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Commuter cycling and health

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Abstract

This paper seeks to explore the motivations and preferences of recreational walkers in near-urban areas. It evaluates health as a motivational factor in relation to others and draws implications for planners of walking routes and trails. A qualitative focus group method was employed, in order to generate open discussion amongst recreational walkers from a range of backgrounds and levels of interest, participation and experience, drawing out themes regarding motivations to walk, and potential issues relating to a proposed walking trail. Additionally, of particular interest were the attitudes of walkers regarding transport to locations for walking.

1 Introduction

Active commuting has gained increasing interest during recent years. Traffic planning was earlier focused on reducing accidents and making cars get faster from point A to B. However, evidence is emerging showing that sedentary living is widespread and has major health consequences. Commuter cycling is an important alternative in the choice of transport, but many countries lack the infra-structure to make this choice safe. It is therefore important to spread the existing knowledge of the health gains of commuter cycling, because politicians may see the importance of improving infra-structure. This chapter will highlight some of the studies performed since 2000, and provide some new data, both in children and adults, and try to quantify the potential health benefits of increased cycling. Health benefits may be improved health profile such as lower levels of cardiovascular disease (CVD) risk factors, which include blood lipids, blood pressure, insulin sensitivity, obesity and low cardiorespiratory fitness level. It may also be lower mortality rates or lower morbidity. These “hard endpoints” include all cause mortality, type 2 diabetes, CVD, hypertension and stroke.

2 Prospective cohort studies

Most studies about cycling and health are observational studies, and little has been published where the effects of interventions have been tested. An important reason for the lack of randomized controlled trials (RCT) is that interventions often include changes in built environment such as new bike lanes, changes in traffic lights, garages where the bikes can be parked safe and dry, and other environmental changes. This type of intervention is difficult to control and rigid designs are rare. Another reason is that it is difficult to randomize subjects to cycling if bike routes are not safe. It would only be possible to conduct RCTs with increased commuter cycling few places in the world such as Denmark and Holland where routes are safe.

The first large scale prospective study which analyzed the association between mortality and cycling habits was published by Andersen et al. in 2000 [1]. Information on bicycling as transportation to work was available for 783 women and 6171 men. Among these 6954 subjects, 2291 died during follow-up. The average time spent cycling in those who did cycle to work was 3 hours per week. Bicycling to work was inversely related to years of education, but after adjustment for age, sex, and educational level, the relative risk in those who cycled was 0.70 (95% CI, 0.55-0.89). After additional adjustment for leisure time physical activity, body mass index, blood lipid levels, smoking, and blood pressure, the relative risk was 0.72 (95% CI, 0.57-0.91). The data in this study was pooled from three prospective studies in Copenhagen, and cycling could be analyzed separately in these cohorts to see if findings were consistent. Questions about cycling differed slightly between the studies, and in the Copenhagen City Heart Study questions were related to commuter cycling in general whereas only transport to work was published in the paper. Cycling in hours per week was assessed in 6,510 women and 8,466 men, 20-93 yr among whom 3,787 died during follow-up. This data has been presented at conferences, but was not included in the original paper, which focused on cycling to work, and I will therefore shortly summarize the results.

Among the women 40% cycled every week, but habits decrease with increasing age from 63% in the age group of 20-45 yr to a little less than 20% among age 65+ yr. In men, 60% cycled in the age group of 20-45 yr and even among 65+ yr 44% cycled every week. The relative risk of mortality was similar to the estimate calculated in the cohorts where only cycling to work was analyzed. After adjustment for age, sex, BMI, smoking, educational level, systolic blood pressure, cholesterol and other physical activity than cycling, relative risk of death was 0.70 (95% CI 0.62-0.78) among those who spent most time cycling (>7 hour per week), 0.76 (95% CI 0.68-0.85) for those who spent 3-7 hours per week cycling, and 0.78 (95% CI 0.69-0.88) for those with the shortest distance (<3 hour per week). The decrease in mortality is not just highly significant, but also substantial. Population attributable risk (PAR) is a measure of how many deaths, which theoretically could be prevented if all subjects had cycled. This measure is based on the relative risk between groups and the number of subjects who potentially could reduce the risk (prevalence of non-cyclist). The number of deaths which could be prevented by increasing commuter cycling was almost 20% in these cohorts. To elucidate the size of potential of cycling, a

Finnish study calculated that PAR for obesity in relation to CVD in published Finnish studies was between 4-7% [3]. A more realistic estimate of the potential health benefit can be estimated from the fact that cycling has decreased in Denmark. The Danish National Statistics reported a decline of 30% during the last three decades. Earlier 45% cycled, which means that 15% of the total population stopped cycling and got a 1.39 times increased mortality rate based on the known rates from the study of Andersen et al. [1]. This has increased number of deaths with 4.8%. About 60000 die every year, and the decrease in cycling therefore accounts for 2880 deaths/year. National statistics on traffic accidents show a rate of 300-400 deaths totally each year in the traffic.

Since the study of Andersen et al, other studies have investigated mortality, CVD, type 2 diabetes and stroke. Hu et al. studied active commuting in Finnish men and women and found a lower rate of type 2 diabetes, but they did not separate between cycling and walking [4]. The main reason for this is probably that few people cycle compared to the Danish studies, and there may be too few deaths to analyze cycling separately. Later, Hu et al. reported the association between active commuting and CVD, and found that commuting was associated with lower CVD rates in women, but did not reach significance in men [5]. It is probably only possible in Holland, Denmark and China to make an analysis with sufficient statistical power to analyze commuter cycling separately. Hu et al. reached a similar conclusion when they analyzed active commuting in hypertensive subjects [6]. Active commuting to and from work was significantly associated with reduced cardiovascular mortality in hypertensive women. Matthews et al. studied a large cohort of 67,143 Chinese women, where there were 1,091 deaths from all causes, 537 deaths from cancer, and 251 deaths from cardiovascular diseases [7]. Exercise and cycling for transportation were both inversely and independently associated with all-cause mortality ($p_{trend} < 0.05$), but walking for transportation was less strongly associated with reduced risk ($p_{trend} = 0.07$). All-cause mortality rates decreased with increasing amount of cycling; 0.1-3.5 MET-hours/day: RR=0.79 (95% CI: 0.61-1.01); and ≥3.5 MET-hours/day: RR= 0.66 (95% CI: 0.40-1.07). Similar estimates were found for death caused by CVD and even higher benefit when cancer was analyzed.

A few studies have looked at the effect of active commuting on cardiovascular risk factors in adults. Hu et al. analyzed blood lipids in 1786 males and 1922 females aged 20±49 years from China [8]. Daily walking or cycling to and from work was inversely associated with serum total cholesterol, low-density lipoprotein cholesterol and triglyceride concentrations among men, and positively associated with high-density lipoprotein cholesterol concentrations among women as compared to traveling to and from work by bus. However, it was not possible in this study to separate the effects of walking and cycling.

To date, we are not aware of any randomized controlled studies where commuter cycling has been investigated. This will probably not be possible in relation to hard endpoints such as mortality and CVD, but it may be possible in relation to other outcomes such as type 2 diabetes or hypertension. We have just finished a RCT with commuter cycling, but where we just measure the effect on cardiorespiratory fitness (not yet published).

3 Health effects in children

Studies in children differ from the studies in adults, because children do not get diseases related to physical inactivity. Biological markers of health status such as fitness, fatness and CVD risk factors may change in relation to physical activity level, but children fortunately don't get the disease until many years later. We and others have therefore analyzed the association between commuter cycling and indirect measures of health such as physical activity level, fitness and CVD risk factors. In different populations there are large differences in commuter habits, and the more sedentary the population is the more important may active commuting be. In the United States, approximately 50% of children aged 5 to 15 years travel to school by car [9,10]. In the United Kingdom, the proportion of primary-school–aged children (5 to 10 years) driven to school increased from 29% in 1993 to 41% in 2002 [11]. Cycling to school is now unusual in many countries, with <2% of trips made by bicycle in UK. It is interesting that children who walk or cycle to school have higher physical activity level during the rest of the day, and the benefit of the active travel may not be limited to the travel itself [12,13].

It is not surprising that children who use active travel have a higher total physical activity level. However, it has previously been thought that the amount and intensity of the transport probably were not sufficient to result in improved fitness or improved health. Recently, a number of studies have been published where physical fitness has been measured in different transport groups. Cooper et al. found an 8% higher cardiorespiratory fitness in children and adolescents from Denmark who cycled to school compared to both passive transport and walking [2]. The study was observational, but included 529 9-yr-old children and 390 15-yr-old adolescents, and finding were consistent across age and gender groups. A difference of 8% is substantial and may translate into a great health benefit. Anderssen et al. analyzed the association between physical fitness and clustering of CVD risk factors in children and found a 13 times increased risk in the least fit quartile compared to the most fit quartile [14]. An eight percent increase could in a low fit child increase the fitness from the least fit to the next quartile, which would reduce the risk of clustered CVD risk factors to one third. The analysis by Cooper et al. was later extended to a longitudinal analysis, where the 9-yr-old children were followed for 6 years [15]. Among the children who at age 9-years were passive travelers, some of them changed to cycling, and in the follow-up analysis these children had 9% higher fitness than their peers who stayed passive travelers. Children who stopped cycling decreased similarly. This observation could indicate that the higher fitness was not just a selection bias where the more fit chose commuter cycling, but that the difference in fitness was caused by the traveling mode. No randomized controlled trial has been conducted, but the observation is supported by other observational studies. Andersen et al. analyzed different types of fitness and compared commuter cyclists with their peers who did not cycle to school [16]. The hypothesis was that we expected a difference in all types of fitness if it was caused by selection bias, but only a difference in the muscle groups that was used during cycling if cycling should have caused the difference. Difference was mainly found in cardiorespiratory fitness, but also muscle endurance in the trunk muscles differed, which could be explained by the fact that most adolescent cyclists in Denmark use racing bikes where they have a position, which put load on the trunk muscles. No difference was found in arm strength or explosive power.

4 Data from European Youth Heart Study

The former studies in children have all analyzed physical activity or physical fitness in relation to commuter cycling. It is equally important to show whether the improved fitness translates into better CVD risk factor profile or other important health parameters. This type of data is available in the European Youth Heart Study, and we will present some key findings in the following. The European Youth Heart Study is presented in detail elsewhere, and we will only describe the populations which are included in the present analysis. We assessed cycling habits, blood lipids, fasting insulin, blood pressure, fatness parameters, physical activity and physical fitness. For details see Riddoch et al. [17], Cooper et al. [2], and Andersen et al. [18].

Children included in the analysis comprise two cross sectional studies of Danish children Living in Odense in 1998 and in 2004. Children in both cross sectional studies were boys and girls 9 years of age and adolescents 15 years of age.

In 1998, commuting data and CVD risk factors were available for 241 girls and 214 boys in the 9-year olds, and passive transport, walking and cycling to school were practiced by 71, 72 and 98 girls, respectively. In boys numbers were 55, 72 and 87 girls, respectively. In 15-year olds 189 girls and 188 boys participated. In girls, 21 used passive transport, 40 walked and 128 cycled. In boys, 21 used passive transport, 38 walked and 129 cycled.

Table 1. Descriptives of European Youth Heart Study cohort from 1998. Statistical difference is calculated on logarithmically transformed variables in the variables: 4 skinfold, total chol:HDL, and HOMA, because these were skewed.

	Girls 9 yr		Boys 9 yr		Girls 15 yr		Boys 15 yr		
Transport mode	passive/ walk	cycle	passive/ walk	cycle	passive/ walk	Cycle	passive/ walk	Cycle	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	P
BMI (kg/m^2)	17.2 (2.5)	17.3 (2.6)	17.3 (2.4)	17.1 (2.1)	20.7 (2.7)	20.9 (2.6)	21.2 (2.8)	20.7 (2.5)	Ns
waist circ. (cm)	58.4 (5.7)	58.2 (6.1)	58.8 (5.5)	58.2 (5.2)	67.3 (5.6)	67.9 (5.5)	72.0 (5.9)	71.3 (6.2)	Ns
4 skinfolds (mm)	39.5 (18.4)	40.4 (20.7)	35.1 (17.8)	32.9 (16.0)	52.9 (19.1)	51.2 (16.6)	39.4 (18.1)	36.2 (18.0)	Ns
systolic BP (mm Hg)	104.7 (7.4)	105.4 (7.1)	105.4 (7.8)	106.0 (6.3)	108.7 (7.5)	110.1 (8.0)	119.8 (12.4)	118.2 (10.4)	Ns
fitness (watts/kg)	2.75 (0.47)	2.91 (0.52)	3.06 (0.56)	3.37 (0.50)	2.71 (0.46)	3.12 (0.45)	3.62 (0.58)	3.84 (0.53)	0.001
cholesterol (mmol/l)	4.58 (0.68)	4.63 (0.71)	4.41 (0.71)	4.63 (0.78)	4.34 (0.83)	4.30 (0.80)	4.10 (0.70)	4.03 (0.61)	Ns
HDL (mmol/l)	1.45 (0.25)	1.45 (0.27)	1.50 (0.30)	1.58 (0.33)	1.37 (0.28)	1.38 (0.25)	1.29 (0.25)	1.31 (0.27)	Ns
total chol:hdl	3.22 (0.63)	3.25 (0.60)	3.01 (0.54)	3.03 (0.73)	3.23 (0.58)	3.20 (0.66)	3.25 (0.72)	3.16 (0.69)	Ns
triglyceride (mmol/l)	0.89 (0.35)	0.91 (0.36)	0.78 (0.30)	0.81 (0.39)	1.05 (0.38)	1.10 (0.40)	1.00 (0.62)	0.95 (0.40)	Ns
glucose	5.05 (0.39)	5.07 (0.33)	5.18 (0.35)	5.17 (0.34)	5.09 (0.38)	5.13 (0.41)	5.38 (0.48)	5.30 (0.50)	Ns
Homa	1.98 (1.05)	1.90 (0.93)	1.73 (0.91)	1.76 (1.40)	3.10 (1.65)	3.00 (1.24)	3.69 (2.72)	3.00 (1.86)	Ns
Composite score	0.01 (1.05)	-0.01 (1.04)	0.07 (0.99)	-0.10 (0.97)	0.14 (0.88)	-0.07 (0.90)	0.24 (1.18)	-0.11 (0.99)	0.05

Cyclists were tested against non-cyclist with adjustment for sex and age group. There was no difference between walking and passive transport and these were therefore analyzed together. Cyclists had 0.46 SD higher fitness level ($p<0.001$), and the composite score of 6 CVD risk factors including systolic blood pressure, total cholesterol:HDL ratio, triglyceride, HOMA score, sum of 4 skinfold and low fitness was lower in cyclists (0.15 SD, $p<0.05$). No difference was seen in any of the other single risk factors. The odds ratio for having clustered risk (sum of z score >1) was 0.68 (95% CI: 0.47-0.97) for cyclists compared to passive traveling and walking.

Table 2. Descriptives of European Youth Heart Study cohort from 2004. Statistical difference is calculated on logarithmically transformed variables in the variables: 4 skinfold, total chol:HDL, and HOMA, because these were skewed.

	Girls 9 yr		Boys 9 yr		Girls 15 yr		Boys 15 yr		
	Passive/ walk	Cycle	Passive/ walk	Cycle	Passive/ walk	Cycle	Passive/ walk	Cycle	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	P<
BMI (kg/m2)	17.5 (2.9)	17.3 (2.3)	17.5 (2.5)	17.3 (2.4)	21.9 (3.4)	21.1 (2.9)	21.1 (3.3)	20.9 (2.5)	0.1
Waist circ. (cm)	62.0 (7.5)	61.0 (6.0)	62.6 (6.5)	62.2 (6.3)	74.2 (8.5)	72.1(6.0)	76.2 (9.5)	75.3 (6.9)	0.05
4 skinfold (mm)	40.2 (19.5)	37.9 (16.2)	31.4 (14.7)	29.7 (14.7)	55.5 (18.4)	51.3 (16.9)	34.8 (22.2)	33.6 (18.4)	0.1
systolic BP (mm hg)	97.2 (7.5)	97.0 (7.0)	100.6 (6.9)	98.4 (6.1)	104.6 (8.3)	105.3 (8.0)	109.3 (8.2)	111.1 (9.6)	0.9
fitness (watt/kg)	2.69 (3.00)	3.00 (0.44)	3.20 (0.52)	3.39 (0.45)	2.76 (0.41)	3.10 (0.41)	3.58 (0.59)	3.87 (0.47)	0.001
cholesterol (mmol/l)	4.52 (0.81)	4.45 (0.73)	4.43 (0.68)	4.48 (0.75)	4.17 (0.80)	3.97 (0.83)	3.59 (0.68)	3.64 (0.59)	0.4
HDL (mmol/l)	1.59 (0.37)	1.57 (0.33)	1.74 (0.38)	1.77 (0.39)	1.53 (0.34)	1.53 (0.36)	1.26 (0.31)	1.36 (0.29)	0.4
total chol:hdl	2.93 (0.64)	2.91 (0.52)	2.65 (0.57)	2.60 (0.57)	2.78 (0.51)	2.65 (0.48)	2.97 (0.70)	2.78 (0.67)	0.05
triglyceride (mmol/l)	0.78 (0.45)	0.74 (0.32)	0.67 (0.37)	0.56 (0.24)	0.85 (0.41)	0.80 (0.36)	0.91 (0.50)	0.70 (0.34)	0.01
Glucose (mmol/l)	5.02 (0.32)	4.96 (0.33)	5.10 (0.31)	5.03 (0.34)	4.95 (0.42)	4.86 (0.37)	5.17 (0.37)	5.14 (0.39)	0.05
HOMA	1.70 (0.91)	1.68 (1.54)	1.48 (0.84)	1.19 (0.55)	2.39 (1.09)	2.10 (0.86)	2.31 (1.12)	2.08 (1.20)	0.001
Composite score	0.11 (1.11)	-,16 (0.92)	0.19 (1.04)	-0,28 (0.99)	0.23 (0.85)	-,14 (0.91)	0.23 (0.98)	-0.14 (1.02)	0.001

The analysis adjusted for age group and sex showed difference or tendencies in all variables, where the cyclists had better values. The standardized values for cyclists compared to subjects using passive transport or walking were BMI -0.11 SD (p=0.1), waist circumference -0.15 SD (p<0.05), sum of 4 skinfold -0.12 SD (p=0.08), systolic BP -0.01 SD (p=0.9)), fitness +0.57 SD (p<0.001), total cholesterol -0.06 SD (p=0.4), HDL +0.06 SD (p=0.4), cholesterol:HDL ratio – 0.06 SD (p<0.05), triglyceride -0.21 SD (p<0.01), glucose -0.17 (p<0.05), HOMA score – 0.24 SD (p<0.001), and composite risk factor score -1.27 SD (p<0.001).

It is clear that the later analysis from 2004 show more consistent results than the data from 1998 with lower risk factor levels in CVD risk factors in cyclist compared to subjects using passive transport or walking as transportation to school. The analysis from 1998 is less convincing, but the difference in physical fitness has an effect size of 0.5, which is substantial. We cannot explain why the two cross sectional studies are different, but a difference of 1.27 SD in composite risk factor score very is high and suggest a major health benefit of cycling. The risk of having a composite z-score of >1.0 was calculated by logistic regression after adjustment for sex and age group. The cyclist had a risk of 0.49 (95% CI 0.30-0.80) compared to passive travelers, and children walking to school had the same risk as the passive travelers (OR=0.92; 95% CI 0.55-1.55).

In conclusion, all prospective studies show consistent findings with lower mortality in commuter cyclists compared to passive travelers after adjustment for other risk factors and other leisure physical activity. In children, cycling to school is associated with a better fitness level and better cardiovascular risk factor profile. No benefit was found for walking in children, which is in contrast to prospective studies in adults.

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