Changes in Cycling and Incidence of Overweight and Obesity among Danish Men and Women

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ABSTRACT

RASMUSSEN, M. G., K. OVERVAD, A. TJØNNELAND, M. K. JENSEN, L. ØSTERGAARD, and A. GRØNTVED. Changes in Cycling and Incidence of Overweight and Obesity among Danish Men and Women. *Med. Sci. Sports Exerc.*, Vol. 50, No. 7, pp. 1413–1421, 2018. **Purpose**: Overweight and obesity are associated with increased risk of several noncommunicable diseases and are a growing public health issue. The primary purpose of the current study was to investigate incidence of overweight and obesity according to 5-yr cycling habits. The secondary purpose was to investigate incidence of remission from overweight and obesity according to 5-yr cycling habits. **Methods**: We analyzed 9014 men and 8661 women without chronic disease who between 1993 and 2003 completed two assessments approximately 5 yr apart. At both assessments, participants reported habitual cycling habits. Also, body weight and waist circumference were measured by a laboratory technician at baseline and self-assessed at second examination. We computed multivariable adjusted odds ratios (OR) with 95% confidence intervals (CI) for development of and remission from abdominal and general overweight and obesity, according to 5-yr cycling habits. **Results**: Continued cycling was associated with lower odds for incidence of abdominal (men, >102 cm; women, >88 cm) and incidence of general (body mass index ≥30 kg·m^{-2}) obesity; compared with no cycling, OR (95% CI) values were 0.82 (0.74–0.91) and 0.74 (0.60–0.92) for abdominal and general obesity, respectively. Also, those who initiated cycling had lower odds for incidence of abdominal obesity; OR (95% CI) was 0.85 (0.73–1.00) relative to no cycling. Although we found no evidence of remission from abdominal and general overweight and obesity according to 5-yr cycling habits, those who continued cycling had significantly larger decreases in waist circumference relative to noncyclists (β coefficient (95% CI), −0.95 cm (−1.56 to −0.33 cm)). **Conclusions**: Continued cycling compared with no cycling was associated with lower odds for abdominal and general obesity. Also, late-in-life initiation of cycling was associated with lower odds for abdominal obesity relative to no cycling. **Key Words:** PUBLIC HEALTH, NONEXERCISE PHYSICAL ACTIVITY, ABDOMINAL OBESITY, CENTRAL OBESITY, CARDIOVASCULAR DISEASE RISK FACTOR, TYPE 2 DIABETES RISK FACTOR, EPIDEMIOLOGY

During previous decades, the worldwide prevalence of overweight and obesity has increased. The global prevalence of a body mass index (BMI) of ≥25 kg·m^{-2} is estimated a staggering 36.9% and 38% among adult men and women, respectively (1). The global prevalence of obesity is estimated at 12% (2). Obesity increases the risk of numerous noncommunicable diseases including type 2 diabetes, ischemic heart disease, stroke, and some types of cancer. However, an increased risk of these diseases is already present in overweight individuals (3).

Engagement in physical activity has been suggested as an approach to lower the prevalence of overweight and obesity (4). In trials of isolated aerobic exercise in subjects with

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Submitted for publication November 2017.
Accepted for publication February 2018.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.acsm-msse.org).

0195-9131/18/5007-1413/0
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DOI: 10.1249/MSS.0000000000001577

overweight or obesity, modest decreases in body weight and waist circumference have been found (5). Results from observational studies show positive associations between physical activity, weight loss maintenance (6), and prevention of weight gain (7,8). Although physical activity seems to contribute toward a healthy body weight, research investigating the role of cycling and weight control has received little attention.

Cycling for transportation and recreation may be important in maintaining or attaining a healthy body weight. It can be incorporated into daily life, for example, in one's daily commute or when completing daily chores. Furthermore, cycling is non–weight bearing, which people who find discomfort in prolonged walking or jogging could find appealing. In cohort studies of adults, recreational or commuter cycling has been associated with a lower incidence of type 2 diabetes (9), coronary heart disease (10), and all-cause mortality (11). However, few cohort studies in adults have investigated the relationship between cycling and body weight; one study found favorable changes in weight with long-term cycling (12), and a recent study found lower odds for incidence of obesity with habitual cycling (13). Five cross-sectional studies found lower odds for overweight or obesity with cycling (14–18), whereas one did not (19). There is a need for more prospective cohort studies of cycling and changes in body weight to more clearly quantify the long-term relationship.

Using data from the Danish Diet, Cancer and Health cohort study, the primary purpose of this study was to compare the incidence of overweight and obesity between different 5-yr cycling habits. A secondary purpose was to investigate the relationship between 5-yr cycling habits and the incidence of remission from overweight and obesity. We hypothesized that any regular cycling would be associated with a lower incidence of overweight and obesity, and a higher incidence of remission to non-overweight or nonobese levels. Remission refers to change in status from overweight or obese to non-overweight or nonobese.

METHODS

Ethics. The Diet, Cancer and Health study was conducted in accordance with the Declaration of Helsinki. It was approved by the Scientific Ethical Committee of Copenhagen (no. H-KF-01-345/93), and the study protocol for the current study was approved by the Danish Data Protection Agency (no. 2015-57-0008). Informed written consent to collect data on health outcomes in medical registries in the years that followed was gathered from all study participants (20).

Participants. Between 1993 and 1997, 80,996 men and 79,729 women were invited to participate in the Diet, Cancer and Health study. Inhabitants of Aarhus and Copenhagen and surrounding cities were invited if between 50 and 64 yr of age, born in Denmark, and without a cancer diagnosis registered in the Danish Cancer Registry. Eligible persons were identified through the Civil Registration System—a unique system in Denmark where Danish residents are assigned a 10-digit identification code (21)—and 27,178 men and 29,875 women agreed to participate (20).

Approximately 5 yr later (mean, 5.4 ± 0.3 yr) between 1999 and 2003, men and women still alive and residing in Denmark were invited for a second examination. A total of 45,245, or 79.3%, of the original cohort participated.

Participants were eligible for analyses if they were free of known chronic disease throughout the study. The following participants were excluded: 2217 registered with diabetes according to the National Patient Registry, the National Diabetes Registry, or via self-report; 1043 with nonfatal acute myocardial infarction according to the National Patient Registry; 751 who according to the National Patient Registry had a stroke prior; and, lastly, 2588 diagnosed with cancer according to the Danish Cancer Registry. In total, 6092 with one or more chronic diseases were excluded. Please consult Figure 1 for a detailed description of each step following invitation to each analytic sample size.

Cycling conditions in Copenhagen and Aarhus. In Copenhagen and Aarhus, as well as most other cities in Denmark, there are good conditions for cycling. One reason for this is the well-built infrastructure for cycling in both urban and rural areas. Examples of this are bike lanes clearly separated from car lanes by a curb (22), which allows for safe active transportation. Therefore, in Denmark, it is possible for individuals of all ages, including seniors, to cycle in everyday life, for example, as part of one's daily commute or as a general mode of transportation in leisure.

Data collection. At baseline, a validated semiquantitative food frequency questionnaire, developed to be compatible with the Danish diet (23–26), was sent by mail and filled out before a visit at a study clinic. At the clinic, an additional questionnaire was completed, addressing general lifestyle habits, for example, physical activity, smoking, and alcohol consumption. Furthermore, a laboratory technician measured anthropometrics (20).

At the second examination, a similar dietary survey, additionally including foods that since baseline had been introduced to the Danish diet, was mailed to the participants. A lifestyle questionnaire was sent also, along with a tape measure to self-assess waist circumference (20).

Assessment of physical activity. Assessment of physical activity has previously been described (9). Briefly, the following activities were reported at baseline: work-related physical activity, walking, total cycling, housework, do-it-yourself work, gardening, sport participation, and stair climbing. The same activities except for stair climbing were reported at second examination, although cycling was reported separately for commuting and recreational purposes, and sports participation was reported according to intensity (light, moderate, or vigorous).

Participants were grouped according to those who did no cycling, ceased to cycle, or initiated or continued cycling from baseline to second examination.

We also created composite leisure-time physical activity variables, including physical activities reported in the questionnaire other than total cycling. These variables were

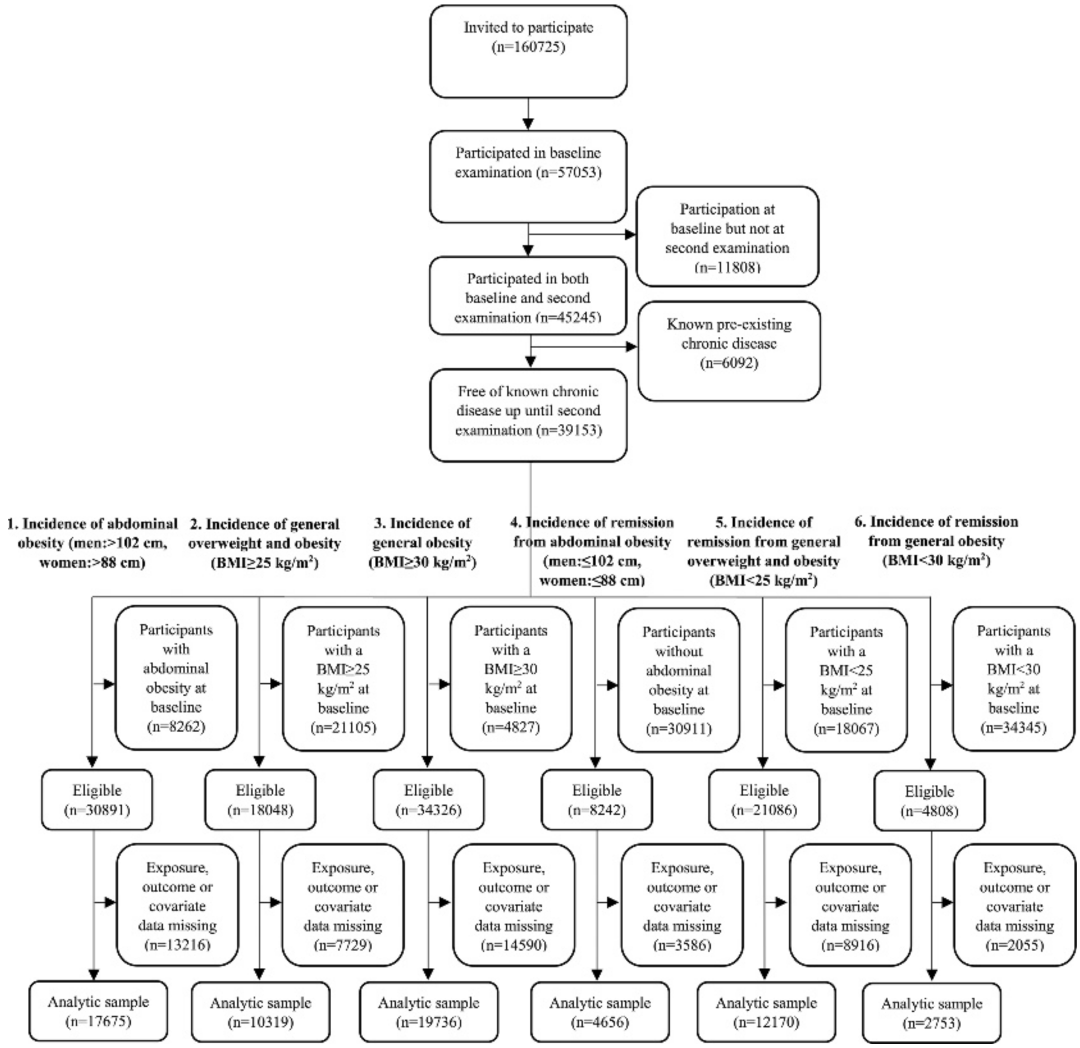

FIGURE 1—Flowchart of participants from invitation to analyses. The following known chronic diseases were excluded up until second examination: diabetes (any diabetes diagnosis), acute myocardial infarction, stroke, and cancer. Participants had to participate in both examinations to be included in the analyses. WC, waist circumference.

converted into MET-hours per week. One MET is considered equivalent to the resting metabolic rate, and MET values express intensity levels as multiples of the resting metabolic rate (27). These variables were created to be included as covariates in regression models.

The physical activity questions at baseline have shown good validity for ranking participants according to overall physical activity levels (28–30) with fair reliability (weighed kappa statistic = 0.6) (28,30). The physical activity questions at second examination have shown moderate-to-high reliability, with an intraclass correlation coefficient of 0.76 for physical activity energy expenditure, and good validity for ranking individuals according to overall physical activity energy expenditure (31).

Assessment of overweight and obesity. Height (cm), body weight (kg), and waist circumference (cm; the narrowest part between the lower rib and the iliac crest) were measured by a laboratory technician at baseline (20,32). BMI was calculated by dividing body weight in kilograms with height in meters squared. At second examination, participants were asked "What is your current weight?" in light clothing. On the basis of baseline height and self-reported body weight, we computed second-examination BMI. Waist circumference was self-assessed at second examination; participants were instructed to measure waist circumference at the level of the umbilicus after exhalation, to the nearest whole centimeters (20). The difference between the method of measurement of waist circumference at baseline and that at second examination was assessed in a separate study in a subsample of the cohort who participated in the second examination of Diet, Cancer and Health. These individuals were invited into a clinic in Copenhagen, where they went through several anthropometric measurements. The mean difference (95% confidence intervals (CI)) between waist circumference measured at the narrowest part between the lower rib and the iliac crest and waist circumference measured at the umbilicus was −0.8 cm (−1.6 to 0.007 cm) and 2.1 cm (1.3–2.9 cm) for men and women, respectively. Limits of agreement (95% CI) were −11.3 cm (−11.1 to −11.5 cm) to

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9.7 cm (9.5–9.9 cm) and −10.5 cm (10.0–11.0 cm) to 14.6 cm (14.2–15.1 cm) for men and women, respectively (32).

We defined abdominal obesity according to National Heart, Lung and Blood Institute criteria: >102 cm for men and >88 cm for women (33). General overweight and general obesity were defined as ≥25 and ≥30 $kg \cdot m^{-2}$, respectively (4).

Statistical analyses. Descriptive statistics for continuous data were computed as medians with 25th and 75th percentiles for asymmetric distributions, and means with SD when approximately normal. Proportions were computed for categorical data.

We conducted six analyses, all combining baseline and second examination data: 1) the odds for the incidence of abdominal obesity (men, >102 cm; women, >88 cm; excluding those with abdominal obesity at baseline); 2) incidence of general overweight or obesity (BMI ≥25 $kg \cdot m^{-2}$; excluding those with general overweight or obesity at baseline); 3) incidence of general obesity (BMI ≥30 $kg \cdot m^{-2}$; excluding those with baseline general obesity); 4) incidence of remission from abdominal obesity (men, ≤102 cm; women, ≤88 cm; excluding those without abdominal obesity at baseline); 5) incidence of remission from general overweight and obesity (BMI <25 $kg \cdot m^{-2}$; excluding those with a BMI of <25 $kg \cdot m^{-2}$ at baseline); and 6) incidence of remission from general obesity (BMI <30 $kg \cdot m^{-2}$; excluding those with a BMI of <30 $kg \cdot m^{-2}$ at baseline). Multivariable adjusted odds ratios (OR) with 95% CI were computed using logistic regression. To compliment these analyses, we computed multivariable-adjusted β coefficients (95% CI) for each analytic sample to assess changes (second-examination measure minus baseline measure) in waist circumference (cm) and body weight (kg), depending on the analysis. All analyses were conducted with 5-yr categories of total cycling (No cycling/Cessation/Initiation/Continuation) as exposure with no cycling as reference.

Assumptions of linear regression were tested. We created residual versus fitted plots to investigate assumptions of linearity and homoscedasticity. Furthermore, we investigated if residuals were normally distributed. Multicollinearity diagnostics of predictor variables were performed by computing variation inflation factors, using conventional cutoffs of >10 for individual variables, or mean of >4, as evidence of multicollinearity. There was no evidence for violations of any of the mentioned assumptions.

In all analyses, we adjusted for age (quintiles of years), sex (male/female), analysis-dependent baseline measure (body weight, BMI, or waist circumference), years of basic school (<7/8–10/>10), years of higher education (0/1–2/3–4/>4), dietary energy intake (quintiles of $kJ \cdot d^{-1}$), alcohol intake (quintiles of $g \cdot d^{-1}$), smoking (never/former/<15 $g \cdot d^{-1}$/15–25 $g \cdot d^{-1}$/>25 $g \cdot d^{-1}$), whole-grain cereal consumption (quintiles of $g \cdot d^{-1}$), physical activity at work (no work/sedentary/standing/manual work/heavy manual work), and reported leisure-time physical activity other than total cycling (quintiles of $MET \cdot h \cdot wk^{-1}$). These variables were all from baseline assessment. Data on dietary energy intake, alcohol intake, and reported leisure-time physical activity other than cycling were also available from second examination and were included. We also adjusted for length of follow-up (years). The difference between self-reported umbilical waist circumference and laboratory-technician measured natural waist circumference was shown to be related to baseline BMI in a subsample of the cohort (32). Therefore, in multivariable analyses including waist circumference as outcome, we also adjusted for baseline BMI.

Some research suggests that adjustment for baseline values in analyses of change may create spurious statistical associations (34). To address this, we ran all multivariable analyses without adjusting for analysis-relevant baseline measure (body weight, BMI, or waist circumference). The associations were almost unchanged, with no differences in direction of associations or statistical significance (data not shown).

In our analyses using logistic regression, we also computed models where we restricted the analyses to those reporting no sport at either baseline or second examination, in further attempt to eliminate residual confounding of sports participation. Among reported physical activities, we suspected that sports participation might affect body weight in particular.

Lastly, in the relationship between cycling and changes in body weight, dietary energy intake might confound, mediate, or neither confound or mediate. Also, cycling may decrease engagement in other physical activities, which overall may be either beneficial or detrimental for changes in body weight. Holding these two variables constant in our analyses could thus create spurious associations. To address these concerns, we conducted sensitivity analyses excluding one or both of these variables.

All analyses were conducted using STATA IC V.15 (STATA Corp, College Station, TX) with $\alpha = 0.05$.

RESULTS

Sample characteristics. Consistent cyclists had the highest dietary energy intake, lowest baseline alcohol intake, largest proportion of "never" smokers and lowest proportion of heavy smokers, the highest intake of whole-grain cereals, the largest proportion of standing and manual workers and the lowest proportion of heavy manual workers, and the highest engagement in reported leisure-time physical activity beyond cycling. For noncyclists, the opposite was true for baseline dietary energy intake, whole-grain cereal intake, and reported leisure-time physical activity beyond cycling. Also, noncyclists had the lowest proportion of manual workers and the largest proportion of heavy smokers (Table 1).

Consistent cyclist had the highest long-term cycling exposure, followed by those who ceased to cycle. Those who initiated cycling had the lowest long-term cycling, when disregarding the no-cycling group (Fig. 2).

Primary analyses. We first analyzed the odds for incidence of abdominal obesity. In the multivariable model, both initiated (OR (95% CI), 0.85 (0.73–1.00)) and continued (OR (95% CI), 0.82 (0.74–0.91)) cycling were associated with lower odds for incidence of abdominal obesity compared

TABLE 1. Characteristics of analytic sample in primary analysis (odds for incidence of abdominal obesity).

	No Cycling	Cessation	Initiation	Continuation	Total
Participants, *n*	3383	1694	1793	10,805	17,675
Age, yr	55 (52–60)	55 (52–59)	55 (52–59)	55 (52–59)	55 (52–59)
Sex, % women	49.4	48.1	42.5	50.1	49
Basic school (<7/8–10/>10), % yr	28.6/47.5/23.9	27.8/48.5/23.7	29.1/45.8/25.1	25.4/48.5/26.1	26.6/48/25.4
Higher education (0/1–2/3–4/>4), % yr	12.9/21.8/40.9/24.3	12.8/20.4/42.7/24.1	10.3/20.5/42.2/26.9	9.5/21.3/43.3/25.9	10.5/21.2/42.7/25.5
Waist circumference baseline/second examination, cm	84.5 (10.1)/90.8 (11)	85 (9.7)/91.3 (10.5)	85.6 (9.9)/91.1 (9.9)	84 (9.6)/89.7 (10.3)	84.4 (9.8)/90.2 (10.4)
BMI at baseline/second examination, $kg \cdot m^{-2}$	24.4 (2.8)/24.5 (3.1)	24.7 (2.7)/24.9 (3.1)	24.6 (2.6)/24.7 (2.8)	24.5 (2.6)/24.5 (2.8)	24.5 (2.6)/24.6 (2.9)
Alcohol intake at baseline/second examination, $g \cdot d^{-1}$	14.4 (6.2–32.6)/13.6 (4.8–32.9)	14.2 (6.8–31.9)/13.7 (4.9–32.9)	14.7 (7.3–32.1)/14.5 (6.4–33.2)	13.6 (6.8–28.8)/13.7 (5.9–31.8)	13.9 (6.8–31)/13.8 (5.6–32.2)
Dietary energy intake at baseline/second examination, $kJ \cdot d^{-1}$	9495.9 (2602.1)/9230 (3038.1)	9704.1 (2620.6)/9203.9 (2703.4)	9696.1 (2498.7)/9396.5 (2619.4)	10008.9 (2651.8)/9596.6 (2767.8)	9849.8 (2632.3)/9468.5 (2805.9)
Smoking status/amount (never/former/<15 g/15–25 g/>25 g)[a]	33.3/24.4/13.1/19.4/9.8	33.2/28.2/11.9/19.8/6.9	37.4/30.7/10.3/15.7/6	40.7/30.5/12.9/11.8/4.1	38.2/29.1/12.6/14.4/5.6
Wholegrain cereals, $g \cdot d^{-1}$	131 (66.6)	137.2 (68)	140.7 (66.6)	152.9 (70.1)	145.9 (69.5)
Physical activity at work (no work/sedentary/standing/manual work/heavy manual work)	21/40.3/16.9/16.7/5.1	22.2/39.4/16.2/18/4.3	12.1/45.1/18/19.9/5	16.5/39.8/18.6/21.6/3.5	17.4/40.4/18/20.2/4.1
Reported LTPA other than total cycling at baseline/second examination, $MET \cdot h \cdot wk^{-1}$	42.8 (27.8–66)/60.8 (38.4–94.3)	46.1 (31–68)/64.2 (38.8–94.9)	44 (28.5–65.5)/67.5 (43.8–99.7)	46 (31.3–68.5)/68.8 (45.1–101.8)	45.3 (30–67.5)/66.6 (43–99.5)

The table presents characteristics of participants in the primary analysis stratified by 5-yr status of total cycling and for the whole sample. Unless otherwise specified, the characteristics are based on data from baseline examination. Descriptive statistics for continuous data were computed as medians with 25th and 75th percentiles when data were asymmetrically distributed, and means with SD when data were approximately normal. Categorized data are presented as proportions. Waist circumference was measured at the natural waist by a laboratory technician at baseline and at the level of the umbilicus by self-assessment at second examination. Also, waist circumference and body weight (used to compute BMI) was measured by a laboratory technician at baseline but self-reported at second examination.

[a]Grams refer to daily amounts for current smokers.

LTPA, leisure-time physical activity.

with no cycling (Fig. 2). These results were supported by significantly larger decreases in waist circumference among those cycling consistently (β coefficient (95% CI), −0.53 cm (−0.81 to −0.25 cm) compared with noncyclists (Fig. 3A).

We then analyzed the odds for incidence of general overweight and obesity. No category was associated with lower odds compared with no cycling (Fig. 2). This was consistent with no significant differences in body weight changes in any cycling category relative to no cycling (Fig. 3B).

We then analyzed the odds for incidence of general obesity where continued cycling was associated with decreased odds for incidence of general obesity (OR (95% CI), 0.74 (0.60–0.92)) relative to no cycling (Fig. 2).

Secondary analyses. We then investigated the odds for incidence of remission from abdominal obesity, incidence of remission from general overweight and obesity, and incidence of remission from general obesity, according to 5-yr cycling. We found no differences of any category of cycling in any multivariable model relative to no cycling (Fig. 2). However, in the analysis of remission from abdominal obesity, those who continued cycling had significantly larger decreases in waist circumference (β coefficient (95% CI), −0.95 cm (−1.56 to −0.33 cm) relative to noncyclists (Fig. 3A). In the two remaining remission analyses, surprisingly, those who ceased to cycle had significant increases in body weight (β coefficients (95% CI), 1.44 cm (0.55–2.33 cm) and 0.36 cm (0.01–0.71 cm)) when compared with noncyclists (Fig. 3B).

Analyses restricted to participants reporting no sport. We then restricted the analysis of odds for incidence of abdominal obesity to those reporting no sport (n = 5073); OR (95% CI) values were 1, 0.87 (0.68–1.12), 0.69 (0.52–0.90), and 0.86 (0.72–1.02) for no cycling, cessation, initiation, and continuation, respectively, compared with no cycling. In all remaining analyses, when restricting to participants reporting no sport, no category of cycling was associated with lower odds compared with no cycling.

Sensitivity analyses. We consistently found almost identical OR (95% CI) with no differences in direction or strength of the associations across the four levels of multivariable adjustments (see Table, Supplemental Digital Content 1, Sensitivity analyses of primary analyses, http://links.lww.com/MSS/B214, and Table, Supplemental Digital Content 2, Sensitivity analyses of secondary analyses, http://links.lww.com/MSS/B215). There was almost no difference in statistical significance; however, in the analysis of the odds for incidence of general overweight and obesity, omission of reported leisure-time physical activity other than cycling as a covariate resulted in significantly lower odds for those cycling consistently when compared with noncyclist (see Table, Supplemental Digital Content 1, Sensitivity analyses of primary analyses, http://links.lww.com/MSS/B214).

DISCUSSION

Summary of the results. In this large population-based cohort study of Danish men and women residing in

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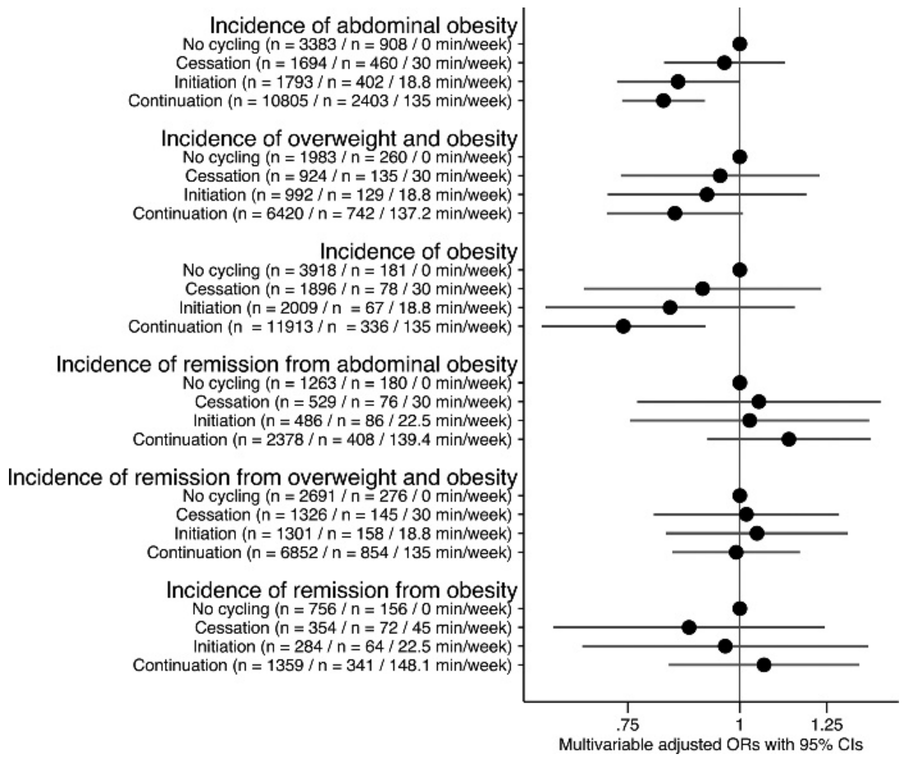

FIGURE 2—Odds for and remission from overweight and obesity according to 5-yr cycling habits. The three *upper sections* illustrate the analysis of incidence of abdominal obesity (men, >102 cm; women, >88 cm), incidence of general overweight or obesity (BMI ≥25 kg·m^{-2}), and incidence of general obesity (BMI ≥30 kg·m^{-2}). The three *lower sections* illustrate incidence of remission from abdominal obesity (men, ≤102 cm; women, ≤88 cm), incidence of remission from general overweight and obesity (BMI ≤25 kg·m^{-2}) and incidence of remission from general obesity (BMI ≤30 kg·m^{-2}). All associations are relative to no cycling. OR values include multivariable adjustment for the following; age (quintiles), sex (male/female), years of basic school (<7/8–10/>10), years of higher education (0/1–2/3–4/>4), dietary energy intake (quintiles), alcohol intake (quintiles), smoking (never/former/<15 g·d^{-1}/>15–25 g·d^{-1}/>25 g·d^{-1}), whole-grain cereal consumption (quintiles), physical activity at work (no work/sedentary/standing/manual work/heavy manual work), reported leisure-time physical activity other than cycling (quintiles), follow-up time (years), and either baseline waist circumference or baseline BMI (analysis-dependent). We adjusted for dietary energy intake, alcohol intake, and reported leisure-time physical activity other than cycling from both baseline and second examination. The information in parenthesis includes number of participants (*n*), number of cases (*n*), and long-term cycling exposure (cumulative average minutes per week of total cycling from the two examinations) in each category.

cycling-friendly cities, approximately 2 h·wk^{-1} of cycling was associated with approximately 20% to 30% lower odds of developing abdominal (OR (95% CI), 0.82 (0.74–0.91)) and general (OR (95% CI), 0.74 (0.60–0.92)) obesity relative to no cycling. Also, initiated cycling was associated with a lower incidence of abdominal obesity (OR (95% CI), 0.85 (0.73–1.00)) compared with no cycling. We found no relationship between cycling and any remission from overweight or obesity. According to proposed standard definitions applied in epidemiology, the strength of the associations in the current study would be considered weak (0.7–0.9) (35).

When restricting our analyses to those reporting no sport, initiated cycling was associated with lower odds for incidence of abdominal obesity, indicating benefits of cycling, independent of sports engagement. However, after restriction, continued cycling was no longer associated with lower odds for incidence of abdominal obesity and incidence of general obesity. Although this would imply residual confounding of sports participant in the original estimates for these two analyses, lack of significance may reflect loss of statistical power. From restriction, <30% of the original analytic samples remained, with considerable loss of cases.

In sensitivity analyses, we essentially found no differences in the associations from the different types of adjustment. However, in the analysis of odds for incidence of general overweight and obesity, in a model without reported leisure-time physical activity other than cycling, consistent cycling was associated with significant decreased odds when compared with no cycling. This might be indicative of either residual confounding or that consistent cycling contributes to a physical activity profile more favorable toward decreases in body weight.

Our analyses included partition models, where we assessed the effect of "adding" (36) cycling in relation to changes in body weight and waist circumference, holding other reported physical activities and other covariates constant. It would have been valuable to assess the effect on these measures when substituting one activity, for example, sitting, with cycling. However, only general physical activity habits during summer and winter, and no sedentary activities in leisure, were reported, making substitution modeling impossible.

Current and existing studies. This study expands upon findings from three cohort studies (12,13,37). One study including American women with a low prevalence of cycling found that cycling was associated with body weight

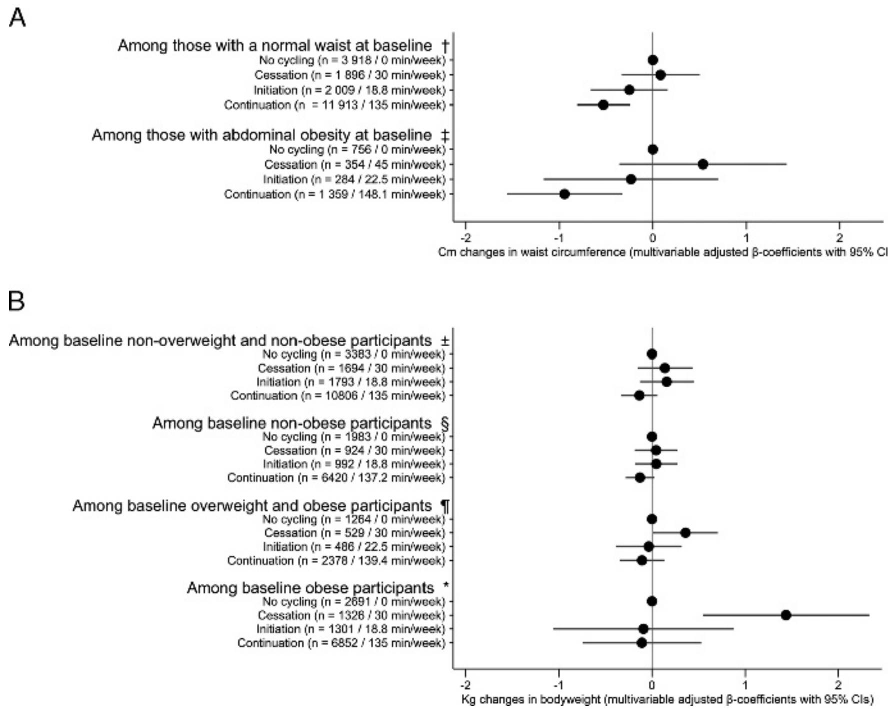

FIGURE 3—Five-year changes in waist circumference (cm; A) and body weight (kg; B) according to 5-yr cycling habits. The figure illustrates changes (β coefficients with 95% CI) in waist circumference (cm; A) and changes (β coefficients with 95% CI) in body weight (kg; B) for the six analytic samples. The changes are presented according to 5-yr cycling status relative to no cycling. β Coefficients include multivariable adjustment for the following; age (quintiles), sex (male/female), years of basic school (<7/8–10/>10), years of higher education (0/1–2/3–4/>4), dietary energy intake (quintiles), alcohol intake (quintiles), smoking (never/former/<15 g·d^{-1}/>15–25 g·d^{-1}/>25 g·d^{-1}), whole-grain cereal consumption (quintiles), physical activity at work (no work/sedentary/standing/manual work/heavy manual work), reported leisure-time physical activity other than cycling (quintiles), follow-up time (years), and either baseline waist circumference or baseline body weight (analysis-dependent). We adjusted for dietary energy intake, alcohol intake, and reported leisure-time physical activity other than cycling from both baseline and second examination. The information in parenthesis includes number of participants (*n*), number of cases (*n*), and long-term cycling exposure (cumulative average minutes per week of total cycling from the two examinations) in each category. †Analytic sample 1; ‡analytic sample 4; ± analytic sample 2; §analytic sample 3; ¶analytic sample 5; *analytic sample 6. Consult Figure 1 for an overview of the analytic samples.

decreases and less weight gain. They also found that initiating cycling was associated with less weight gain (12). A study of Swedish men and women found lower odds for incidence of general obesity among commuter cyclists. Also, switching from passive travel to cycling was associated with 36% lower odds for incidence of general obesity (13). In the current study, taking up cycling was associated with lower odds for incidence of abdominal obesity, even after restricting the analysis to those reporting no sport. The current study also expands on evidence from cross-sectional studies; one of which found no association (19), whereas five found significant negative associations between cycling and BMI (14–18). To the best of our knowledge, this is the first cohort study to examine the relationship between cycling and abdominal obesity, as well as examine cycling and remission from overweight and obesity.

Mechanisms. Cycling may affect one's waist circumference and body weight by contributing to a negative energy balance and thereby maintaining one's body weight or facilitating weight loss. Results from the few experimental studies of free-living cycling in adults show conflicting findings; two studies in adult men and women found no significant change in body weight after a commuter cycling intervention (38,39), one study including young adult men found an increased fat percentage after intervention (40), whereas a recent trial in adults with overweight or obesity (BMI, 25–35 kg·m^{-2}) found a reduction in fat mass (41). Two of these studies were randomized controlled trials (38,41), and except for one study (41), the study populations were generally healthy and without obesity (38–40), leaving less potential for decreases in body fat. More high-quality randomized controlled trials of adults, including different population groups, investigating the effect of free-living cycling on changes in body weight and waist circumference are needed.

Clinical relevance. The current findings may have clinical relevance as continued and initiated cycling may be protective against obesity. Our findings are especially interesting when considering that participants were of middle and old age, that is, a group at high risk for chronic disease. We have previously shown in the same cohort that initiated and consistent cycling was associated with lower type 2 incidence, potentially mediated by baseline waist circumference or BMI (9). Cycling-induced changes in these measures may thus contribute to prevention of chronic diseases such as type 2 diabetes for which overweight and obesity are well-established risk factors (3).

Strengths and limitations. Strengths of our study include use of unique data based on a population of both men and women with widespread engagement in cycling across sociodemographic groups. Also, the combined use of exposure and outcome data from two examinations is also a major strength. Limitations include use of self-reported physical activity and, therefore, potential systematic bias and random error. In relation to the outcome measures, waist circumference and body weight were measured objectively at baseline but subjectively at second examination. Although the two measures of waist circumference show systematic differences in measurement (32), we have no reason to suspect that this misclassification is related to cycling. We would argue similarly for misclassification of body weight. These methodological limitations may, most likely, null-bias the associations. However, future cohort studies should include objective measures throughout to avoid potential information biases. Another limitation is use of BMI to investigate changes in body fat status from habitual cycling, because cycling-induced increases in fat-free mass may mask the effect of cycling on fat mass if body weight remains relatively unchanged. Another limitation of our findings relate to the temporality of measurements; cycling exposure and anthropometry were measured at the same time, making it impossible to truly claim that changes in the exposure preceded changes in the outcome. Generalizability of our results may be somewhat limited; the cohort was composed of white men and women 50–65 yr of age at baseline, limiting the extent to which the findings can be generalized to other ethnicities and younger populations. Another limitation is that numerous hypothesis tests may increase the risk of making type I errors. Lastly, residual confounding or unknown confounding cannot be ruled out; however, many known or potential confounders were controlled for, which, when included in the models, consistently attenuated strengths of the associations.

CONCLUSIONS

Consistent cycling for commuting or recreational purposes in middle and old age was associated with small decreased odds for incidence of abdominal obesity and incidence of general obesity. Also, taking up cycling at this stage of life was associated with lower odds for incidence of abdominal obesity. We found no associations between cycling and remission from overweight and obesity. Future research should include high-quality randomized controlled trials investigating the effect of free-living cycling on changes in body weight and waist circumference in a variety of populations groups. It should also include cohort studies using only objective measures of body weight and waist circumference.

The authors would like to thank the participants of the Diet, Cancer and Health cohort study for their valuable contribution.

The Diet, Cancer and Health study was funded by the Danish Cancer Society. A. G. was supported by the Lundbeck Foundation (R151-2013-14641) and the Danish Council for Independent Research (DFF-4004-00111). The remaining authors received no funding for this work. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

The authors declare no conflict of interest.

The results of the present study do not constitute endorsement by the American College of Sports Medicine.

The authors declare that the results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

EPIDEMIOLOGY

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