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Weight gain and the risk of knee replacement due to primary osteoarthritis

A population based, prospective cohort study of 225,908 individuals

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SUMMARY

Objective: To study the association between weight gain and the risk of knee replacement (KR) due to primary osteoarthritis (OA), and to evaluate whether the association differs by age.
Design: 225,908 individuals from national health screenings with repeated measurements of height and weight were followed prospectively with respect to KR identified by linkage to the Norwegian Arthroplasty Register. Cox proportional hazard regression was used to calculate sex-specific relative risks (RR) of KR according to change in Body Mass Index (BMI) and weight, corresponding analyses were done for age categories at first screening.
Results: During 12 years of follow up, 1591 participants received a KR due to primary OA. Men in the highest quarter of yearly change in BMI had a RR of 1.5 (95% confidence interval (CI) 1.1–1.9) of having a KR compared to those in the lowest quarter. For women the corresponding RR was 2.4 (95% CI 2.1–2.7). Men under the age of 20 at the first screening had a 26% increased risk for KR per 5 kg weight gain, for women the corresponding increase was 43%. At older age the association became weaker, and in the oldest it was lost.
Conclusions: Weight gain increases the risk for later KR both in men and women. The impact of weight gain is strongest in the young, at older age the association is weak or absent. Our study suggests that future OA may be prevented by weight control and that preventive measures should start at an early age.

Introduction

The strong association between Body Mass Index (BMI) and OA of the knee is well established[1–7]. Few have however studied the effect of weight change and the effect of weight change at different ages. In a study of life course BMI and the risk of symptomatic OA, Wills *et al.* reported that a high BMI from early age is positively associated with later knee OA, and that this association seems to be due to prolonged exposure rather than the impact of high BMI in this particular period[2]. In a previous study of the association between weight gain and the risk of total hip replacement (THR) we found that weight gain at young age was strongly associated with later THR, whereas the association in the middle aged was small or absent[8].

We wanted to study the association between weight gain and severe OA of the knee using knee replacement (KR) due to primary OA as a marker of severe OA. We also wanted to evaluate the difference in the impact of weight gain according to age, our hypothesis being that weight gain at a young age is more detrimental to the joint than weight gain at an older age.

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Method

Population

We included participants in population based health screenings in Norway. The National Health Screening Service (now the Norwegian Institute of Public Health), performed a nationwide compulsory Tuberculosis screening during 1963–75[9], and numerous standardized cardiovascular screenings from 1974–1994[10]. In addition, population based health screenings have been performed in the city of Oslo[11], Bergen[12], Tromsø[13], and in the county of Nord-Trøndelag[14].

Exposure variables

The person's first weight- and height-measurement was obtained from screenings performed between 1963 and 1975; the Tuberculosis screening, the Bergen Blood Pressure Study, and the Oslo Study. The person's second weight- and height-measurement was obtained from screenings performed between 1974 and 1994; the First and Second Cardiovascular Survey of Oppland, Finnmark and Sogn og Fjordane, the Second and the Third Tromsø Study, the First Nord-Trøndelag Health Study, and the 40-year Surveys.

The purpose of the Tuberculosis screening was to identify individuals with tuberculosis in the general population, and since low weight was a known predictor for the disease, standardized measurements of weight and height were included in the screening program[9]. The other studies were all performed to investigate cardiovascular risk factors. The participants received a questionnaire which included information on smoking habits, and we categorized the participants as; never smoker, former smoker, or current smoker. Their weight and height were measured by trained nurses at consultation[10–12,15–17]. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Change in body stature was expressed as change in BMI per year: the difference in BMI between the last and the first screening divided by the numbers of years between the screenings (ΔBMI/Year). We divided the cohort into sex-specific quartiles according to the ΔBMI/Year, and compared the quartiles with greater change in ΔBMI/Year with the quartile with the lowest change in ΔBMI/Year (the reference quartile). The analyses were also performed using weight change in kilograms between the two screenings.

To investigate if there was any difference between gaining weight in persons with a low BMI at the first screening compared to those with a higher BMI at the first screening, and to investigate any effect of the amount of weight gain, we performed analyses stratifying on quartiles of BMI at the first screening and on quartiles of ΔBMI/Year.

To investigate any difference in the impact of weight gain at different ages on later knee OA, the cohort was divided into strata of 20 years according to the age at the first screening.

Endpoint

By using the national 11-digit personal identification code we were able to link the data from the health screenings with the data on performed KR's from the Norwegian Arthroplasty Register. The Norwegian Arthroplasty Register was established by the Norwegian Orthopaedic Association, and started to include information on KR's from January 1994[18]. The operating orthopedic surgeon submits a standardized form to the register for each joint replacement performed. The form contains information on the diagnosis that lead to the operation, any previous KR or other surgery performed in the joint, the type of implant used, and information on how the procedure is performed.

The event was defined as the first recorded KR for the diagnosis of primary OA, either a total knee joint replacement with or without a patella button, or a medial unicondylar KR.

Data on death and emigration was collected from the Norwegian Registry of Vital Statistics.

The start of follow up in this study was set to January 1st, 1994, the date the Norwegian Arthroplasty Register started registration of KR's. End of follow up was set to February 1st, 2006.

Exclusion

A total of 271,537 individuals had repeated measurements of weight and height. Of these 225,908 (83.2%) were eligible for the study. We excluded individuals younger than 16 years at the initial screening ($n = 29,764$) and older than 80 years at start of follow up ($n = 3856$). We also excluded individuals who had information in the register about revision surgery, but no information on primary surgery ($n = 127$), individuals with irregularities in the registry data ($n = 2$), and individuals who according to the Norwegian Registry of vital statistics had died or emigrated before start of follow up ($n = 11,880$).

Statistical methods

Descriptive statistics was provided as means, standard deviation (SD) and occurrence per 10,000 person-years. Person-years were calculated as number of years form start of follow up until event, or censoring. The analyses were performed as a survival study using the Cox proportional hazard regression method, calculating hazard ratios (hereafter called relative risks (RR)) with a 95% confidence interval (CI) for having a KR.

Censoring occurred for KR performed for other diagnosis than primary osteoarthritis (OA), for death, for emigration, and at end of follow up.

The analyses regarding ΔBMI/Year and weight change were adjusted for age, BMI and height at the first screening, and for smoking habits at the second screening. ΔBMI/Year was in addition analyzed separately for age groups (17–20, 21–40 and 41–60 years). All analyses were given gender specific. Since the age at start of follow up varied among those in the same age group at first screening, the analyses were also performed adjusting for age at start of follow up.

We performed analyses stratified on BMI at the first screening and on different levels of ΔBMI/Year; e.g., comparing those who had a high BMI at the first screening and a large weight gain with those who had a low BMI at the first screening and a small weight gain per time.

We inspected Log minus log curves for each of the covariates, and the visual inspection showed approximately parallel lines indicating that the proportional hazard assumption of the Cox model was satisfied. The numbers of included individuals in the tables may vary slightly due to some missing values. The analyses were performed using the statistical program package SPSS version 19 (SPSS Inc., Chicago, IL).

The study was approved by The Norwegian Data Protection Authority, and the Regional Committee for Medical and Health Research Ethics South East.

Results

105,190 men and 120,718 women were included in the study. The mean age at first screening was 26.6 (SD 8.9) years, at second screening 44.4 (SD 8.0) years, at start of follow up 50.9 (SD 9.4) years, and at end follow up 62.3 (SD 8.4) years (for sex-specific numbers see Table I). During the 12 years of follow up, 1591