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An association between adult lifespan and stature in preindustrial Lithuanian populations: Analysis of skeletons

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ABSTRACT

The aim of this study was to test the null hypothesis that no relationship between maximal living stature and adult lifespan had existed in prehistoric and historic Lithuanian populations. The sample analyzed consisted of 1713 skeletons of adult individuals who died between the 2nd century CE and the beginning of the 19th century CE, collected from 118 archaeological sites located in the current territory of Lithuania. A cumulative logit model was applied to model ordinal age-related changes in the auricular surface and the pubic symphysis (measures of lifespan) as a function of maximal length of femur (an indicator of maximal living stature), sex, burial site and its chronology as a proxy for the place of residence and period. The lack of strong association between adult lifespan and femur length was observed for males and females, various periods and places of residence. However, the results failed to reject convincingly the hypothesis that no relationship between these two variables had existed in preindustrial Lithuanian populations. In addition to concerns regarding sampling and measurement errors, heterogeneous frailty in early life and resulting selective mortality may partly explain the results obtained.

Introduction

Relationship between adult stature and lifespan, one of the main quantitative measures of biological living standards, is very complex and not fully understood. Both stature (height) and lifespan (age at death) are easily measured. Yet, associations between these two indicators are not so easy to determine. Many covariates should be taken into account, and often results obtained by different researchers are the matter of selected methods.

Height reflects not only body size, but also health status, risk of certain diseases and quality of life. From the growth indices, conclusions are made about the environmental factors that influence growth. Height is a polygenic trait – up to 80% of its variation between relatives and around 30% in the entire population is under genetic control (McEvoy and Visscher, 2009). The rest is controlled by environmental factors such as diet, disease exposure, etc. Early-life undernutrition and disease seem to reduce final stature, especially affecting leg length (Cameron and Bogin, 2012). Historical data suggest that infections, such as smallpox, have reduced height up to 25 mm in affected individuals (Leunig and Voth, 1998; Voth and Leunig, 1996), although the latter findings remain highly debatable (Heintel and Baten, 1998; Razzell, 1998). However, according to the latest auxological findings, the impact of both genetic and environmental factors may be less important compared to the so-called “community effect” – phenotypic plasticity which allows individuals to adjust their phenotype to different environments within their lifespan (Hermanussen, 2013).

The common tendency to associate taller stature with physical attractiveness, authority, leadership, higher cognitive functions

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and social and professional success leads to the perception that, in the realm of human growth similar to economic growth, bigger is better (Bartke, 2012). However, during the recent years, the "bigger is better" theory has been largely disputed. In modern anthropological studies taller people often tend to be leaner in comparison to shorter people, especially when upper-class people are compared to working-class. If taller people are lean and short people have higher BMI, the longevity findings will tend to favour taller people. However, when a population is exposed to a life-long healthful diet and lifestyle, shorter height is more likely to promote longevity (Salaris et al., 2012; Samaras, 2014).

Certain genes have been reported to influence both stature and longevity (e.g., IGF1, mTOR, FOXO3, etc.). The evidence indicated that shorter, smaller individuals were healthier and lived longer (Govindaraju et al., 2015; He et al., 2014). The aforementioned associations are very obvious in nematodes and mice. However, since the life-history strategies of humans are very different from those of mice, these hypotheses are not warranted (Le Bourg, 2015). In developing countries, an association between taller and bigger maternal body and higher mortality of their children has been reported (Monden and Smits, 2009). The explanation that the bigger maternal body used more resources for itself than shared with an infant has been provided by the authors. Lastly, some types of cancers are more common in taller people. In contrast, shorter people appear to experience an increased risk of coronary heart disease (Batty et al., 2009).

An association between stature, health and longevity is not clear even in modern populations. Moreover, when it comes to analysis of historic and prehistoric people, it becomes even more obscure as a reconstruction of life histories of human beings requires a "holistic approach that uses our empirical testing of skeletal data as well as our imaginations" (Agarwal, 2016, p. 143). For instance, according to the "osteological paradox" hypothesis, short stature and short lifespan, past populations with high frequencies of periosteal lesions actually might have been healthier (Wood et al., 1992). Tall stature may be indicative of high selective pressures that eliminated short-statured individuals with greater mortality (Agnew et al., 2007; Gunnell et al., 2001; Vercellotti et al., 2014), whereas tall people displayed longer lifespans (Kemkes-Grottenthaler, 2005). Short stature was also reported to increase risks of mortality during the Black Death (DeWitte and Wood, 2008; DeWitte and Hughes-Morey, 2012). Finally, the relationship between height and mortality may be nonlinear and shaped like an inverted "J" (Alter, 2004; Waaler, 1984).

Summing up controversies elucidated by former studies, we do formulate the null and three alternative hypotheses to be tested:

- H0: no relationship between stature and longevity existed in preindustrial Lithuanian populations.
- H1: in preindustrial Lithuanian populations, tall adults lived longer;
- H2: in preindustrial Lithuanian populations, short adults lived longer;
- H3: in preindustrial Lithuanian populations, the relationship between stature and lifespan existed but was nonlinear.

One of the main problems studying the relations between the stature and the lifespan in past populations is due to the fact that only a few of important extraneous factors that may confound the effect can be reliably controlled in bioarchaeological studies. Therefore, on the one hand, a possible correlation between lifespan and stature does not necessarily imply causation. On the other hand, failure to include important variables may result in biased estimates. To partly avoid such problems, this study tested the abovementioned hypotheses by controlling three covariates that have been identified as significant mortality and stature predictors in past Lithuanian and other populations: sex (Česnys and Balčiūnienė, 1988; Jankauskas, 1995, 2002; Jatautis and Mitokaitė, 2013; Jorkov, 2015; Kurila, 2007; Vercellotti et al., 2014; Watts, 2011, 2013; Yaussy et al., 2016), chronological period (Česnys and Balčiūnienė, 1988; Jankauskas, 2002; Ozer et al., 2011) and burial site as a proxy of residence place (Jankauskas, 1995; Redfern et al., 2015).

Materials and methods

Data and variables

The sample used in this study consisted of skeletons of adult individuals from archaeological excavations stored at the Department of Anatomy, Histology and Anthropology, Faculty of Medicine, Vilnius University, of whom the information on all of the following variables was available: sex, age-at-death, maximal femur length, chronology and place of residence. The assumption was made that excluding all skeletons without needed information did not bias the results as the missing data are missing at random. In total, the sample comprised 1713 individuals who died between the 2nd century CE and the beginning of the 19th century CE. The skeletons were discovered in 118 archaeological burial grounds located in the current territory of Lithuania (the range of the distances between the sites was 30–300 km).

Sex was determined employing the standard morphological differences of the pelvis, (Phenice, 1969; Buikstra and Ubelaker, 1994; White and Folkens, 2005).

Information on adult age-at-death was obtained by studying age-related morphological changes in the auricular surface of the ilium and the pubic symphysis. We decided not to estimate individual ages-at-death based on observed skeletal traits since it is a complex and error-prone process (Bocquet-Appel and Masset, 1982; Konigsberg and Frankenberg, 1992; Seguy and Buchet, 2013). Instead, we used age-related morphological changes as an index of lifespan by avoiding adding biases resulting from problems related to age-at-death estimation of adult skeletons. The right side of the pelvis was studied, and the left side was used when the right side was unavailable or too abraded to record. In the present study, the scoring systems of Lovejoy et al. (1985) and Suchey-Brooks (Brooks and Suchey, 1990) were implemented to classify age-related changes in the auricular surface and the pubic symphysis, respectively, into ordinal categories. Similarly to Osbourne et al. (2004), one modification was made for the scoring technique of