer mortality, Heart failure, stroke, CHD	◯ No association between AT and CVD mortality, cancer + AT reduces risk of diabetes by 30%, risk of mortality by 8%, risk of CVD by 9% + Cycling commuters have a lower risk of all-cause (–24%) and cancer mortality (–25%)
31	Henriques-Neto et al.	2020	Cross-sectional	Finland	*n* = 781, aged 18–90 years (1 study)	Walking, Cycling; self-reported	Cardiorespiratory fitness (VO_2max, heart rate, BMI, waist circumference)	+ AT has positive association with fitness + Cycling has a positive relationship including increased physical performance
32	Lorenzo et al.	2020	Cross-sectional and longitudinal	Canada, China, Japan, Norway, USA	*n* = 107,222, aged 18–79 years (10 studies)	Walking; self-reported	Waist circumference, blood composition, blood pressure	+ Walking has benefits of a smaller waist circumference, risk of abdominal obesity, lower blood pressure, hypertension ◯ Minimal to no evidence to suggest a relationship between walking and metabolic measures (high-density lipoproteins, triglycerides, hypertriglyceridemia, fasting glucose, diabetes, cardiometabolic syndrome)
33	Peruzzi et al.	2020	Cross-sectional and longitudinal	Australia, Denmark, UK, USA	*n* = 382,435 (9 studies), aged 18–90 years	Cycling; self-reported	Hypertension, diabetes, dyslipidemia, metabolic syndrome, ischemic heart diseases, heart failure, mental illness	+ Cycling has benefits of reduced risks of CVD, obesity and cardiometabolic diseases, depression + Cycling has benefits of improved mood
34	Saunders et al.	2013	Longitudinal	China, Denmark, Finland, Japan, UK	*n* = 139,537 (11 studies), aged 20–93 years	Walking, Cycling: self-reported	Blood pressure, lung function, blood composition	◯ Modest benefits of all-cause mortality/cardiovascular outcomes ◯ Small effect on diabetes prevention
35	Xu et al.	2013	Cross-sectional, systematic review	China, Sweden	*n* = 26,088 (3 studies, 1 review), aged 15+	Walking, Cycling: self-reported	BMI, blood composition, blood pressure, SRH, mental health	+ Inverse association between AT and body weight + Walking is associated with lower probability of dyslipidemia + The likelihood of hypertension increased along with time of AT

The sample size *n* of the selected reviews only includes studies that fulfilled the inclusion criteria of this review
BMI body mass index, *CHD* coronary heart disease, *CRF* cardiorespiratory fitness, *CVD* cardiovascular disease
+ positive associations, – negative associations with health parameters, ◯ neutral associations

tions between AT (walking and cycling) and reduced risk for cardiovascular and cardiometabolic diseases were found (3, 6, 9–11, 21, 23–25, 27, 28, 30, 32, 33). Cycling as AT revealed health advantages in some studies (3, 24, 30, 33), while walking was not inversely associated with clustered cardiometabolic risk (27) but helped to lower blood pressure and hypertension (24). The existing longitudinal studies and reviews strengthen the hypothesis of the health advantage of cycling as AT. They showed significant impacts of cycling on cardiovascular and cardiometabolic diseases (10, 11, 30, 33) as well as on more critical objective health parameters, such as lower risks of mortality (all-cause 20%, CVD 24%, cancer 16%) and cancer (11%) (20, 22, 30). In longitudinal studies, walking as AT was found to be associated with reduced risk of mortality as well, but the risk reduction was much lower than in cycling (all-cause mortality 8%, CVD 9%, cancer 7%) (22, 30). Regarding the distance, AT walkers covered between 0.4 km (short-term) and 9.7 km (long-term) on average, and cyclists covered 1.3 km (short-term) and 10.8 km (long-term) (22). Hazard ratios suggested commensurate effects on health in favor of distance but not mode (7, 22).

Compared to these parameters, the association of AT with overweight/obesity is not as clear. The majority of the papers (12 papers) showed small but positive associations between AT (walking and/or cycling) and parameters of body composition, in particular lowering the risk of obesity (3, 4, 8, 11, 14, 17, 19, 24, 25, 27, 33, 35). This was especially apparent in comparison to non-AT modes, e.g., travel with car/motor vehicle/PT. However, four papers showed no clear associations, especially when looking at being overweight in general opposed to being obese (7, 16, 29, 32) and one paper (13) showed no association between AT and being overweight or obesity respective, which means that the evidence for an effect of AT on obesity is still inconclusive (29), and it could not be determined whether walking or cycling are more powerful as AT. Some longitudinal studies showed that walking could reduce waist circumference and the risk of abdominal obesity (32), while others showed that cycling as AT may reduce the risk of obesity (33). Other studies found positive effects of AT on BMI for both travel modes (8), but no rehabilitative effect for obese people. Furthermore, being overweight or obese was assumed to decrease bicycle use (7). Finally, walking distance has a positive impact on BMI, as indicated by a study where individuals who walked at least 3 km per day were less likely to be obese compared to non-active commuters (15). Among individuals who cycled exclusively, there was a correlation between commuting distance and body fat, but not for walking (16).

Associations of AT and health-promoting parameters

Both walking and cycling were associated with greater cardiovascular (6) and physical fitness (6, 27) and this relationship was particularly visible in the case of cycling as AT (27, 31). No longitudinal studies were identified which support this outcome. Most of the studies assessing subjective health parameters indicated a positive association with AT (2, 8, 12). In particular, cycling was linked with positive mental health cross-sectionally (26) as well as longitudinally (1, 18), and only one study could not find any associations between AT and self-rated health (16). The health promotion significance of cycling as AT, increasing with distance, also becomes clear (7). Other investigations gathering distance data did not draw any conclusions with regard to health (31).

Discussion

This review investigated the existing literature over the last decade (2013–2023) that examined associations between AT and general health parameters. Our review reveals both a growing interest in the health impact of AT but also an inconsistent landscape in terms of research methods and designs. On the one hand, there has been a noticeable increase in longitudinal research and reviews over the past decade, with 12 longitudinal studies and seven systematic reviews identified. In addition, there are three reviews that combine longitudinal and cross-sectional studies. However, it is worth noting that cross-sectional studies continue to be prevalent, with 16 conducted in the same time frame. In response to the research question, data largely indicate that AT has significant associations with several health parameters, but the associations are partly dependent on travel mode and/or type of health parameter.

Most of the studies target objective parameters, e.g., cardiovascular and cardiometabolic risks, particularly diseases which are of central importance for public health (Zemedikun, Gray, Khunti, Davies, & Dhalwani, 2018). In this review AT proved to have inversed associations with both cardiovascular and cardiometabolic risks.

The available longitudinal studies make clear that cycling has stronger disease-preventing effects than walking (Dinu et al., 2019; Peruzzi et al., 2020; Patterson et al., 2020; Mytton, Panter, & Ogilvie, 2016a). This is physiologically explicable since cycling evokes a higher cardiovascular load and therefore leads to a higher MVPA (Vaara et al., 2020). Thus, engaging in PA of sufficient duration and intensity can lead to improvement in cardiometabolic health, which is not given in walking only.

However, walking may have some beneficial health effects. If certain conditions are met, walking can have significant impact on disease prevention. Reduction of cardiovascular diseases through AT is shown longitudinally regardless of mode and dose, when investigating individuals with sedentary work lifestyles, inconsistent exercise routines, a history of being overweight or obese, and low physical fitness levels (Eriksson et al., 2020).

However, when summarizing the information out of cross-sectional and longitudinal studies about the prevention of obesity, the associations with and impacts of AT on obesity prevention are weak and inconsistent, so no robust conclusion can be drawn. Also, the inverse effect does exist, meaning that increased overweight is negatively connected to bicycle use (de Haas, Kroesen, Chorus, Hoogendoorn-Lanser, & Hoogendoorn, 2021) and BMI does have a negative influence on walking behavior and later levels of AT (Kroesen & de Vos, 2020).

AT does also provide benefits to reduce even more serious health problems like cancer or mortality risks. Inversed associations between AT and chronic diseases like diabetes were observed (Bopp, Kaczynski, & Campbell, 2013; Dinu et al., 2019; Saunders et al., 2013). Regarding mortality and cancer, cycling evokes stronger effects than walking only (Patterson et al., 2020; Dinu et al., 2019), which is in line with previous research (Shepard, 2008).

Besides the risk reduction of diseases, AT is strongly associated with health-promoting parameters like physical fitness (Bopp, Bopp, & Schuchert, 2015; Riiser, Solbraa, Jenum, Birkeland, & Andersen, 2018; Vaara et al., 2020; Henriques-Neto et al., 2020). Only cross-sectional studies could be found on this health outcome, and additionally, the question, whether walking or cycling have a stronger relationship with fitness has not yet been consistently answered.

Fewer subjective than objective perspectives were gathered, but an increase of papers during the last five years is notable. The literature could confirm lower feelings of loneliness, more time spent with family and friends, and higher vitality after AT (Avila-Palencia et al., 2018; Tamminen et al., 2020), but the research was not fully consistent. Longitudinal effects of AT on self-rated health were found for cycling only (de Haas et al., 2021; Mytton, Panter, & Ogilvie, 2016b). Also, the authors highlighted that the effect of cycling on self-rated health is stronger than the reverse effect, and that those effects increased with travel distance. Avila-Palencia et al. (2018) also found positive associations of car travel on lower feelings of loneliness and Masterson and Phillips (2022) did not find any associations between AT and self-rated health.

Strengths and limitations

The strengths of this scoping review include the large databases searched, the large samples, and the holistic health approaches. Due to the variety and distribution of participants included in this review, risks of selection bias—which often occurs in intervention trials—are not expected to be present. Our scoping review can therefore help to give a broad overview and identify trends and research gaps. The extracted longitudinal studies help to foster such trends and allow inference of causal directions, i.e., the impact of AT on health, with the use of large sample sizes.

The scoping review also has some limitations. Including cross-sectional data is the main limitation since only associations and hints on evidence can be revealed. Based on the cross-sectional data, this review cannot answer the question if AT leads to improved health or if rather healthier individuals are more inclined to travel in an active mode (Kroesen & de Vos, 2020). Also, we identified some measurement and methodological issues. Numerous self-reported measurement tools such as questionnaires were used, which minimizes the objectiveness of the outcomes to a certain extent. No research gathered data of types of AT other than walking or cycling. Furthermore, there were inconsistencies in how AT was compared to non-active modes of travel, i.e., car or other motorized travel, or PT, and the categorization of AT across different studies (i.e., yes/no vs. minutes of AT with certain thresholds).

Conclusion

Active travel (AT), e.g., walking and cycling, can enhance several health parameters such as lowering the risk of obesity or result in greater cardiovascular and physical fitness. Therefore, AT can serve as a contribution to enhancing public health.

Still, not enough research has been done to disentangle which mode of AT is the best for health, but cycling does appear favorable when it comes to health benefits. It is also unclear whether health-promoting parameters or subjective health can be influenced in the same way as disease-preventing factors. Further longitudinal research is strongly recommended. Nonetheless, in times of increasing prevalence of noncommunicable diseases (NCD), world inactivity, and the need for societal transformation toward more sustainability, AT can play an important role in addressing these challenges.

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Declarations

Conflict of interest. S. Tittlbach, A. Brockfeld, S. Kindig and M. Herfet declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

Appendix

Search terms

Table 3 Web of Science

Search Term (Core Research)
TI = ("active transportation" OR active commut* OR walk* OR bik* OR bicycle* OR pedestrian*) *AND TI* = ("physical activity" OR "physical activity recommendation*" OR "physical activity guideline*" OR "health" OR "health benefits" OR "health effects" OR "health outcomes" OR "mental health" OR cardiovascular OR overweight OR body weight OR fitness OR "sustainability" OR "greenhouse gas emission*" OR "air pollution" OR "environment" OR infrastructur* OR "participatory intervention") *NOT TI* = (animals OR child* OR kid* OR minor* OR youth OR adolescen* OR teen* OR teenager* OR disabled OR school OR biological transport OR "substrate cycling" OR Amikacin OR "chromosome walking" OR Dandy-Walker-Syndrome OR therapy OR physiology OR ergometer OR exercise test* OR exercise OR treadmill OR gait OR cell* OR cell membrane* OR membrane* OR ATP OR "social distancing" OR nurse OR patient OR tourism OR tourist OR food OR nutrition OR diet)
Filter
Year: 2013–2021, *Language*: English and German; *Article Type*: Review, Article, and Data Paper
Search Term (Updated Research)
TI = ("active transportation" OR active commut* OR walk* OR bik* OR bicycle* OR pedestrian*) *AND TI* = ("health" OR "health benefits" OR "health effects" OR "health outcomes" OR "mental health" OR cardiovascular OR overweight OR body weight OR fitness) *NOT TI* = (animals OR child* OR kid* OR minor* OR youth OR adolescen* OR teen* OR teenager* OR disabled OR school OR biological transport OR "substrate cycling" OR Amikacin OR "chromosome walking" OR Dandy-Walker-Syndrome OR therapy OR physiology OR ergometer OR exercise test* OR exercise OR treadmill OR gait OR cell* OR cell membrane* OR membrane* OR ATP OR "social distancing" OR nurse OR patient OR tourism OR tourist OR food OR nutrition OR diet)
Filter
Year: 2021–2023, *Language*: English and German, *Article Type*: Review, Article, and Data Paper

Table 4 The Cochrane Library

Search Term (Core Research)
(active transport* OR active commut* OR active travel OR non-vehicle OR non-motor* OR bicycl* OR bik* OR pedestrian OR cycl* OR walk*) in *Record Title AND* ("physical activity" OR "physical activity guideline*" OR "physical activity recommendation*" OR health OR health benefits OR health effects OR health outcomes OR "sustainable" OR sustainability OR "greenhouse gas emission*" OR "air pollution" OR "environment" OR "infrastructur*" OR urban OR intervention* OR "participatory intervention") in *Record Title NOT* (animals OR child* OR kid* OR minor* OR youth OR adolescen* OR teen* OR teenager* OR disabled OR school OR biological transport OR "substrate cycling" OR Amikacin OR "chromosome walking" OR Dandy-Walker-Syndrome OR therapy OR physiology OR ergometer OR exercise test* OR treadmill OR gait OR cell* OR cell membrane* OR membrane* OR ATP) in *Record Title*
Filter
Year: 2013–2021, *Language*: English and German

Table 5 PubMed

Search Term (Core Research)
(travel OR transport OR commut* OR transport mode* OR commuting behav* OR travel behav* OR active travel OR active transport* OR active commut* OR non-vehicle OR non-motor* OR bicycl* OR bik* OR pedestrian OR cycl* OR walk*) *AND* (physical activit* OR exercise OR leisure time physical activit* OR leisure activit* OR physical activity guideline* OR physical activity recommendation* OR health OR health impact* OR health outcome* OR health benefit* OR health effect* OR health status OR physiological health OR physical health OR mental health OR psychological health OR mortality OR cardiovascular disease OR cancer OR diabetes OR obesity OR body weight OR fitness OR physical function* OR green OR sustainable OR sustainability OR environmentally friendly OR environment-friendly OR eco-friendly OR environmental friendliness OR eco-friendliness OR greenhouse gas* OR greenhouse gas emission* OR global warming OR air pollution OR pollution OR neighborhood OR neighbourhood OR environment OR "natural environment" OR "built environment" OR "physical environment" OR "urban environment" OR "suburban environment" OR "street environment" OR "travel environment" OR "road environment" OR "objective environment" OR infrastruct* OR urban planning* OR urban design* OR walkability OR pedestrian-friendly OR city planning* OR social environment OR personal environment OR intervention* OR "participatory intervention*" OR "collaborative intervention*" OR "cooperative intervention*" OR "collective intervention*" OR "collaborative planning*" OR "cooperative planning*" OR "collective planning*" OR collaboration* OR cooperation* OR co-creation* OR promot* OR plan* OR communit* OR citizen* OR "member of the public") *NOT* (animals OR child* OR kid* OR minor* OR youth OR adolescen* OR teen* OR teenager* OR disabled OR school OR biological transport OR "substrate cycling" OR Amikacin OR "chromosome walking" OR Dandy-Walker-Syndrome OR therapy OR physiology OR ergometer OR exercise test* OR treadmill OR gait OR cell* OR cell membrane* OR membrane* OR ATP OR "social distancing" OR food OR nutrition OR diet OR patient* OR nurse* OR tourist* OR tourism)
Filter
Year: 2013–2021; *Language*: German and English; *Target group*: adults ≥18 years, and human species
Search Term (Updated Research)
(travel OR transport OR commut* OR transport mode* OR commuting behav* OR travel behav* OR active travel OR active transport* OR active commut* OR non-vehicle OR non-motor* OR bicycl* OR bik* OR pedestrian OR cycl* OR walk*) *AND* (health OR health impact* OR health outcome* OR health benefit* OR health effect* OR health status OR physiological health OR physical health OR mental health OR psychological health OR mortality OR cardiovascular disease OR cancer OR diabetes OR obesity OR body weight OR fitness OR physical function*) *NOT* (animals OR child* OR kid* OR minor* OR youth OR adolescen* OR teen* OR teenager* OR disabled OR school OR biological transport OR "substrate cycling" OR Amikacin OR "chromosome walking" OR Dandy-Walker-Syndrome OR therapy OR physiology OR ergometer OR exercise test* OR treadmill OR gait OR cell* OR cell membrane* OR membrane* OR ATP OR "social distancing" OR food OR nutrition OR diet OR patient* OR nurse* OR tourist* OR tourism)
Filter
Year: 2021–2022, *Language*: German and English, *Target group*: adults ≥ 18 years, and human species; *Article type*: Clinical Study, Clinical Trial, Comparative Study, Controlled Clinical Trial, Multicenter Study, Observational Study, Pragmatic Clinical Trial, Randomized Controlled Trial, Review, Systematic Review, Clinical Trial (Veterinary), Validation Study, Observational Study (Veterinary), and Twin Study

Table 6 Science Direct

Search Term (Core Research & Updated Research)
1) Impact of AT on PA
(active commute OR active transportation) *AND* ("physical activity") *NOT* (school OR pilots OR minors OR cell OR patients OR noise)
2) Impact of AT on Health
General Health: (active commute OR active transportation) *AND* ("health") *NOT* (school OR pilots OR minors OR cell OR patients OR noise)
Cardiovascular Health: (active commute OR active transportation) *AND* ("cardiovascular") *NOT* (school OR tourist OR animals OR cell OR patients OR noise)
Mortality: (active commute OR active transportation) *AND* ("mortality") *NOT* (school OR tourist OR animals OR cell OR patients OR noise)
Health Outcome: (active commute OR active transportation) *AND* ("health outcome") *NOT* (school OR tourist OR animals OR cell OR patients OR noise)
Mental Health: (active commute OR active transportation) *AND* ("mental health") *NOT* (school OR tourist OR animals OR cell OR patients OR noise)
Obesity: (active commute OR active transportation) *AND* ("obesity") *NOT* (school OR tourist OR animals OR cell OR patients OR noise)
Filter
Year: 2013–2021, *Language*: English and German; *Article Type*: Review Articles, and Research Articles

With Science Direct, the original search term cannot be entered, since only a maximum use of 8 Boolean operators is allowed. Therefore, the term had to be divided into several components, especially in the research area of health impacts

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