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Social status influences human growth – A summary and analysis of historical data from German school girls in 1914 with comparison to modern references

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Abstract

Background In the animal kingdom body size is often linked to dominance and subsequently the standing in social hierarchy. Similarly, human growth has been associated and linked to socioeconomic factors, including one's social status. This has already been proposed in the early 1900s where data on young German school girls from different social strata have been compared.

Objectives This paper aims to summarize and analyze these results and make them accessible for non-German speakers. The full English translation of the historic work of Dikanski (Dikanski, 1914) is available as a supplement. Further, this work aims to compare the historical data with modern references, to test three hypotheses: (1) higher social class is positively associated with body height and weight, (2) affluent people from the used historical data match modern references in weight and height and (3) weight distributions are skewed in both modern and historical populations.

Methods Comparison of historical data from 1914 with WHO and 1980s German data. The data sets, for both body weight and height for 6.0- and 7.0-year-old girls, were fitted onto centile curves and quantile correlation coefficients were calculated.

Results In historical data social status is positively associated with body height and weight while both are also normally distributed, which marks a significant difference to modern references.

Conclusion Social status is positively associated with height, signaling social dominance, making children of affluent classes taller. Children from the historical data do not reach the average height of modern children, even under the best environmental conditions. The children of the upper social class were not skewed in weight distribution, although they had the means to become as obese as modern children.

Take home message for students Comparing modern references with historical data suggests both community effect on height and strategic growth adjustments. The average height of modern references is not met by historical data, not even by the affluent classes, who lived under favorable circumstances. Additionally, historical data show that weight distributions are not always skewed.

Introduction

Social hierarchy in association with reproductive rights and breeding order has been extensively studied in animal societies. Less well studied is the association of social hierarchy, growth rate, and body size. Huchard and colleagues (Huchard et al., 2016) studied wild Kalahari meerkats (Suricata suricatta), where both male and female subordinates increase their growth rate in response to experimentally altered rivals of the same sex, showing that they adjust their growth to match their closest competitor. Huchard's study suggests that these responses also occur in other social mammals, domestic animals and primates. Since humans are social and consequently rely on social cues and symbols to navigate their respective communities, it is not a leap to assume that dominance in humans is also linked to body height and weight. This connection has been the subject of research for some time. In 1963 James Tanner described growth as a "target seeking process" which is at least partially influenced by the individual's social environment (Niere et al., 2020; Tanner, 1963). Even though, this connection is still often dismissed or disregarded in studies of human growth and development (Hermanussen et al., 2019). However, not unlike the previously mentioned meerkats, humans may also perceive body height and mass as a symbol of social dominance and subsequently of social hierarchy. Lourenco shows how children already interpret physical size as a sign of social dominance (Lourenco et al., 2015). Additionally, taller statue has been linked to higher social status across different cultures (Bogin et al., 2002; Czapla and Liczbińska, 2014; Hermanussen and Scheffler, 2016; Niere et al., 2020; Stulp et al., 2015). The influence of socioeconomic status and one's standing in social hierarchy, is already well researched; there is an association between body height and social status (Koziel et al., 2019). The social environment of a person influences their growth, and research indicates that taller stature is associated with higher socioeconomic status and vice versa (Hermanussen and Scheffler, 2016).

This connection, however, has only gained popularity in the field of human growth and development research in the 21st century. For example, the results listed on PubMed if one searches for 'social influence on height/ weight' only date back to 1976 and pick up at around the year 2000. This is certainly connected to problems of digitalization, lacking translations of non-English historical data from the field of auxology (defined as the scientific study of growth and development) (Grupe, 2005). In accordance with the nature of a developing field, studies that reach further back than 1970 are usually descriptive and atheoretical. For instance, samples were presented and described and then often compared to similar data without investigating hypotheses for possible explanations (Bogin, 2021a, 2021b). In the present article, we show that the connection between different social strata and differing body height and weight was made as early as 1914 in a German dissertation (Dikanski, 1914). Here, we compare historical data with modern German and international growth references to test the hypothesis: (1) higher social class is positively associated with body height and weight. In addition, we test two further hypotheses, (2) affluent people of historical data, in this particular case 6- and 7-year-old girls from upper-class families, match modern references in weight and height and, consequently, (3) weight distributions are always (i.e. including historical populations) skewed. Hypotheses 2 and 3 are tested to evaluate the applicability of modern growth references, which are sometimes claimed to represent a universal ideal pattern of hu-

man growth for historical and non-Western populations.

Background

The historical data used in this article were taken from the German-language dissertation by Mordchaj Dikanski who wrote about "The influence of social status on the body measurements of school children" to obtain his doctorate in 1914. The following is a summary of his work and proceedings (Dikanski, 1914).

At the beginning of his work Dikanski noted that the extent of social deprivation and its influence on physical development had been studied many times. Mostly children from different social classes were measured and their mean values of body height and weight were compared, both in Germany and abroad. He provided a table with data from England, Italy, Germany, Russia, Denmark and Sweden. Dikanski argued that the results of the compared data vary in their differences. There were large variations between studies, with the difference between social classes being small or large, and decreasing or increasing with age. This prompted him to conduct his own study with material about Munich elementary school children.

Dikanski used a method of comparison which, according to him, was new at the time. He sorted the entire material from three Munich elementary schools, whose students belonged to different social classes, into three classes based on the parents' occupations: the rich and affluent middle class (Class I), the working class (Class III), and the rest middle class (II). Class I included occupations such as pharmacists, doctors, bank officials and railway administrators; Class II included chauffeurs, printers, electricians, field weavers, hairdressers and gardeners; Class III included assistants to various trades, hired hands, clerks and factory workers. Dikanski noted two more distinguishing features of his study, first, the body measurements are strictly net values (surveyed without shoes and clothes) and second, they are reduced to certain age groups, namely to the age of exactly 6.0 or 7.0 years.

He processed his data according to the rules of the 'collective measure theory'. Through mean values, error sums and other parameters, Gaussian curves were calculated. Although Dikanski did not provide detailed calculations, it was possible to recalculate the centiles for weight and height using the data provided and compare them with modern WHO references.

Sample and Method

In Dikanski's data set, data from 1843 girls were used (Table 1). This material is divided into distinct social and age groups, as shown in Table 1, which is taken and translated directly from Dikanski's work.

Since Dikanski does not provide raw, individual data in his work, the centiles according to body height and weight for all social classes were re-calculated. This was possible through the data provided in his dissertation which included: Gaussian curves with values given in per mille, mean values, error square sums and standard deviations. Afterwards, using the software R, LMS-scores were calculated to make the data comparable.

Modern references were taken from data from Germany (Flügel et al., 1986) in the 1980s and data from WHO growth references. The WHO growth reference and the data collection method is freely accessible online (de Onis et al., 2007; WHO, 2022a, 2022b). For this paper, only the data of the

six- and seven-year-old girls (72 and 84 months respectively) for both height and weight were used. The original study for Germany from the 1980s included 41035 participants aged 0 to 70 years. Only the relevant and comparable groups of girls were used, i.e., a total of 2284 girls, including 1185 six-year-old and 1099 seven-year-old girls.

All three data sets, for both body weight and height, were fitted onto centile curves for comparison. Additionally, quantile correlation coefficients (Choi and Shin, 2021) were calculated to further emphasize differences and similarities.

Results

German girls in the 1980s are both the tallest and heaviest, following the WHO reference. According to the historical data, the affluent class (I) is the tallest and heaviest. Dikanski's middleclass girls (II) are both shorter and less heavy than the affluent class, but taller and heavier than the working class (Figure 1 and 2). On average, the affluent class of Dikanski with 5.23 cm and 1.7 kg for the 6-year-old and 7.7 cm and 3 kg for the 7-year-old shorter and lighter compared to 1980s German girls. In comparison to the WHO reference, the affluent class with 3 cm and 0.7 kg for the 6-year-old and 5 cm and 1.8 kg for the 7-year-old shorter and less heavy.

Weight in all three of Dikanski's social classes is normally distributed, while modern weight is non-normally distributed (Figure 2). The WHO and the German curves are comparatively more skewed, flatter and deviate to the right, especially with regard to higher weights. Dikanski's curves are merely shifted to the left on the X-axis. It shows that, in contrast to modern references, the weight distribution of all three of Dikanski's classes is not skewed.

These results are emphasized and illustrated by the quantile correlation coefficients (Table 2). Since height is always normally distributed, only the quantile correlation coefficients for weight are included in the table. The lowest correlation is between the data from the 1980s and Dikanski's data since the difference in weight and curve shape is greatest between these two (highlighted in red). The figures for the WHO reference and the 1980s are almost identical since these two are very similar in shape and distribution (highlighted in green). The low figures of the coefficients also underline the difference between the normally distributed weight in the historical data and the non-normally distributed weight in the modern references. Since Dikanski's classes are normally distributed for weight, the correlation between them is always 1, which, for the sake of clarity, is not included in Table 2.

Table 1 The division of Dikanski's data, split into two age groups and three social classes.

Social Class	Girls, age 6	Girls, age 7	Total number
I	174 = 18,3%	176 = 19,7%	350
II	246 = 25,9%	281 = 31,5%	527
III	530 = 55,8%	436 = 48,8%	956
	950 = 100%	893 = 100%	1843

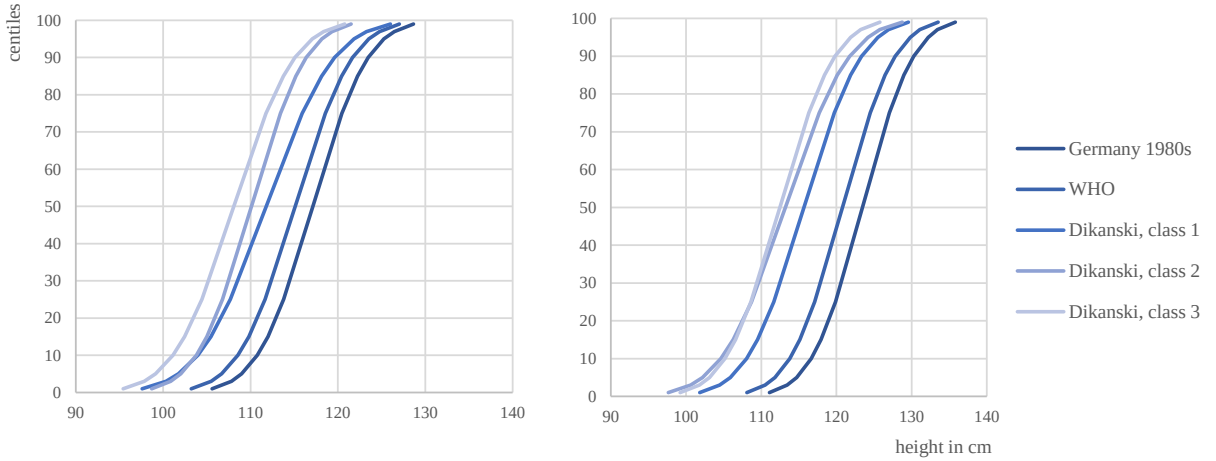

Figure 1 Height comparison between 6- and 7-year-old girls from historical data (Dikanski 1914), WHO reference (2007) and 1980s Germany (Flügel et al. 1986).

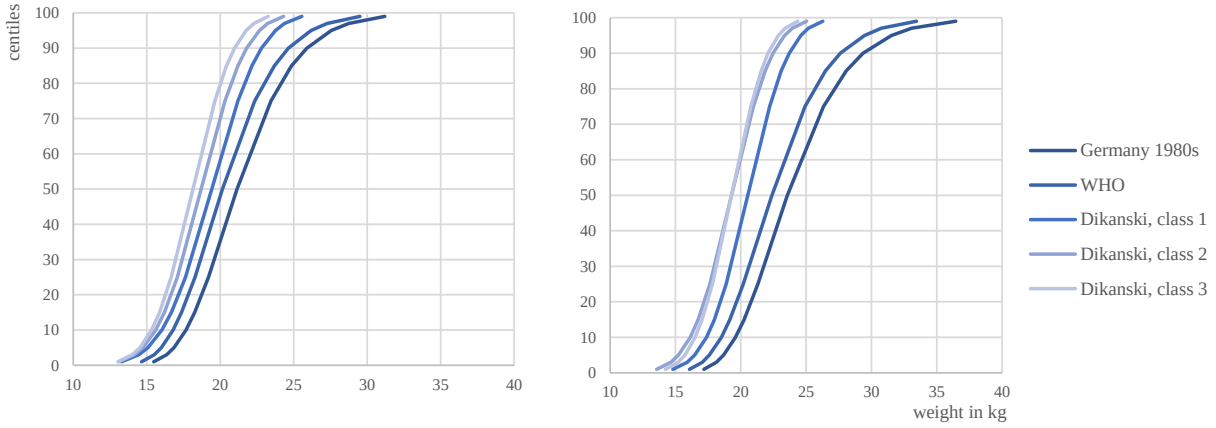

Figure 2 Weight comparison between 6- and 7-year-old girls from historical data (Dikanski 1914), WHO reference (2007) and 1980s Germany (Flügel et al. 1986).

Discussion

Hypothesis (1), namely that higher social class is positively associated with body height and weight, can be accepted. This is in line with other results and research (Bogin et al., 2002; Czapla and Liczbińska, 2014; Hermanussen and Scheffler, 2016; Stulp et al., 2015) and, again, confirms and emphasizes the influence of social factors

Table 2 Quantile correlation coefficients.

	WHO, age 6	WHO, age 7	80s Germany, age 6	80s Germany, age 7
WHO, age 6	1	0,999	0,998	0,981
WHO, age 7	0,999	1	0,999	0,988
Dikanski's classes	0,762	0,736	0,729	0,633
80s Germany, age 6			1	0,991
80s Germany, age 7			0,991	1

on human growth and development. It also underlines the fact that this is not a recent phenomenon but has been present for at least a hundred years (Hermanussen, 2016). Hypothesis (2), that affluent people of historical data, in this particular case 6- and 7-year-old girls, match modern references in weight and height, must be rejected. The affluent class which included children from doctors and bank officials is below the body height and weight of the WHO reference or schoolgirls of 1980s Germany. This shows that even children who grew up under advantageous social circumstances do not reach the average height of the chosen contemporary references. Hypothesis (3), that weight distributions are always (i.e. including historical populations) skewed distributions, must also be rejected. The assumption that the weight distribution needs to be skewed because individuals may gain fat with almost no upper limit, but cannot lose weight below the minimum necessary to live is not true for the historical data.

There are merely about 70 years between Dikanski's data and the data from the 1980s in Germany, so a genetic component can almost be completely ruled out; such a drastic change over this short period seems very unlikely. The diet, especially considering the richer population, has changed between 1914 and 1980s Germany, but it seems unlikely that the discrepancy could be explained through nutrition alone (Hermanussen and Scheffler, 2016), especially since nutrition and growth in height are not necessarily linked to each other (Hermanussen et al., 2019). According to the German Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, 2018), in the early 1900s meat consumption doubled in cities, where the standard of living was higher. Among workers, sugar consumption was on the rise, since it was cheap and could be stored indefinitely. Thanks to the improved infrastructure, larger quantities of food could be brought to the cities, including fresh fish, vegetables, and grain, which were eaten in various flour dishes, like pasta and different kinds of mash. In larger cities, the first delicatessens appeared, selling coffee, rice, and cocoa. In the 1980s, more emphasis was put on quick, ready-to-eat food, and the traditional eating habits moved towards frozen food. However, environmental awareness grew between 1979 and 1989, the number of health food and organic food shops rose from 100 to over 1,000. In the socially higher classes dishes such as lobster, caviar or truffles were served. By and large, consumer interest in whole foods and organic foods increased. As the variety and quantity of an individual's diet is a major determinant of growth, it is also related to other influences, like one's socioeconomic status (Bogin, 2021a). This means that while diet or individual food preferences may have changed between 1914 and the 1980s in Germany, the nutrients needed for growth were sufficient at both times and it is unlikely that the discrepancy in height and weight should be explained by diet alone (Hermanussen and Scheffler, 2016). This is also supported by a study (Hermanussen et al., 2018), that investigated 19th and 20th century journals from various German pediatricians, which revealed that historical literature does not see a strong relationship between nutrition, child growth, and adult height.

Consequently, this means that the social component must play a crucial role here. Independent of nutrition, taller stature is usually associated with higher socioeconomic status, and it has been shown that there is a bilateral link between height and social position (Bogin et al., 2017). Children of the affluent class are taller than children of 'lower' social classes, which pertains to the phenomenon of strategic growth adjustment (Hermanussen

et al., 2019; Hermanussen and Scheffler, 2016). Strategic growth adjustments were observed in nonhuman species (Bogin, 2021a; Huchard et al., 2016), but can also be observed in historical height data (Hermanussen et al., 2018) where social transitions, like World War I and II, lead to an increase in growth of the lower social strata, seemingly followed by an adjustment of the upper strata whose individuals even grew taller in response (Hermanussen et al., 2019). Over the past 130 years, such secular trends, which refer to increases in mean height relative to modern populations, have been observed in European populations (Hermanussen, 2013; Hochberg, 2011). The fact that even under the best environmental conditions, the schoolgirls of the historical affluent class do not reach the average height of modern children may be an expression of the community effect on height, which denotes the effect of social interaction between individuals of the same group (Bogin, 2021a; Hermanussen et al., 2021). People of the same community are similar in height, which means that people who are surrounded by tall people are also tall, while individuals surrounded by short people are short. Both mentioned phenomena are linked through size signaling status: tallness is associated with dominance and greater social power, making the affluent class the tallest, while the 'lower' classes are short, signaling subordination (Bogin, 2021a; Hermanussen and Scheffler, 2016). The children of the parents from the affluent class were aware of their status, knowing that they belong to the elite and were most likely treated as such by the lower social strata which in turn might have contributed to maintaining their height differences. The fact that the schoolgirls of the historical affluent class, even under good environmental conditions, do not reach the average height of modern children may be an expression of the aforementioned community effect.

A further point of interest is the normal distribution of weight in all three classes of the historical data, which stands in contrast to the modern references. In many current studies increasing weight and obesity are called a "pandemic phenomenon" (Kostovski et al., 2017). The current ideas of weight distribution that we consider 'normal' are already an expression of the existing 'obesity pandemic'. Our modern references are not 'normal'. Children of the historical affluent social class who had all the reasons and means to become as obese as modern children did not have skewed weight distributions. While some research explains the "obesity pandemic" purely with dietary changes (Baker and Friel, 2014; Delpeuch and Maire, 1997; Popkin, 2001), this does not fully answer the question why in the historical data all three social classes, and especially the affluent class, were normally distributed in weight.

Limitations and further study

Unfortunately, due to the nature of historical data, the sample size was relatively small and it only compared girls of two distinct age groups. While the results show a clear positive association between body height and weight with social status, it would be interesting to see if there is a difference when comparing final body height, for example. Additionally, finding and comparing other historical data from the same period would also be of interest in this context.

The normal distribution of weight is interesting and brings up a number of questions as well as starting points for future research.

Conclusion

The results of the present study show that the German historical data from 1914 correspond to current research and thus support the idea that socioeconomic status, and in this case especially the position in social hierarchy, has a biologically important effect on human growth. It also shows that about a hundred years ago, weight was, at least for the data set used, normally distributed, which is no longer the case in modern references.

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