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Body height and mortality - mortality follow-up of four Swiss surveys

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ABSTRACT

Background. Adult body height is largely determined by genetics, but also by dietary factors, which in turn depend on socioeconomic status and lifestyle. We examined the association between adult body height and mortality in Switzerland, a country with three main language regions with different cultural background.

Methods. We included 16,831 men and 18,654 women, who participated in Swiss population-based health surveys conducted 1977–1993 and who were followed up until end of 2008. Multivariable Cox proportional hazards models were computed to examine the association of body height with overall, cardiovascular, and cancer mortality.

Results. We observed a positive association between adult body height and all-cause mortality in women (HR = 1.34, 95% CI 1.10–1.62, tallest vs. average women). In men, mortality risk decreased with increasing height, with shortest men tending to have higher (1.06, 0.94–1.19) and tallest men a lower (0.94, 0.77–1.14) risk compared with men of average height (p-trend 0.0001). Body height was associated with cancer mortality in women, such that tallest women had a higher risk of dying from cancer than women of average height (1.37, 1.02–1.84), but there was no such association in men (0.95, 0.69–1.30). In both sexes, height was not associated with cardiovascular mortality in a statistically significant manner.

Conclusion. Our study does not support an inverse association of body height with all-cause mortality. On the contrary, our data suggests a higher overall risk in taller women, mainly driven by a positive association between body height and cancer mortality.

1. Introduction

In Switzerland, as in many other Western countries, adult body height increased considerably in the past century. Historic data of Swiss conscripts show that the average height of 19-year old conscripts increased by 14.9 cm since 1878 with a mean height of 178.2 cm in 2009 (Staub et al., 2011). Up to 80% of variation in body height is explained by genetics (Wood et al., 2014). However, whether or not an individual reaches its maximal predetermined height depends on various other factors, which are strongly linked to an individual's socioeconomic status and standard of living (Grasgruber et al., 2014).

Generally, being taller was inversely associated with all-cause and cardiovascular disease (CVD) mortality, but positively with cancer mortality, for example in a meta-analysis with >1 million participants from all-over the world (Anon, 2012). These associations were still observed after adjusting for total body fat mass, lifestyle, or socioeconomic factors. The relationship between body height and mortality is largely similar across countries and regions worldwide, although most studies were conducted in Caucasian populations. The Swiss population is culturally very diverse, and this diversity is mainly defined by the language regions: German-, French- and Italian-speaking regions, which have cultural influences from and links with the respective neighboring countries. This not only affects dietary and other lifestyle habits in these regions, but also influences cause-specific mortality, which varies despite similar all-cause mortality (Faeh et al., 2009). Since lifestyle, in particular in childhood and adolescence, influences body growth and adult height, we examined the association between body height and all-cause as well as cause-specific mortality in Switzerland. In our analysis, we particularly focused on effects of potential confounders on risk estimates, and regional/cultural differences.

2. Methods

2.1. Study participants and study variables

The dataset used for this analysis included four population-based cross-sectional studies, which were conducted in Switzerland between

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1977 and 1993: NRP 1A (National Research Program 1A, 1977–79), SOMIPOPS (SOcio-Medical Indicators for the POPulation of Switzerland, 1982), Swiss MONICA (MONItoring of trends and determinants in CArdiovascular disease, three waves: I, 1984–86; II, 1988/89; III, 1992/93), and the first SHS (Swiss Health Survey, 1992/93). Cause-specific mortality follow-up until 2008 was obtained via anonymous record linkage with the Swiss National Cohort (SNC) (Roh et al., 2014; Bopp et al., 2009). Participants were between 14 and 99 years old at recruitment and were followed-up for a maximum of 18.9 to 31.9 years, depending on the survey. In our analysis, we included 16,831 men and 18,654 women with any follow-up information and non-missing height data.

Height and weight were measured in the NRP1A and MONICA surveys, and otherwise self-reported by the participant. All study participants answered a self-administered questionnaire, which assessed information on demographics, smoking behavior, and alcohol consumption.

2.2. Statistical analysis

Mean height in men was 174 cm, and in women 162.5 cm, both with a standard deviation of 7 cm. Height was divided into 5 categories. The tallest height category included all heights taller than 1.5 SD above the sex-specific mean, in other words, taller than 184.5 cm for men or taller than 173 cm for women. Similarly, the shortest group includes all men shorter than 163.5 cm, and all women shorter than 152 cm. The remaining middle range of heights was divided into 3 categories, each 7 cm wide.

Mean height appears to increase slightly by year of birth, an additional 1.14 cm on average for every 10 years later. Therefore, year of birth, centered at 1942, the median over all 4 surveys, has been included in all models. Additionally, survey (MONICA wave 1, 2, or 3, SHS, NRP1A and SOMIPOPS) has been included in all models.

Body mass index (BMI) has been divided into categories at 18.5, 25, and 30, with reference category 18.5–<25.0 kg/m^2 BMI in categories was a better fit to the data than BMI (continuous) or body weight, as examined with AIC, thus, only categorical BMI was included as a predictor. Alcohol use was categorized as yes or no, and smoking status as never smoker, former, light or heavy current smoker. Education was categorized according to the International Standard Classification of Education ISCED into mandatory or less, secondary, upper secondary, or tertiary (Bopp and Minder, 2003; Lynch et al., 2004). Marital status was single, married, widowed or divorced. Occupational status was jobless or working/housewife. Language was divided in three groups: German, French, or Italian. Nationality was considered as Swiss, French, German, Italian, Spanish, British, or other.

We considered four endpoints: all-cause mortality, deaths due to CVD, and deaths due to cancer, and death due to remaining causes. Survival times were defined as starting at the age of entry into the cohort, and ending at the age of death or end of study. Survival estimates have been computed with the method of Kaplan and Meier (1958). For all-cause and cause-specific mortality, we compared height categories using Cox proportional hazards regression (Cox, 1972) and present hazard ratios (HR) and corresponding 95% confidence intervals (CI).

For each endpoint, we considered a range of models. In the unadjusted model, only height, year of birth and year of survey were included as predictors. Other models also adjusted for BMI; alcohol and smoking; education, marital status and professional status; nationality and language; and a full model included all considered predictors. Males and females have been analyzed separately, so that we do not need to assume that hazard rates for men and women are proportional.

Previous studies reported that body height was inversely associated with ischemic heart disease (IHD), but not other cardiovascular diseases such as stroke, atrial fibrillation or venous thromboembolism (Schmidt et al., 2014). Therefore, we separately examine mortality due to IHD and due to stroke in addition to overall CVD. Secondly, we separately analyzed cancer likely associated with insulin-like growth factor-I (IGF-I) concentration (colon, rectum, thyroid, and haematological cancers) because one mechanism by which body height is thought to contribute to cancer risk is based on higher circulating levels of IGF-I (Smith et al., 2000).

Multiple imputation of missing data using chained equations (White et al., 2011) has been performed to confirm that the results are not affected by the presence of missing data (among others, height was missing for 295 subjects). Because the results of this multiple imputation analysis were essentially the same as those of the complete case analysis, only the complete case analysis results have been reported. In subanalyses, we examined whether the associations differed by height assessment method, language region, nationality and follow-up period. We also considered a set of models including an interaction between survey and height category. However, the interaction terms were by and large not statistically significant and goodness of fit (using AIC) was better for all models without interaction. The statistical analysis has been performed using STATA 13.1, College Station, TX, USA.

3. Results

During a median follow-up time of 18.6 years in men and 19.3 years in women, 3826 men and 3402 women died (Table 1), with CVD being the most common cause of death.

Taller men and women were considerably younger at recruitment than shorter participants. Tall participants tended to have a higher educational level than short participants and were less often unemployed. They also more often had a low or normal BMI and were more often single.

In our analysis, we observed a positive association between adult body height and all-cause mortality in women (HR = 1.34, 95% CI 1.11–1.61, tallest vs. average women, linear p-trend 0.005; Table 2). In men, the risk decreased with increasing height with shortest men tending to have higher mortality (HR = 1.06, 95% CI 0.94–1.19) and tallest men a lower risk (HR = 0.94 95% CI, 0.77–1.14) compared with men of average height (statistically significant linear trend, p = 0.026). We examined if results differed by height assessment and observed that all-cause mortality tended to be higher in shortest men compared with average men when height had been measured (HR = 1.15, 95% CI 0.99–1.32, linear trend p = 0.87), but not when height had been self-reported (HR = 0.90, 95% CI 0.73–1.12, no linear trend, p = 0.93). Independent of assessment methods, there was no association in tallest men (measured: HR = 0.91, 95% CI 0.69–1.19; self-reported: HR = 0.96, 95% CI 0.74–1.24). In women, results did not differ appreciably by type of height assessment (results not shown).

We did not observe statistically significant associations of height with CVD mortality (Table 2). When we restricted our analysis to IHD, there tended to be an inverse trend in men such that shortest men had a tendency to an increased risk of IHD (HR = 1.12, 95% CI 0.86–1.46) and tallest men to a decreased risk (HR = 0.85, 95% CI 0.52–1.39) compared with average men (linear trend p = 0.08). Among women, the risk tended to be lowest among shortest women (HR = 0.89, 95% CI 0.59–1.33) and highest among tallest (HR = 1.65, 95% CI 0.99–2.74), but there was not statistically significant linear trend (linear trend p = 0.56).

Body height was not associated with cancer mortality in men, but we observed a positive association in women such that tallest women had a 42% higher risk of dying from cancer than women of average height (Table 2). Restricting the analysis to tumor entities that are likely associated with high circulating IGF-I concentrations hardly changed the observed associations (results not shown). We also examined if the exclusion of cancer strongly linked with smoking (lung, upper aero-digestive tract, pancreas, bladder, liver) changed the observed association. The association for tallest women became inverse (HR tallest vs. average women = 0.92, 95% CI 0.46–1.82), whereas the association for the shortest women did not change appreciably (HR = 0.93, 95% CI 0.56–1.57, compared with women of average height).