RESEARCH PAPER

Sexual stature dimorphism as an indicator of living standards?

Kitae Sohn

Department of Economics, Konkuk University, Seoul, South Korea

Abstract

Background: A group of researchers has argued that sexual stature dimorphism (SSD) can serve as an indicator of living standards. This argument is based on evidence that boys' physical growth is more sensitive to environmental conditions than girls' physical growth. Because Korea's economic growth in the second half of the 20th century was unprecedentedly rapid, according to their logic, it is likely to see an increasing trend in SSD.

Aim: We aimed to determine whether SSD can serve as an accurate indicator of living standards for a population that would exhibit a pronounced trend in SSD, providing that the logic for use of SSD is correct.

Subjects and methods: We employed nationally representative Korean men born in 1941–1990 (n = 17,268) and women born in 1941–1991 (n = 22,543) and estimated mean heights by sex and birth years. We then calculated SSD values and charted the trend.

Results: Although male height increased faster than female height, the SSD trend was flat for the pooled observations and for sub-groups by socioeconomic status.

Conclusion: These results cast doubt on the argument for using SSD as an indicator of living standards.

Introduction

Although a consensus has not been reached on sex differences in environmental sensitivity during the growth period, evidence suggests that men are more sensitive (Cavelaars et al., 2000; Jantz & Jantz, 1999; Sohn, 2015a; Stinson, 1985). When applied to height, the evidence would suggest that under unfavourable conditions with respect to nutrition, disease burden and workload, boys' physical growth is negatively affected to a greater degree than girls' physical growth. A corollary is that, under favourable conditions, boys' physical growth would be positively affected to a greater degree than girls' physical growth. If nothing unusual intervenes, sexual stature dimorphism (SSD)—the height ratio between men and women in a population—would decrease under unfavourable conditions and increase under favourable conditions.

If this is true (this is a big if, as we showed below), SSD could serve as an indicator of living standards. Unfortunately, empirical evidence is not clear-cut. For example, Stini (1972) re-examined data from 41 European and 49 African populations and found that the mean male height exceeded the female mean height by 7–8% among Europeans, compared to a mode of 6–7% among Africans. Based on this minuscule difference, unlike Stini (1972), Tobias (1975) argued in favour of the usefulness of SSD as an indicator of living standards. Eveleth (1975) took the middle ground by saying, ‘There might be value in comparing sex dimorphism in a single population from one point in time to another as an indicator of nutritional improvement . . . but to assess this will require further investigation on other populations’ (p. 38). This advice motivated the current study.

Camara (2015) used self-reported height information collected from Spanish individuals born in 1910–1979 and aged 25–79 and estimated SSD values by 5-birth year intervals. His reason for examining individuals from Spain was as follows:

Having maintained a homogeneous ethnic background until recent times, Spain is an interesting case report due to its rapid process of socioeconomic modernisation during the 20th century, which has permitted cohorts with diverse life experiences to be surveyed by modern health surveys (p. 168).

His results showed no trend in SSD for the birth years 1910–1939, but an increase for the subsequent birth years. He asserted that the patterns were explained by the unfavourable conditions for the early period and the favourable conditions for the later period. Despite the long-term series of SSD
values, however, his values were also within a narrow range of 1.06–1.08. Because the trend was in such a narrow range, it is possible that the increase was a statistical artifact (roughly speaking, a false positive).

We investigated whether SSD is a useful index of living standards, using a more dramatic case than Spain: South Korea (henceforth, Korea). The Korean case is more dramatic because its economic growth is unprecedented. Rhee (2014) reported that the increase in Korean GDP per capita from 1953 to 2000 (14.9-times) was the greatest among 142 countries. Therefore, individuals in our data underwent more diverse life experiences than those considered by Camara (2015). If the logic about use of SSD is correct, we would see an increasing trend in SSD, at least faster than that of Camara (2015).

**Data and methods**

We analyzed the Korean National Health and Nutrition Examination Survey for all of the digitally available years: 1998, 2001, 2005 and 2007–2013. The Korean Ministry of Health and Welfare conducted the survey, using a stratified, multi-stage probability sampling design to select household units. The survey is nationally representative, covering non-institutionalised Korean civilians. This survey is not the only nationally representative source for height. The National Anthropometric Survey of Korea is a valuable alternative, and researchers have used it (e.g. Pak, 2004). However, the latest round of this alternative survey was conducted in 2010, while that of the survey used in this study was conducted in 2013. Although the difference of 3 years would not change the substance of our results, we chose our survey for its up-to-datedness.

Trained personnel measured height, thereby removing potential measurement error and bias inherent in self-reported heights. We restricted heights to 120–200 cm, because values outside this range were likely to be recording errors; the substance of the results remained the same without the restriction (not shown). We restricted ages to 20–60 to allow individuals to reach maximum heights (i.e. age 20) and to exclude survival bias (i.e. age 60). That is, if women are more likely to survive to old ages than men of the same birth years and women at old ages are weaker (and shorter) than men of the same birth years, SSD values are biased upward. However, slightly adjusting the minimum and maximum ages hardly affected our results (not shown). When we calculated sex-by-birth year mean heights, we used sampling weights to make it representative, but the results remained the same whether we applied them or not (not shown). Finally, we selected birth years for which at least 80 individuals were available for each sex to improve estimation precision; slightly changing the cut-off point did not change the substance of the results (not shown). The range of birth years was 1941–1990 for men \((n = 17, 268)\) and 1941–1991 for women \((n = 22, 543)\).

For height, we used these different ranges for each sex to fully exploit the data; for SSD, we used the overlapping years, namely, 1941–1990.

Selection stemming from war conscription was not a concern because even the oldest men in the data were too young to fight in the Korean War in 1950–1953. Nevertheless, assuming that boys’ physical growth is more sensitive to environmental conditions than girls’, one can consider two conflicting effects on SSD. If the harsh conditions weeded out sickly boys (who would have been short in adulthood) and only healthy boys survived, the SSD values for the cohorts would be higher than otherwise. On the other hand, if the conditions retarded the growth of surviving boys, the SSD values would be lower. \textit{A priori}, it is unknown which force is greater. If they cancelled each other, however, the SSD trend would be little affected by the war. In addition, the Korean population is homogeneous to the extent that only in 2010 did the birth register start providing parental citizenships (roughly the same as ethnicities). In that year, 94.4% of new babies were born to Korean mothers and Korean fathers and 0.5% of new babies to non-Korean mothers and non-Korean fathers. One can safely ignore any issues arising from mixing different ethnicities.

Because SSD trends have been discussed with living standards at the national level, we wish to limit our attention to the national population. Since this study is closely related to that of Camara (2015), however, we examined SSD trends by socioeconomic status (SES) in childhood. We followed him in using education as a proxy for SES, but we did not follow him in classifying observations by SES. Whereas he used one category of education for people born before 1950 and another for people born afterwards, we used a median education level by sex and birth year. The middle-upper SES group consisted of people with education at or above the median; the rest constituted the lower SES group. This classification more accurately reflected the continuous increases in education levels over time at different levels and speeds by sex. The discrete cut-off points used by Camara (2015) did not fit well with the continuity and sex differences. For each group, we considered birth years with at least 40 observations for each sex to improve estimation precision.

**Results and discussion**

Figure 1 shows three Korean trends in GDP per capita (thick solid line), age at menarche (thin solid line) and life expectancy at birth (dashed line) during the period of 1950–2010; the data for the 1940s are sketchy, so we omitted them. This period covers the growth period of people in the data. GDP per capita is expressed in 1990 international Geary-Khamis dollars and log scaled. The year for age at menarche refers to 10 years after the birth year. For instance, the age at menarche in 1950 concerns women born in 1940. We considered the 10-year lag since age at menarche reflects the childhood environment. We reversed the scale for age at menarche to ease comparisons with the other trends. We obtained data on GDP per capita from the Maddison-Project at http://www.ggdc.net/maddison/maddison-project/home.htm, 2013 version, on age at menarche from Sohn (2015b) and on life expectancy at birth from Clio Infra at https://www.clio-infra.eu/datasets/select/indicator/223.

Let’s first focus on the trend in GDP per capita. The trend clearly shows the spectacularly fast growth of the economy. It increased from GKS854 in 1950 to GKS21, 701 in 2010. Amsden (1989) provided an authoritative description of this phenomenon and it keeps attracting scholars in economic
growth (e.g. Acemoglu & Robinson, 2012, chs. 2, 3). If SSD can serve as a reasonable indicator of living standards, one would expect a similar upward trend in SSD. Figure 2 betrays this expectation, showing no notable trend in SSD. This is not because the Korean population is genetically idiosyncratic. The range of 1.069–1.092, with a mean and median of 1.08, is well within that typically observed across the world. To formally check whether the slope was different from zero, we regressed SSD on birth year, weighted by the number of observations for each birth year (weighting was inconsequential, not shown). The coefficient on birth year was 0.000051, with a \( p \) value of 0.276, indicating that the slope was essentially zero and the trend was statistically flat. We repeated this exercise by SES. Figure 3 presents the same flat trends, regardless of SES; in separate regressions, the coefficient on birth year was small and statistically non-significant for both groups.

One could assert that Koreans’ heights and other biological measures are not sensitive to environmental conditions. The upward trends in height for both sexes in Figure 4 demonstrate that this assertion is ill-founded. Not only the directions but also the slopes of the trends suggest that the degree of sensitivity is ‘just right’. When GDP per capita grew the fastest in the world, one would expect that height also grew the fastest in the world. When we regressed height on birth year by sex, weighted by the number of observations for each birth year (weighting was inconsequential, not shown), the coefficient on birth year indicated a 2.16 cm (95% CI: 2.03–2.29) per decade increase in height for men and 1.92 cm (95% CI: 1.81–2.02) per decade for women. The rates of increase in height are the fastest, compared to other populations over a period of at least 20 years (Hauspie et al., 1997; Malina, 1990). It is not that the ethnicity of Koreans somehow contains genetic factors for the recent growth spurt. Pak (2004) contrasted height trends for South and North Koreans and showed that only South Koreans exhibited the fast increase in height.
The faster growth rate for men is consistent with the argument that boys are more sensitive to environmental conditions than girls. One may presume that a faster male growth rate would result in an upward trend in SSD, since SSD is a ratio of male-to-female heights. This is not always true, however, because a sex difference in growth rate concerns absolute values, whereas SSD concerns relative values. For example, 2 over 1 is the same as 6 over 3, while the denominator increases by 2 and the numerator increases by 4. As Figures 2 and 4 demonstrate, a faster male growth can coincide with no trend in SSD, as long as the male growth rate is not too much greater than the female rate.

Improvement in living standards is further supported by two other biological indicators of living standards; namely, age at menarche and life expectancy at birth (Figure 1): age at menarche decreased from 16.46 years for women born in 1940 (1950 in the figure) to 13.04 years for women born in 1991 (2001 in the figure); life expectancy at birth increased from 47.9 years in 1950 to 80.6 years in 2010. Sohn (2015b) reported that the rate of decrease in age at menarche in the Korean population was the fastest ever known. Yang et al. (2010) described that the increase in life expectancy at birth for the Korean population was, too, the fastest at least among OECD countries. The three trends move in lockstep and all of the biological indicators, including height, tell the same story as that of GDP per capita.

These consistent changes in direction and speed stand in stark contrast to no change in SSD. The present study is not the only one to find an increasing trend in height but no trend in SSD. Gustafsson et al. (2007) reported the same patterns for 20th-century Sweden. Cross-sectional evidence also supports the present results. For example, Gustafsson and Lindenfors (2004) estimated no relationship between height and SSD among 124 human populations. Therefore, it is doubtful that SSD can serve as an indicator of living standards. The flat trend in SSD supports Stini’s (1972) argument that, under unfavourable conditions, men can compensate for slow growth by growing for a longer period.

In our case, this argument can be re-phrased as follows: under favourable conditions, men stop growing earlier. In either case, SSD values are expected to remain similar, whether the growth conditions are favourable or not. On the other hand, Tobias (1975) appeared to stretch the argument too far, as it was based on the small difference in SSD between European and African populations (7–8% vs 6–7%). The small difference is probably statistically non-significant, meaning that one cannot place much confidence in the difference; Gaulin and Boster (1985) supported this suspicion. Tobias’ justification was that men are less successful than women in coping with unfavourable conditions. This is not controversial by itself, but it entails contradictions when naively applied to SSD. If unfavourable conditions weed out weak men, who would have been short in adulthood, and ignite the male compensatory mechanism for the surviving men, SSD values do not necessarily decrease. Therefore, even if Tobias’s small difference were true, his justification is weak. We believe that this is why SSD is little related to important characteristics, such as polygyny (Gaulin & Boster, 1992; Gray & Wolfe, 1980; Holden & Mace, 1999), the amount of hunting and agriculture (Holden & Mace, 1999), latitude (Gustafsson & Lindenfors, 2009), low vs high dependence on agriculture and sexual division of labour (Wolfe & Gray, 1982), defying some well-known hypotheses or even rules in evolution. Wolfe and Gray (1982) reported SSD results even opposite to the related hypotheses, after comparing societies with no agriculture and agricultural societies.

We speculate that the increasing trend in SSD reported by Camara (2015) resulted from a statistical artifact. We do not say this to discredit his argument. Nor do we argue that our proposed reasons entirely account for his low SSD trend for the early period. We only suggest that the same result could be driven by reasons other than sexual difference in growth, so it is worth having a grain of salt when interpreting his results. It would be better if we could provide evidence to support our speculation, but that is not our focus. Nevertheless, future researchers using SSD may want to bear this point in mind.
In principle, SSD could provide more nuanced interpretations about the influence of socioeconomic processes on some aspects of living conditions because its direction may not coincide with the height trends separately observed by sex. For example, suppose that SSD values are relatively small for some cohorts while their height trends for both sexes are upwards. Then, one could suspect that their growth conditions were not as favourable and balanced as the height trends imply. In practice, one hardly observes this because of the small range of SSD values, the male compensatory mechanism and the greater male susceptibility to the growth environment. Even the extreme case of Korea failed to display it. Of course, this study concerns only one country for a certain period, so it would be hasty to claim that SSD is not an accurate indicator of living standards for other countries and other periods. However, researchers who wish to use SSD may want to remember that the SSD trend did not budge, even when the conditions were most likely to push them up.

Acknowledgements

This paper was supported by Konkuk University in 2015. I appreciate the two anonymous reviewers for their helpful and generous comments and suggestions.

Declaration of Interest

The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.

References


