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Title

Trends in cycling and cycle related injuries and a calculation of prevented morbidity and mortality.

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Abstract

The objectives were to describe trends in cycling and cycle related injuries in Denmark overall and in the four largest Danish cities to see if changes in cycling trips and injuries were associated. Further, we compared number of prevented deaths, type 2 diabetes (T2D), cardiovascular diseases (CVD) and cancers with registered injuries. We analyzed cycling trends over past 17 years in Denmark based on national statistics from 56 electronic counters as an ecological study. Cycle related injuries were collected by Statistics Denmark from hospital records. We also calculated the annual prevented disease and mortality accrued from the health benefits of physical activity in cycling based on relative risk (RR) of cycling derived from population studies, number of cyclists, and number of death, T2D, CVD and cancers in Denmark.

Since 1998 till 2015, cycling has increased by 10% in the whole country; the cycling related injuries however, have gradually declined and were only 45% in 2015 as compared to 1998 level. In Copenhagen specifically, cycling even increased more than 30% since 1998 while cycling related injuries decreased during the same period to one third. Diseases prevented in Denmark by cycling were annually 3328 T2D cases, 5742 CVD cases and 2076 cancer cases and prevented deaths were 6190. In comparison, in 2015, 26 cyclists were killed in the traffic, 512 were seriously injured and 297 experienced light injuries in the whole country.

In conclusion, in Denmark, the number of cycling trips have steadily increased over the past 17 years while cycling related injuries show a concomitant decline. Intuitively one might expect cycle related injuries to increase with increased cycling, but a decrease was observed in injuries. Health benefits of cycling calculated from cohort studies were 21 times higher than risk of injuries and for mortality alone the ratio was 238.

Key words. Active transport, bicycling, traffic injuries, secular trend

1. Introduction

The world is struggling with the rising burden of non-communicable diseases (NCDs) and is looking for doable and deliverable population based interventions to prevent them (GBD_Risk_Factors_Collaborators, 2016; Giles-Corti et al., 2016). In addition, environmental and inequity concerns need actionable solutions. A shift to cycling from motorized transport can enhance physical activity levels in daily living of populations, is cost saving, is good for the environment and enhance equity. A major concern, however, is a potential rise in the road traffic and transport injuries (Giles-Corti et al., 2016; Lozano et al., 2012). Globally, road injuries was the leading cause of deaths in the 15-24 years olds in the recent 2015 global burden of disease (GBD) analysis, and the 8th leading cause of death worldwide (GBD_Mortality_Causes_of_Death_Collaborators, 2016). The burden on low-income individuals was proportionately high (GBD_Risk_Factors_Collaborators, 2016). Further, the fear of injury from cars has been found to be the most important perceived barrier to bicycling (Manton et al., 2016). In a recent study, Stevenson et al. modeled the relationship between land-use, transport and population health based on six cities - Melbourne, Delhi, Copenhagen, London, São Paulo and Boston. The association between cycling, walking for transport and traffic related injuries during bicycling was expected to be positive in five of six cities including Copenhagen (Stevenson et al., 2016). It may therefore be relevant not just to model expected changes, but to measure trends over time in cities where changes actually occur to verify whether expected changes are true.

Cycling is known to promote health and has a potential to increase physical activity globally (Hallal et al., 2012). Prospective cohort studies (Oja et al., 2011) and four randomized trials (Hemmingsson et al., 2009; Hendriksen et al., 2000; Moller et al., 2011; Ostergaard et al., 2012) have consistently shown health benefits of cycling. However, with increase in cycling, a possible rise in cycling related injuries is a perennial concern. Therefore, it is important for public health to know whether it is possible to increase cycling but decrease injuries or at least prevent injuries from rising. There are to our knowledge no studies of high quality using national statistics, which report the trends in cycling and cycle related injuries over the years.

The Scandinavian countries have always prided themselves with the most health friendly federal structure, local laws, and road design, with a high priority on maintenance of roads, cycling lanes and pedestrian paths. Cycling for daily transport is taken up by people across all economic sections and all age groups. In this manuscript, we describe time trends in cycling trips and in cycling injuries over the last 17 years in whole of Denmark and in the four larger cities of Denmark specifically. With Denmark specific data, we also estimate prevented deaths and morbidity for selected common diseases due to high levels of cycling. We chose type 2 diabetes (T2D), cardiovascular disease (CVD) and cancers, because relative risk (RR) in relation to cycling does not exist for other diseases.

2. Methods

Denmark is a small country with only 5.7 million citizens, 75.000 km roads and detailed monitoring of population statistics. The average temperature during the day is 2˚C in the winter months and 20˚C in the summer. We retrieved and synthesized cycling statistics from several sources summarized below.

2.1 Sources of data for trends in cycling

Data from the whole country was extracted and synthesized from the Danish Road Directory (Vejdirektoratet) (Vejdirektoratet, 2016a). Cycle statistics from Vejdirektoratet describe trends in number of cycle trips and kilometers driven in Denmark since 1998 as shown in

Figure 1 (upper grey curve). Data was based on electronic counters and collected in a database called MASTRA (Machine Traffic Registration) held by Vejdirektoratet under the Ministry of Transport and Building (Vejdirektoratet, 2016a). In 1990, there were 28 electronic counters, which were extended to 56 counters in 2008. Counts from counters in different parts of the country are weighted and an index calculated. The level of cycling in year 2000, measured as number of trips from the counters, was used as reference and set to 100, and level in other years were calculated according to year 2000 level. The index is based on many million counts per year and has been validated against the TU Studies (Transport Behavior Studies) (Transport_Institute, 2016). The TU studies consist of 8000-24,000 annual interviews in relation to transport behavior where responders are randomly selected from the Central Personal Registry (CPR). All citizens in Denmark have a unique CPR number, which means the population contacted is representative of the population and the only selection bias is that caused by dropout. Based on the interviews it was possible to calculate kilometers ridden and number of trips. Two years of TU data were used in the validation (1993 and 2009) and comparison showed high validity of the cycle index(Transport_Institute, 2016). The cycle index includes both cycling and mopeds. However, moped transport has decreased over time and constituted only 3% of the index in 2007 (Vejdirektoratet, 2016b).

The cycle index used in Figures 2a-2d for the four larger cities in Denmark are comparable within the city, but different methods have been used by each city to calculate their index, which differed from the National index (Vejdirektoratet, 2016c). All the methods used electronic counters, but some cities have added manual counting to their index. The reason is that cities are responsible for maintaining roads and therefore they keep their own records of cycling beside the national statistics. In Copenhagen, the cycle index was based on total kilometers ridden on bicycle in the city. Kilometers were calculated from electronic counters and estimated distances. In Aarhus, the index was calculated from different registrations which were weighted. Forty percent came from 12 electronic counters, 20% from six five-weeks counts, 20% from 20 one-week counts and 20% from ten manual counts. In Aalborg, the index was based on eight electronic counters. In Odense, the index was based on interviews conducted by the TU Studies (Danish_Technical_University, 2016). Within each city the index was calculated in the same way for all time points and the amount of cycling in year 2000 was used as the reference.

2.3 Bike-related mortality and injury statistics for Denmark. Statistics Denmark provided traffic injury statistics (Statistics_Denmark, 2016b) and mortality statistics (Statistics_Denmark, 2016a). Statistics of bike related injuries were based on injuries reported to the police, which included persons visiting hospital and incidents reported to an insurance company. Cycle specific injuries were registered in relation to geographic location, gender, age and severity, which allowed a local comparison between cycle index and cycle injury statistics.

2.4 Statistical calculations of cycling attributable mortality and morbidity. Number of lives saved attributed to cycling was based on the prevalence of cyclists, the difference in the risk (RR) of mortality and morbidity between cyclists and non-cyclists, and total annual number of deaths and newly diagnosed disease of T2D, CVD and cancers in Denmark (Table 1 and appendix Table). Cycling attributable deaths were calculated as the sum of cases prevented for each level of cycling: $\sum((1\text{-}RR)*N*P)$. N is the total number of cases in Denmark in 2015 for the specific condition and P is prevalence for the group. Prevalence was defined as persons cycling every week at least during the summer period from the same cohort study as the RR was calculated. In all calculations multivariate adjusted RRs were used including all known confounding (see Table 1). Cycling was assessed as total cycling (leisure and commuting) and as commuter cycling only. Table 1 includes all Danish prospective cohort studies which have published RR of mortality and morbidity between cyclists and non-cyclists and appendix Table show details of calculations. Other diseases were not included since such data do not exist. We did a systematic search on PubMed and included studies reporting RR of disease and death from other countries, but we only used Danish data in the calculations of prevented disease except for cancer where the study of Matthews et al. (Matthews et al., 2007) was used, because no data existed for cancer from Denmark (Appendix). Some studies reported RR for different levels of cycling in order to analyze dose-response relationships while others only reported RR for cycling versus no cycling. Prevalence of cycling was related to age and older age was related to higher rates of deaths. We therefore used conservative estimates of prevalence of cycling in studies including younger age groups. The RR for cycling versus non-cycling was similar in all age groups (Andersen et al., 2000). Prospective cohort studies used for calculation of prevented diseases and deaths are summarized in Table 1 where existing studies from other countries were also added.

Total number of new annual cases in Denmark for T2D, CVD and cancers were found at the home pages for the Danish Heart Foundation (Danish_Heart_Foundation, 2016), Diabetesforeningen (Diabetesforeningen, 2016) and the Danish Cancer Society (Danish_Cancer_Society, 2016). In the study of Matthews et al. amount of cycling was calculated in equivalents of resting metabolic rate (MET) *hours per day, where cycling was defined to require an energy expenditure of 4 METs. Prevalence of cycling was lower in China than in Denmark, but higher in the Netherlands, which results in an underestimation of cases in Denmark in the study of Matthews et al. (Matthews et al., 2007) and an overestimation using Dutch prevalence from Houvenaar-Blom et al.(Hoevenaar-Blom et al.,

2011) (Table 1). The prevalence of cycling in UK is very low, and estimates do not apply to Denmark.

3. Results

3.1 Trends in cycling and in cycle related injuries

In 2015, there were 26 deaths in cycle related traffic injuries in the whole country (Figure 1) (Statistics_Denmark, 2016b). Total number of reported injuries were 835, where 297 persons only had light injuries, 512 severe injuries and 26 died. From 1998 to 2015 there has been a steady decline in number of injured cyclists in Denmark, with a 55% decline. However, this covers large regional differences. The decrease in injuries occurred simultaneously with an increase in cycling measured as trips by electronic counters of 10% (Figure 1). Figure 2 shows trends in the four larger cities in Denmark. Since 1998, cycling has increased in three of the four larger cities in Denmark. In Copenhagen, which had the largest increase in cycling, injuries went down from 402 in 1999 to 129 in 2015. In Copenhagen, the capital, cycling increased about 30% since 1998 while cycling increased 16% in Aarhus, which is the second city of Denmark, around 30% in Odense but no change was seen in Aalborg. On a national level, injuries with fatal outcome are quite rare and a slight decrease was observed since 1998 (Figure 1).

Insert Figure 1

Insert Figure 2a-2d

3.2 Mortality and morbidity prevented from cycling in 2015 in Denmark

Total number of deaths in Denmark was 52,555 persons in 2015 (Statistics_Denmark, 2016a). The average annual number of newly diagnosed T2D cases in Denmark from 2010-2014 was 28,835. The annual number of new CVD diagnoses in 2015 was 52,283 and number of new cancer cases was 35,432.

In the study of Andersen et al. (Andersen et al., 2000) the mean prevalence of commuting to work was 25%. We calculated that 3679 more commuter cyclists would have died if cyclists had the same mortality rate as non-cyclists (RR for cyclists 0.72), in 2015 in Denmark, which is 7.0% of all deaths. Commuter cycling also prevented 2610 cases of T2D and 3129 cases of CVD (Table 1) (Rasmussen et al., 2016). No studies have provided data on commuter cycling and cancer. Similarly, we calculated that 3328 T2D cases, 5742 CVD cases and 2076 cancer cases and 6190 deaths were prevented from total cycling each year (Table 1).

Insert Table 1. References in Table 1: (Andersen and Cooper, 2011) (Andersen et al., 2000) (Rasmussen et al., 2016) (Blond et al., 2016) (Matthews et al., 2007) (Hoevenaar-Blom et al., 2011) (Celis-Morales et al., 2017)

4. Discussion

4.1 Trends in cycling and injuries

The present study elucidates that increase in cycling does not need to increase the number of injuries. Analysis of trends is based on ecological data and we cannot conclude about causes, however, we would intuitively expect an increase in injuries with more cycling, and it did not happen. In fact, in Denmark cycle related injuries have gone down from 1838 to 835 since 1998 even though cycling has increased by 10%. From 2000 to 2010

kilometers driven by car also increased 10% (Statistics_Denmark, 2011), but this change was mainly related to an increase in kilometers driven on highways. There has been a strong political commitment towards larger public safety, which was essentially the reason behind cycling and pedestrian friendly road design, provision of cycling space aligned to the population load, cycling prioritization in road design and traffic signal laws, high quality maintenance of the road construction, and context specific cycling supportive environment. This has consistently been improved and worked towards over the years by successive governments in Denmark. High safety in cycling has been a main priority in built environment and has contributed to cycling being socially desirable in all age groups, in women, children and elderly and all socio-economic strata. All investments in cycle infrastructure in the country are thoroughly registered, because cities can apply for 50% co-funding from the Government, but need to describe their projects in detail.
Copenhagen has invested heavily in cycle infrastructure during the last two decades and during this time cycling increased more than 30% while traffic injuries decreased to almost one third compared to levels in the late 1990s. An example is the 'super-bike-lane-system' (www.supercykelstier.dk). Super bike lanes connect different parts of Copenhagen almost without crossing streets. They go in straight lines and tunnels and bridges have been built to pass streets with heavy traffic. Copenhagen is split by a harbor and all traffic had to pass one of three bridges in the old days. Now they have built several bridges exclusively for cyclists and pedestrians over the harbor. This means that the fastest way to travel for all distances below 10 kilometers in Copenhagen is by bike. However, we need to emphasize that this data does not allow conclusion of why cycling increased and injuries decreased. It is not possible to use randomized trials in the improvement of infrastructure, because randomizing where bike lanes are built does not make sense.

A series of articles was published in the Lancet in 2016 emphasizing the importance of city planning to improve health. In this series, Stevenson et al. modelled how increased active transport would affect health (Stevenson et al., 2016). The models were based on data from six cities from five continents and one of the cities was Copenhagen. The models predicted a positive association between active transport and road injuries. However, modelling differences between cities may give another result than observing what actually happens over time in a specific city when a behavior such as cycling changes. In the present study we observed a substantial decrease in road injuries at the same time as cycling increased. The increased cycling in cities like Copenhagen and Odense may have been a result of major improvements in infrastructure. City planning in relation to improvement of cycling facilities is well described on the home pages of these cities (Copenhagen_City, 2017; Odense_City, 2017). The lack of association between amount of cycling and injury rate is supported by some studies. Jacobsen et al. found that across Europe and North America bicycling varied tremendously while fatal injury rate was more or less the same per capita and he formulated the hypothesis 'safety in numbers', which suggest that increased number of cyclists raise awareness among car drivers, which makes accidents go down (Jacobsen, 2015). Mueller et al. identified 21 studies, which estimated health impact of exposure to traffic in terms of fatality and injury risk (Mueller et al., 2015). Fourteen of these studies predicted an increase in fatalities and injuries, and six studies a decrease with increase in active transport, while one study assumed no change. The present study suggests that the safety of cycling depends on how carefully infrastructure in all its details is planned and prioritized and is not necessarily related to traffic density. The four larger cities have prioritized differently. In 2000, the City of Odense became 'cycle city' and more than 50 infrastructure projects were initiated. During the next three years cycling increased 20% and injuries decreased 20%

(Troelsen, 2005). Aarhus followed a few years later with improvements in infrastructure, and Copenhagen has been in front over decades. Aalborg has lagged behind and has not invested in infrastructure for cycling. Still, it will not be possible to conclude about causality and even the most thorough description of initiatives will not solve the methodological problems in establishing causality. However, we are not aware of any cities in the World where cycling has increased during the last decades without thorough infrastructure planning.

4.2 Calculation of prevented disease/mortality

Calculation of prevented diseases included only T2D, CVD and cancers, because no data exists for other chronic diseases. Together with deaths these cases summed up to around 17,000 annually using conservative estimates. It is assumed that there is a causal relationship between the lower morbidity and mortality and cycling. This cannot be concluded from prospective cohort studies alone. We used multivariate adjusted RR including adjustment for leisure time physical activity, socioeconomic status and other CVD risk factors. Some evidence does support that the association between cycling and health is causal. Cohort studies show consistent results and benefit is similar in subgroup analyses such as age groups, genders and socioeconomic groups (Oja et al., 2011). The four existing randomized trials using cycling as transport also showed consistent findings (Hemmingsson et al., 2009; Hendriksen et al., 2000; Moller et al., 2011; Ostergaard et al., 2012). Prevented disease and death should be compared with traffic injuries where only 26 cyclists were killed, 512 were seriously injured and 297 experienced light injuries in Denmark in 2015. The benefit-hazard ratio was very high (238:1) for deaths and around 20 for total cases versus total injuries when only three common diseases were included.

This ratio cannot be explained by confounding or selection. Selection of healthy individuals becoming cyclists is not a serious problem in Danish cohort studies. Cycling is not something people choose to get healthy, it is a common mode of transport in Denmark. There is not even a strong social gradient and in the first published cohort studies, subjects with low educational level were more frequently cyclists than the better educated (Andersen et al., 2000). Among men >65 years of age there were still 44% who cycled every week. It is likely that there is a great degree of self-selection in cohorts where the behavior is rare such as UK-Biobank where only 2.6% were cyclists, but in Denmark it is >60%.

4.3 Strengths and limitations

A major strength is the availability of reliable high quality, granular data from 1998 to 2015 detailed up to the city level related to changes in cycle habits and injuries. This part of the study is ecological, and it is therefore not possible to argue for any causality. There is little doubt that registration of injuries was not complete. Number of cycle related deaths in the traffic is complete, but some minor injuries may not be reported. However, most injuries were reported to the insurance companies simply because car owners may have their vehicle repaired or the cyclist claims compensation. It is likely that many 'sole' accidents only involving the cyclist were not reported, but it is not possible to quantify. The observational character of the studies used to calculate health benefits is a weakness. It is not possible from these studies to conclude about causality, but data were consistent and adjusted for known confounding. Calculations of prevented mortality and morbidity were based on the assumption that there is a causal relationship between cycling and health. There is therefore a large degree of uncertainty in these calculations, but the ratio between benefit and hazard was very big leaving room for uncertainty before the main conclusion should be rejected. Still the quantification or extrapolation from cohort studies to the prevention on national level may be difficult. This could result in both over- and underestimation. Last, data was collected in a developed country with a good infrastructure for cycling and conclusions may not be generalizable to environments with poor infrastructure.

4.4 Conclusion

Cycling related injuries have gone down in Denmark despite cycling going up over 17 years. A public health intervention for public health good with diligence and detail may accrue large benefits. A study launched the hypothesis 'safety in numbers', which suggested that increased number of cyclists itself increased safety (Jacobsen, 2003), but the substantial decrease in injuries even in cities with a smaller increase in cycling may point towards the importance of infrastructure. Danish results suggest that increasing safety of cyclists can both increase cycling and decrease injury rates, and other countries should be encouraged to implement strategies of protecting cyclists that are appropriate to their contexts. Health benefits of cycling calculated from cohort studies were 21 times higher than risk of injuries and for mortality alone the ratio was 238.

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Table 1. Calculation of annual (2015) morbidity and mortality from cardiovascular diseases and type 2 diabetes prevented by cycling. Internal relative risk and prevalence were used for each specific study in the calculations and the proportion was multiplied with total morbidity and mortality in Denmark. Cycling attributable disease/deaths was calculated as the sum of cases prevented for each level of cycling: ∑((1-RR)*N*prevalence for the group). As a sensitivity analysis upper and lower 95% CI of RR were used to calculate 95% CI for prevented number of cases. Annual cases (column 4),,prevalence (column 6) and RR (column 6) were used to calculate prevented cases (column 7). Percentage of all cases (column 8), was calculate from prevented cases (column 7) divided by annual cases (column 4).

Study	Population at baseline	Disease/ Mortality in the cohort	Annual cases in DK in 2015 (N in equation)	Type of cycling analyzed	Amount; Prevalence of cycling (P); Relative Risk for group (RR)	Prevented cases, N (95% CI)
Andersen, Cooper 2011	♂8466,♀6510 20-93 yr	Mortality, 3787 deaths	52,555 deaths in age group 40-69 yr	Total cycling	<3h/w, P=17%, RR=0.78 (0.69-0.88); 3-7h/w, P=16%, RR=0.76 (0.68-0.85); >7h/w, P=14%, RR=0.70 (0.62-0.78)	6190 (3954-8293)
Andersen et al 2000 “	Total 6,964 6171♂, 783♀ 40-60 yr	Mortality, 2291 deaths	52,555 deaths in age group 40-69 yr	Commuter cycling	Mean 3 h/w, P= 25%; RR=0.72 (0.57-0.91)	3679 (1181-22,599)
Rasmussen et al 2016	Total 52,513 24,623♂ 27,890♀ 50-65 yr	Type 2 Diabetes, 6778 cases	28,835	Total cycling	1-60 min/w, P= 22.3%, RR 0.87 (0.82-0.93); 61-150 min/w, P= 17.9%, RR=0.83 (0.77-0.89); >150 min/w, P= 28.0%, RR=0.80 (0.74-0.86)	3328 (2148-4444)
Rasmussen et al 2016*	Total 15,063♂♀ 50-65 yr	Type 2 Diabetes, 1327 cases	28,835	Commuter cycling	1-60 min/w, P=13.6%, RR=0.72 (0.60-0.87); 61-150 min/w, P= 11.8%, RR=0.83 (0.69-1.00); >150 min/w, P=10.8%, RR=0.70 (0.57-0.85)	2610 (979-3963)

Blond et al 2016	Total 53,723 ♂25,329 ♀28,394	CVD, 2892 cases	52,283	Total cycling	1-60 min/w; P=22.3%,RR=0.84 (0.76–0.93); 61-150 min/w; P=13.9%, RR=0.89 (0.80–1.01): >150 min/w; P=32.7%, RR=0.82 (0.75–0.90)	5742 (2453-8526)
Blond et al 2016	Total 16,181♂♀	CVD, 463 cases	52,283	Commuter cycling	1-90 min/w; P=17.6%, RR=0.78 (0.58–1.03); >90 min/w; P=17.6%, RR=0.88 (0.68–1.15)	3129 (-1656-6809)
Matthews et al 2007	67143♀ 40-70 yr	Mortality 1091 deaths	52,555	Total cycling	<3.4 Met h/d , P=19.3%; RR=0.79 (0.61-1·01) >3.4 Met h/d, P=5.3%, RR=0.66 (0.40-1.07)	3078 (-296-5626)
Matthews et al 2007	67,143♀ 40-70 yr	CVD mortality, 251 deaths	52,283	Total cycling	<3.4 MH/d, P=19.3%, RR=0.75 (0.41-1.37); >3.4 MH/d, P=5.3%, RR=0.63 (0.20-2.01)	3806 (-6532-6354)
Matthews et al 2007	67,143♀ 40-70 yr	Cancer mortality, 537 deaths	35,432	Total cycling	0.1-3.4 MetH/d, P=19.3%, RR=0.82 (0.59-1.14); >3.4 MetH/d, P=5.3%, RR=0.55 (0.27-1.11)	2205 (-1164-4175)
Houvenaar-Blom et al 2010	16,442 ♂♀ 42±11 yr	CVD, 923 cases	52,283	Total cycling	>0; P=76.5%, RR=0.82 (0.71-0.95)	8342 (2000-11,599)
Celis-Morales et al 2017	239,265 (51.7% ♀); 40-69 yr	Mortality, 2430 deaths	52,555 deaths in age group 40-69 yr	Commuter cycling	y/n; P=2.55%; RR=0.59 (0.42-0.83)	550 (229-779)

Celis-Morales et al 2017	254,151 (51.7% ♀); 40-69 yr	CVD incidence, 1110 cases	52,283	Commuter cycling	y/n; P=2.55%; RR=0.54 (0.36-0.88)	613 (160-853)
Celis-Morales et al 2017	243,808 (52% ♀); 40-69 yr	Cancer incidence, 3748 cases	35,432	Commuter cycling	y/n; P=2.55%; RR=0.55 (0.44-0.69)	407 (280-506)

*Calculated from person-years of follow-up, because prevalence was not reported in the article.
“We used a prevalence of 25% for women and 50% for men in the calculations, which was found in the age group of 60 years, because most deaths occur in the older groups.
CVD: cardio vascular disease; MH/d: MET*hours per day; LTPA: leisure time physical activity, PA: physical activity; BP: blood pressure; SES: Townsend deprivation index

Appendix Table A1. Detail of calculation morbidity and mortality in 2015 in the Danish studies. Total number of deaths in Denmark was 52,555, CVD was 52,283, T2D was 28,835 and cancer was 35,432. Cycling attributable disease/deaths was calculated as the sum of cases prevented for each level of cycling: $\sum((1-RR_i)*N*P_i$ (P: prevalence for the group, N: total cases in Denmark). Reference group is non-cycling.

Study	Outcome	Type of cycling analyzed	Level of cycling	Relative risk (RR)	Prevalence	Prevented cases (1-RR)*P*N	Result preven cases
Andersen, Cooper 2011	All-cause mortality N=52,555	Total cycling	Non-cycling	1	0.53	0	
			Level 2 <3 h/w	0.78	0.17	0.22*0.17*52555	1965
			Level 3 3-7 h/w	0.76	0.16	0.24*0.16*52555	2018
			Level 4 >7 h/w	0.70	0.14	0.30*0.14*52555	2207
Andersen“ et al 2000	All-cause mortality N=52,555	Commuter cycling	Non-cycling	1	0.75	0	
			Cycling	0.72	0.25	0.28*0.25*52555	
Rasmussen et al 2016	Type 2 diabetes N=28,835	Total cycling	Non-cycling	1	49.0%	0	
			Level 2 1-60 min/w	0.87	22.3%	0.13*0.223*28835	836
			Level 3 61-150 min/w	0.83	17.9%	0.17*0.179*28835	877
			Level 4 >150 min/w	0.80	28.0%	0.20*0.28*28835	1615
Rasmussen et al 2016*	Type 2 diabetes N=28,835	Commuter cycling	Non-cyclists	1	0.738	0	0
			Level 2 1-60 min/w	0.72	0.136	0.28*0.136*28835	1098
			Level 3 61-150 min/w	0.83	0.118	0.17*0.118*28835	578
			>150 min/w	0.70	0.108	0.30*0.108*28835	934
Blond et al 2016	CVD N=52,283	Total cycling	Non-cyclists	1	0.55	0	0
			Level 2 1-60 min/w	0.84	0.223	0.16*0.223*52283	1865
			Level 3 61-150 min/w	0.89	0.139	0.11*0.139*52283	799
			>150 min/w	0.82	0.327	0.18*0.327*52283	3077

Blond et al 2016	CVD N=52,283	Commuter cycling	Non-cyclists	1	0.648	0	0
			Level 2 1-90 min/w	0.78	0.176	0.22*0.176*52283	2025
			Level 3 >90 min/w	0.88	0.176	0.12*0.176*52283	1104
Matthews et al 2007	Cancer N=35432	Total cycling	Non-cyclists	1	0.754		
			Level 1 0.1-3.4 MetH/d	0.82	0.193	0.18*0.193*35432	1231
			>3.4 MetH/d	0.55	0.053	0.45*0.053*35432	845

"We used a prevalence of 25% for women and 50% for men in the calculations, which was found in the age group of 60 years, because most deaths occur in the older groups.

Figure 1. Trends in cycle traffic and cycling related casulaties in the traffic since 1998 in Denmark.
Cycle traffic index is based on electronic counters.

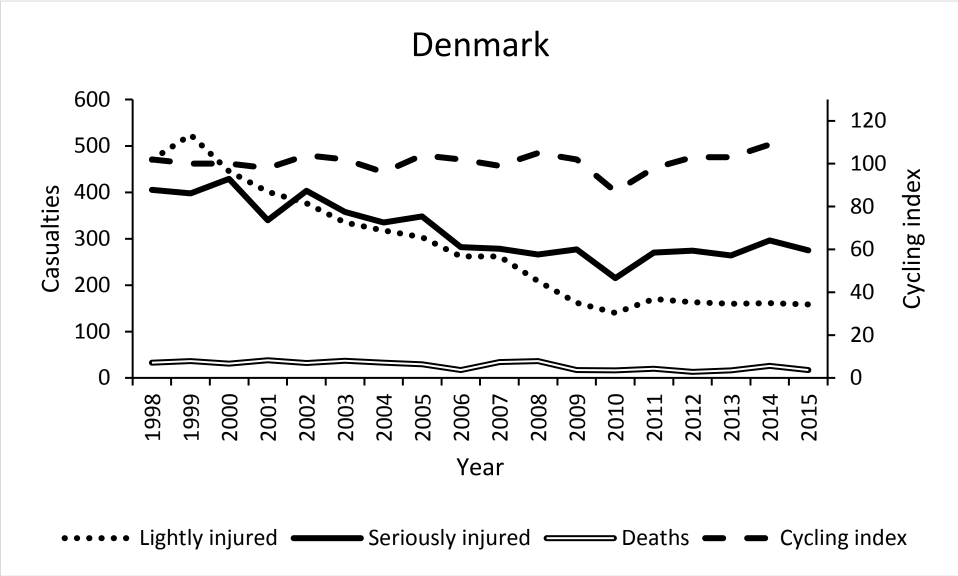
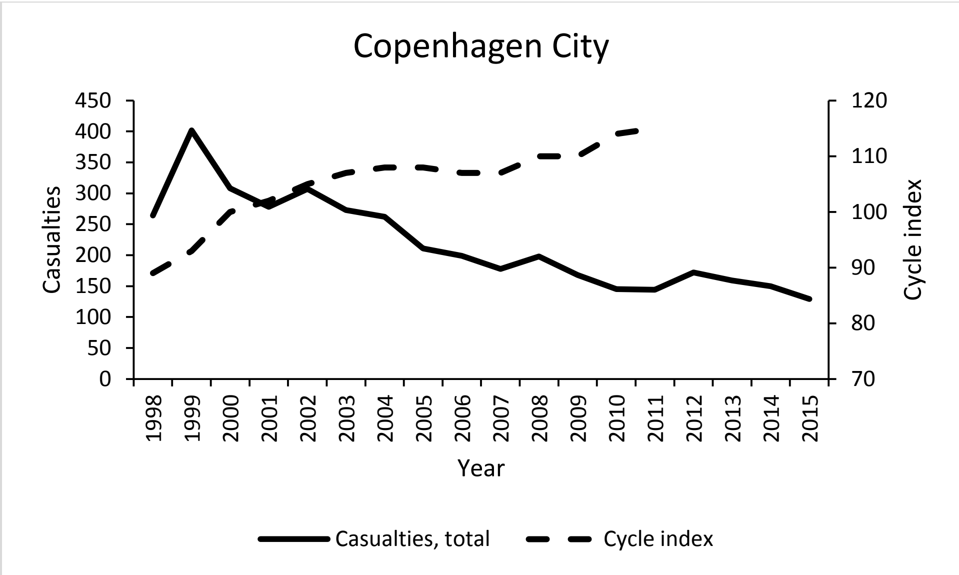
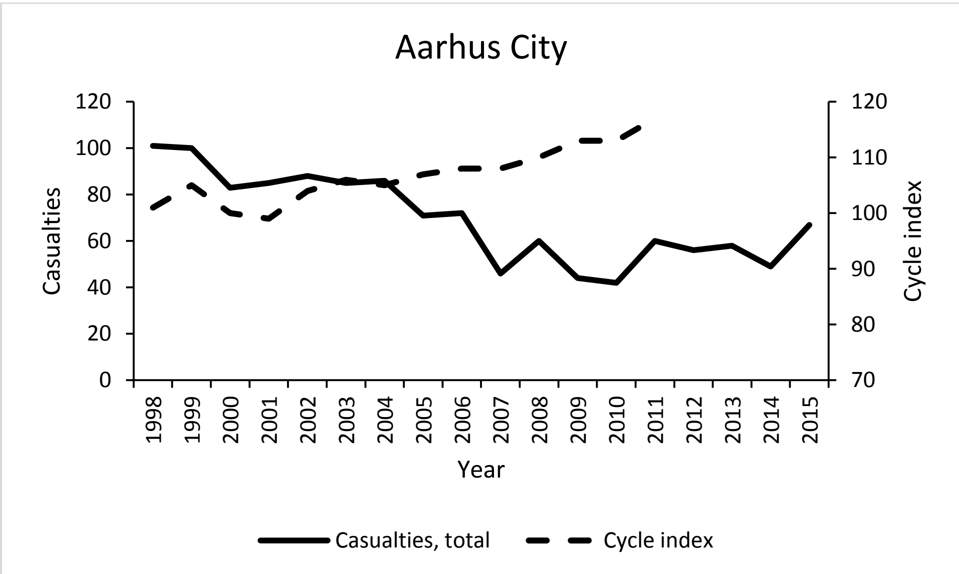
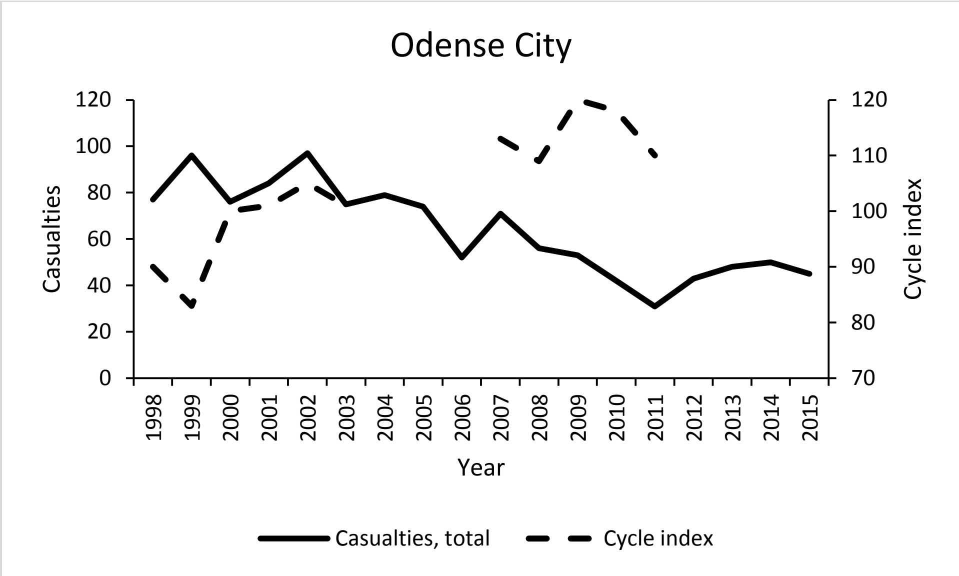
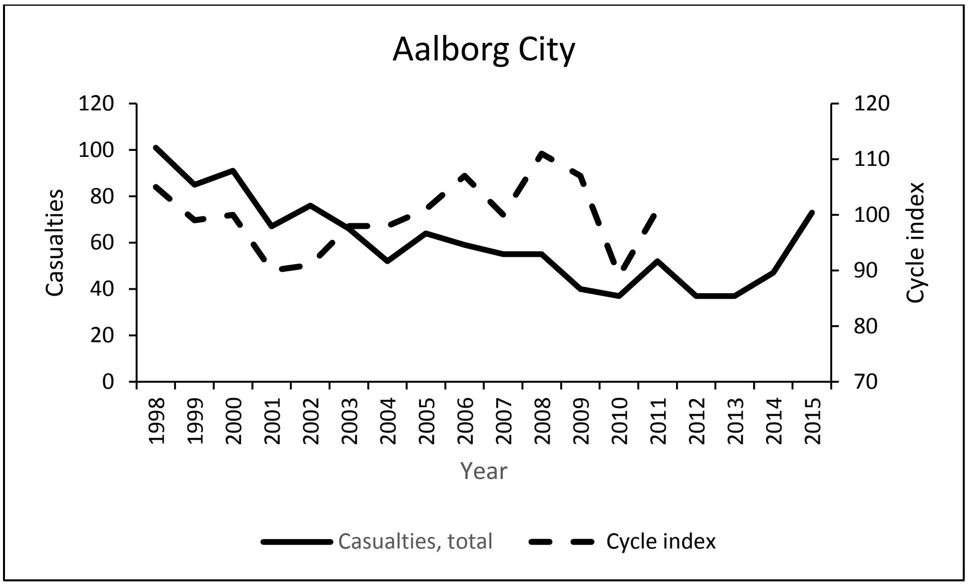


Figure 2a-2d. Trends in cycling habits and cycle related casualties in the four larger cities in Denmark since 1998. Cycle index is calculated differently for each city, but is consistent within each city. Cycle index is lacking between 2003-6 in Odense. Casualties include light and serious injuries and deaths.






Odense City
Casualties
Cycle index
120
100
80
60
40
20
0
120
110
100
90
80
70
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
Casualties, total
Cycle index


Aalborg City
Casualties
Cycle index
120
100
80
60
40
20
0
120
110
100
90
80
70
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
Casualties, total
Cycle index