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REVIEW ARTICLE

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Health effects of active commuting to work: The available evidence before GISMO

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Sedentary lifestyle is a major modifiable risk factor for many chronic diseases. Global guidelines recommend for maintaining health in adults, at least 150 minutes of moderate intensity of physical activity throughout the week, but compliance is insufficient and health problems arise. One obvious way to overcome this is to integrate physical activity into the daily routine for example by active commuting to work. Scientific evidence, however, is scarce and therefore we set out to perform this systematic review of the available literature to improve understanding of the efficiency of active commuting initiatives on health. Literature searches were performed in PubMed and Cochrane database. Altogether, 37 studies were screened. Thereof, eight publications were reviewed, which included 555 participants. The mean study duration of the reviewed research was 36 ± 26 (8-72) weeks. Overall, active commuting in previously untrained subjects of both sexes significantly improved exercise capacity, maximal power, blood pressure, lipid parameters including cholesterol, high-density lipoprotein, and waist circumference. Improvement was independent of the type of active commuting. Despite relatively few studies that were previously performed, this review revealed that active commuting has health beneficial effects comparable to those of moderate exercise training.

KEYWORDS
active transport, cardiovascular disease risk factors, exercise, health outcomes, public health, workplace

1 | INTRODUCTION

The World Health Organization recommends 150 minutes of moderate physical activity per week to provide substantial health benefits.[1] Unfortunately, the majority of adults in high-income countries fails to achieve the recommended amount of activity[2] and spends most of the waking day sedentary. This behavior increases the risk of morbidity and mortality of cardiovascular diseases as well as of most non-communicable diseases.[3,4] Indeed, obesity rates are increasing in countries in which active travel declines.[5] Daily walking or bicycling to work, however, lead to a lower BMI,[6] percentage of body fat,[7] waist circumference,[8] and improves mental and physical well-being.[9] Further, pedestrians and cyclists have fewer diseases like diabetes[6,8] or arterial hypertension and have a reduced risk for coronary heart diseases (CHD) compared to car commuters.[10-13] Studies also show that regular cycling decreases all-cause mortality by approximately 30%.[14,15] In industrialized countries, lack of time is often claimed to be a crucial barrier for increasing daily physical activity levels. An opportunity for employees to comply with the recommended amounts of activity is regular active commuting by walking or cycling the distance between home/work, while using public transportation. It is the purpose of this review to assess current literature on intervention studies including the effects of active commuting and its benefits for health and wellbeing.[16-23]

2 | METHODS

This systematic review conformed with the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines.[24] Therefore, no Institutional Review Board approval was necessary. One reviewer searched for potentially relevant studies. If the title and the abstract had no clear context to active commuting, the paper was reviewed in detail by the authors CS and BM.

2.1 | Literature search methodology

An electronic search was performed utilizing Pubmed (Medline) and Cochrane Library database of articles published up to November 9th 2018. The search query based on the PICO model.[25] In detail, we searched for humans (P), active commuting (I), control group (C), improvement of quality of life and maintenance or improvement of the health status (O). Subjects were older than 18 years. Depending on the capability of the databases, MeSH-Terms were entered into the search. The Boolean operator "AND" was used to combine the research terms "health effects" and "active commuting". Additionally, the reference lists of each included article were controlled for further relevant articles.[17-20]

2.2 | Inclusion and exclusion criteria

Studies were included in the review based on the following criteria: (a) intervention studies; (b) health effects as the target; and (c) active commuting as the primary intervention. Studies were excluded if (a) they were protocols/conference papers/ posters/ presentations, (b) they were observational, for example, retrospective and single cross-sectional, and (c) the intervention period was less than three weeks in duration. Search strategy and inclusion/exclusion results are summarized in Figure S1. Data from studies that met the inclusion criteria were extracted by one reviewer (CS) into structured templates and checked by a second reviewer (BM).

2.3 | Statistical analyses

Percent change and Cohen's d effect sizes (ES) were calculated wherever possible to indicate the magnitude of the practical effect. As recommended by Cohen,[26] effect sizes were interpreted as follows: small = >0.2, medium = >0.5, and large = >0.8. The sample size of each included study has been taken under consideration and therefore weighted mean values were calculated wherever possible.

3 | RESULTS

The results of the systematic search process are shown in Figure S1. The search revealed a total of 176 titles. After removal of duplicates and exclusion of non-relevant titles, 32 articles were screened by their abstracts. The main reason for exclusion by abstract was because the study was not focused on active commuting and its health effects. Twenty-four articles were reviewed of which 20 were excluded because they were observational studies; that is, retrospective and single cross-sectional studies or study protocols/ conference papers/ interviews, or the intervention period was less than three weeks. However, four articles were added manually. Of these, two articles dealt with the same study population.[18,19] Thus, a total number of six studies published in eight articles met the inclusion criteria[16-23] (Table 1). Baseline characteristics of each included study are shown in Table S1.

3.1 | Active commuting and physical activity in healthy normal weight subjects

Summarizing the studies which focused on a normal weight study population, 305 participants (188 male, 117 female) were recruited with an average sample size of 76 ± 30.3 (42-115). Subjects were from Finland,[16] from different companies in Amsterdam,[17] members of a health insurance company from Belgium,[18,19] and from different companies on the Island of Funen, Denmark.[21] Of the included studies, the weighted mean age of the reported participants was 41 ± 7.2 years (37-45). None of the studies examined competitive athletes or well-trained participants but rather sedentary subjects as evidenced by the baseline results of the physical performance analysis, as well as their inclusion/exclusion criteria. All studies excluded participants who were already commuting actively prior to beginning of the studies. All four included investigations were randomized controlled trials, with an intervention group (IG) and a control group (CG). The mean length of the intervention was 30.5 ± 24.8 (8-52) weeks, with an average of 4.0 ± 1.15 (range = 3-5) sessions per week. Both,

TABLE 1 Overview of main characteristics and outcomes examined in included studies

Reference	Study design	Type of intervention	Method of recording active commuting	N	Subjects	Country	Duration	Improvement in physical fitness	Improvement in other health parameters
Oja[16]	Randomized controlled trial; Stratification into walking or cycling group according to home-to worksite distance, random selection for IG and CG	IG: commuter cycling or walking CG: continued use of a car or bus	Daily log of distance, duration and subjective strain as well as diary for leisure-time exercise, 2 times 5 d of heart rate recording using portable telemetric cardiometer	Recruited: 68 Completed: IG: 35 CG: 33	Healthy untrained participants of postal survey M = 38 F = 30 40 ± 8y	FIN	10 wk	Maximal exercise test (cycler on cycle ergometer, walker on treadmill), VO_{2peak}, $VO_{2peak/kg}$, HR_{max}, $Time_{max}$, VE_{O2max}, $RER_{max,}$ lactate	Weight, BMI, lipids
Hendriksen[17]	Randomized controlled trial; Stratification according to sex and age	IG: commuter cycling at least 3 times per week for 1 y CG: 6 mo no change in behavior, then start of commuter cycling	Self-reported diary, distance recorder on bicycle, telemetric heart rate recording twice during one-way trip	Recruited: 122 Completed: IG: 57 CG: 58	Healthy untrained employees of two companies with administrative jobs M = 84 F = 31 38 ± 7 y	NLD	1 y	Maximal exercise test (cycle ergometer), VO_{2peak}, $VO_{2peak/kg}$, P_{max}, $P_{max/kg}$, HR_{max}, RER_{max}	Weight, BMI, cycle distance, heart rate during cycling, intensity of cycling
de Geus[18,19]	Randomized controlled trial; Stratification based on distance to work and travel frequency	IG: commuter cycling at least 3 times per week CG: no change in behavior	Self-reported diary, distance recorder on bicycle	Recruited: 92 Completed: IG: 65 CG: 15	Healthy untrained members of a health insurance company M = 37 F = 43 44 ± 6y	BEL	1 y	Maximal exercise test (cycle ergometer), VO_{2peak}, $VO_{2peak/kg}$, P_{max}, $P_{max/kg}$, HR_{max}, RER_{max}	Weight, BMI, lipids blood pressure, quality of life, leisure-time physical activity diary, km/wk, km/h, bouts/wk, kcal/wk, MET
Hemmingsson[20]	Randomized controlled trial, stratified for age and waist circumference	IG: moderate intensity group (commuter cycling) CG: low intensity group (commuter walking)	Distance recorder, pedometer, daily diary of commuting mode, self-reported activity diary every other month (total 70 d)	Recruited: 120 Completed: IG: 54 CG: 45	Women with abdominal obesity (waist circumference 88-120 cm), F = 120 48 ± 8 y	SWE	18 mo	-	Increase cycling behavior >2 km/d, increased daily step count >10 000 steps/d, waist circumference, sagittal abdominal diameter
Møller[21]	Randomized controlled trial; Stratification according to sex, age, and daily cycling distance	CG: daily commuter cycling	Distance recorder on bicycle, weekly diary on cycling and leisure-time exercise	Recruited: 48 Completed: IG: 19 CG: 23	Healthy untrained members of various occupational affinities M = 29 F = 13 45 ± 9 y	DEN	8 wk	Maximal exercise test (cycle ergometer), VO_{2peak}, $VO_{2peak/kg,}$ HR_{max}, $RER_{max,}$ lactate	Body fat, blood pressure, weight, BMI

(Continues)

TABLE 1 (Continued)

Reference	Study design	Type of intervention	Method of recording active commuting	N	Subjects	Country	Duration	Improvement in physical fitness	Improvement in other health parameters
Gram[22]/ Quist[23]/ Rosenkilde[46]/ Blond[47]	Randomized controlled trial, stratified for gender	IG: 1. Group: active commuting by bike, 2. Group: moderate intensity leisure-time exercise, 3. Group: vigorous intensity leisure-time exercise CG: no change in behavior	Three-axial accelerometry for 7 consecutive days (total and non-exercise activity) Heart rate monitors with built-in GPS for recording of exercise sessions.	Recruited: 130 Completed: IG 1:19 IG 2:31 IG 3:24 CG: 16	Healthy and no regular active people with a BMI: 25-35 kg/m^2 M = 61 F = 69 34 ± 7 y	DEN	6 mo	Maximal exercise test (cycle ergometer), VO_{2peak},	Fat mass, weight, fasting glucose

Abbreviations: BEL, Belgium; BMI, body mass index; CG, control group; DEN, Denmark; FIN, Finland; HR, heart rate, RER, respiratory quotient; IG, Intervention group; MET, metabolic equivalent; NLD, Netherlands; P_{max}, maximal power in Watt; $P_{max/kg}$, maximal power in Watt in relation to the bodyweight; SWE, Sweden; UK, United Kingdom; VE_{O2max}, maximal minute ventilation; VO_{2peak}, peak oxygen uptake; $VO_{2peak/kg}$, peak oxygen uptake in relation to the bodyweight.

one year interventions of de Geus et al[18,19] and Hendriksen et al[17] started in April. The 8-week interventions of Møller et al[21] started in February and the interventions of Oja et al[16] started in May. Interventions were cycling[16-19,21] and/or walking,[16] while one study included a control group, which cycled only 26 instead of 52 weeks.[17] The commuter cycling studies analyzed the cardiorespiratory fitness,[16-18,21] the physical performance,[16-18] and the influence on indexes of health.[16,19,21] One study examined the physiological effects of walking and cycling.[16]

Participants of all four investigations[16-19,21] reported their physical activity via self-reported diaries. One study[17] measured heart rate with a telemetric heart rate recorder to calculate the intensity of the commuter cycling twice during a one-way trip, one study[16] measured heart rate twice for five consecutive days with a telemetric heart rate recorder and three studies used a distance recorder mounted on bicycles.[17-19,21]

When synthesizing statistically significant results, measures of VO_2max increased in all four studies (delta % pre vs. post = 0.4%-13%, Cohen's d effect size (ES) IG vs. CG = 0.488-2.118).[16-18,21] Three studies showed significant increase in maximal power, and duration of the exercise test, respectively (4.9%-11.0% pre vs. post; ES = 0.857-1.792 IG vs. CG).[16-18] Further significant results were described by two studies for diastolic blood pressure (−8.9% to −5.9% pre vs. post, ES = −0.136 to 0.289 IG vs. CG).[18,21] Additionally, two studies analyzed lipid parameters,[16,19] but only one[19] showed significant improvement in total cholesterol (−8.84% to +1.8% pre vs. post, ES = −0.282 to +0.076) and high-density lipoprotein cholesterol (0.7%-5.6% pre vs. post, ES = 0.451-0.726). A graphical overview of the results is shown in Figure S2.

3.2 | Active commuting and physical activity in overweight and obese subjects

Summarizing the studies which focused on overweight and obese subjects, 250 (61 male, 189 female) were recruited with an average sample size of 125 ± 7. Subjects were from the Copenhagen area, Denmark[22,23] and Stockholm, Sweden.[20] Of these two studies[20,22,23] the weighted mean age of the reported participants was 40.8 ± 7.4 years. Participants were healthy, physically inactive, overweight and obese. The two included investigations were randomized controlled trials, with a control group (CG) and an intervention group (IG) that in the case of the GO-ACTIWE study[22,23] was divided into an active commuting group, moderate intensity exercise group and vigorous intensity exercise group. In the case of Hemmingsson et al,[20] the CG was mainly focused on walking and the IG on cycling.

The mean length of the intervention was 48 ± 33.9 (24-72) weeks. Interventions were cycling and/ or walking.[20,22,23] The randomized controlled trial from the GO-ACTIWE study[22,23] started at several time points and Hemmingsson et al[20] started in April and lasted 18 months. This study showed that the compliance especially for cycling fluctuated with the season.

GPS tracking and heart rate recorders were used for all exercise sessions of the participants in the GO-ACTIWE study.[22,23] Hemmingsson et al[20] documented cycling with help of a distance recorder, walking was measured with a pedometer, and exercise activities were additionally documented in a daily diary.

4 | DISCUSSION

The aim of this study was to synthesize and critically review the available intervention studies on active commuting and beneficial health effects before the publication of the GISMO study (Niederseer et al,[27] Loidl et al,[28] Schmied et al,[29] Neumeier et al,[30] Fernandez La Puente de Battre et al.,[31] Sareban et al.,[32] Reich et al.,[33]). Only eight articles on a total of six studies were detected, and the researchers reported a diverse range of results relating to active commuting type, duration, and output.[16-23] Nevertheless, the main results indicate that cycling and walking to work at a self-paced intensity have a positive impact on indexes of fitness and health parameters.

In the reviewed intervention studies, no intervention included public transportation. All included studies found significant improvement in the measured parameters of exercise capacity in the intervention groups. The studies showed that the improvement of fitness is greater in people with lower starting fitness levels compared with those who started already at a higher physical performance level. Already a single trip distance of 3 km was enough to lead to a significant gain in maximal power in previously inactive subjects. The intensity of commuter cycling is usually lower than the intensity of leisure-time cycling, because people wish not to get sweaty on their way to work,[17] which is especially the case if there are no showers. Still physical activity improved, especially in previously inactive people.[17,21] The study of Hendriksen et al showed that the increase in the exercise capacity and maximal power was reproducible independent of the season, as the control group started commuter cycling 6 months after the intervention group.[17] In contrast, a seasonal influence in the attendance of commuter cycling has been shown in the study of Hemmingsson et al, which reported lower compliance levels for active commuting during winter months compared to the rest of the 18 months of the study period.[34]

Two studies showed a significant reduction in diastolic blood pressure by commuter cycling, but only one also reported significantly lower systolic blood pressure.[19,21]

However, not only commuter cycling increases daily activity levels. The Study of Oja et al demonstrated that 10 weeks of commuter walking increased exercise capacity.[16] Several studies have shown that users of public transportation tend to walk more than those who travel by car.[35-37] Because in some cases they are inclined to add walking to bus journeys by getting off the bus early or walking to the next bus stop. Studies have also revealed that there are certain strategies like walking home from work rather than to work when time pressure exists.[38] But still, very few studies[16,39] have objectively measured the contribution of walking to work to physical activity levels and increase in physical performance, so that more evidence is still needed.[40]

Even though there is a reported increase in the activity level due to active commuting, some people become more physically inactive overall, because the increase due to commuting is counterbalanced or even outweighed by a compensatory decrease in leisure-time physical activity.[41]

The question remains how people can be assisted in order to change their way of transportation to and from work. Mutrie et al showed that a provision of written interactive materials including local maps, distances from local stations, local cycle retailers, and reflective safety accessories, leads to an increase in active commuting behavior (walking).[38] Interestingly, this study was not successful in increasing cycling behavior due to barriers regarding the cycling environment in this particular region (Glasgow). To improve the adherence to commuter cycling, modification of the transport infrastructure to support active travel (walking and cycling) is necessary. For example, new and expanded cycle routes may be constructed[41] and in particular, spatial factors should be taken into account in promoting active commuting.[42] Still, the biggest influencer for active commuting is the employer. When workplaces promote active commuting, employees are more likely to change the way they commute to and from work.

Active commuting is not only an important part of the solution against sedentary lifestyle, but also a way for achieving a range of health and social goals, like reducing traffic congestion and carbon emissions.[43]

This present review revealed that there is a major lack in studies analyzing health effects of active commuting in recent years especially concerning intervention studies with robust measurements. In addition, studies have only been performed in five European countries (Finland, Belgium, Netherlands, Sweden, and Denmark) and therefore, generalization has to be made with caution. Furthermore, the willingness and frequency of active commuting most likely varies by region as well as by season. For example, the study by Gordon-Larson et al showed that in a study cohort in the United States 16.7% used some mode of active commute,[39] whereas 21.1% of the people in Cambridge cycled to work.[41]

Despite such particularities, the World Health Organization and several public health policy makers confirm the importance of increasing physical activity levels, especially among the most inactive individuals[1] that are often obese. There is a clear consensus that overweight is linked with poor health outcomes and increased risk of premature mortality. In this review, two papers with obese study participants showed that already the change to an active commuting behavior improves different health parameters.[22,23,34] Unfortunately, the long-term analysis of Hemmingsson et al[34] did not analyze exercise capacity but rather focused on behavioral changes for overweight and obese women.

Huge cross-sectional, observational studies[7,8,44,45] indicated that active commuting is significantly and independently associated with reduced cardiovascular risk factors including BMI and percentage body fat. Indeed, sedentary lifestyle which is one of the major modifiable risk factors for cardiovascular and other non-communicable diseases[3,4] can be overcome by active commuting.[11,12] Taken the current interest in reducing greenhouse-gas emission into account, it may become easier to persuade employees but also employers to change toward active commuting in order to combat climate change.

4.1 | Perspectives

This systematic review summarized the current available literature on active commuting and health benefits. The results identify active commuting as a potential strategy to mitigate intermediate risk factors associated with physical inactivity such as body mass index, body weight, fat mass, cholesterol, and physical fitness. It has been shown in various intervention trials that overweight and obese benefit from exercise training at least as much as normal weight subjects. In fact, with regards to morbidity and mortality, it is the untrained that benefits the most. Therefore, recommendations also for active commuting should be individually tailored. Still, findings have to be interpreted with caution as the included studies were conducted in similar areas and the behavior of active commuting is likely to vary by region. As none of the studies measured long-term effects of active commuting behavior or addressed the individual, social, or environmental determinants of behavior change, there is a need of further studies. The GISMO study that is published alongside this systematic review may fill a gap in our understanding of this emerging field of preventive medicine.

CONFLICTS OF INTEREST

There is no conflict of interest to report.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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