

Measuring Gender Well-being with Biological Welfare Indicators

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1. Introduction

Measuring gender well-being for the period before the 20th century is a difficult task, given that quantitative information is often lacking. However, some studies have employed height as an indicator for measuring biological welfare in general and gender differences in welfare in specific (to mention a few examples: Nicholas and Oxley 1993; Johnson and Nicholas 1995; Harris 1998A; Horrell et al.1998; Baten and Murray 2000). We review these research papers and some others that applied gender differences in height as a proxy of net nutritional status, and health. Moreover, we will review previous research has studied the gender inequalities during the Middle Ages, the early modern period that includes the ‘witch hunting’ period, the early industrial revolution in Britain, as well as still agricultural societies in other countries such as Bavaria and Ireland in the 19th century. In addition, modern

societies at the transition from socialism to market economy were also considered for this overview.

Our review considers the quantitative evidence regarding gender-specific well-being. In the following section we discuss gender dimorphism and gender differences in height, reviewing the biological literature on the topic. In the third section we argue that gender difference in stature is not a simple biological mechanism. In the fourth and fifth sections we report the studies on the impact of economic factors on gender differences in height and recent archaeological findings about male and female stature during the Middle ages and the early modern period. We will then discuss the problems and advantages of these methods by reviewing the literature that applied them for studying the welfare of the eighteenth and nineteenth centuries. Gender inequality in the transition period from socialism to market economy during the 20th century is discussed in the section seven and we conclude with plans for future research in section eight. In this paper we use archaeological data of Koepke and Baten (2005) and Baten and Murray's southern Germany data (2000) to support our discussion.

2. Human stature and **gender dimorphism**

The average height of a larger population group is mostly influenced by the quality and quantity of nutrition, and the disease environment. Many economic historians used height as a measure of net nutrition and living standards (Fogel et al. 1983; Komlos 1985; Steckel 1995; Floud and Harris 1997; Steckel and Floud 1997; Baten 2000A). This literature argued that it could be useful to supplement the conventional indicators of well-being, such as GDP per capita, with other welfare measures, especially anthropometric indicators. In particular, anthropometric indicators have been successfully implemented to analyse living standards in historical and pre-historical periods (Koepke and Baten 2005). Moreover, research teams at the World Health Organization suggest measures of height as principal index of nutritional status for both males and females even today (WHO Working Group 1986).

Average heights were proved to be a successful proxy of economic welfare as heights are sensitive to nutritional status and health care. Historical data on mean stature was used to trace the trends and levels of well-being in a population. However, only in the recent years, stature has been accepted as an indicator for measuring gender differences in the biological well-being of population.

The final size a child attains as an adult is the result of a continuous complex interaction between genetic and environmental factors during the growth period (Eveleth and Tanner 1976). According to them, two genotypes that could produce the same adult height under optimal environmental circumstances produce different heights under circumstances of deprivation. Thus, two children that would be taller in a well-off community may be shorter under poor economic conditions. Moreover, one might be significantly smaller than the other due to non-additivity of genotype and environmental factors. A child's development may be stunted due to lack of environmental stimulus -- that is essential for child's growth -- during 'sensitive periods'. During illness, a child's growth may slow down and in case of availability of better nutrition this slowdown is followed by a catch up. However, this catch up less often occurs among girls if there is bias against girls in terms of allocation of food and health care.

At which ages is the influence on final adult heights strongest? The use of anthropometric indicators for measuring nutrition rests on a well-defined pattern of human growth between childhood and maturity that reflects the interaction of genetic, environmental, and socioeconomic factors. The average annual increase in height is greatest during infancy, falls sharply up to age three, and then falls more slowly during the remaining pre-adolescent years, except for the teenage growth spurt (Fogel et al. 1983). Baten (2000A) found that environmental conditions during the first three years plays an important role in determining adult height compared to later part of the growth period. In contrast, the height of still growing children and young adults is also strongly influenced in the one or two years preceding the measurement of height. For those still growing persons, catch-up growth

normally wipes out temporary influences until final adult height is attained. Thus, height data can be extended to study differences in the quality of net nutritional status and health care during early childhood between males and females.

The term gender dimorphism in stature¹ (also known as Sexual Size Dimorphism by biologists and anthropologists) is used to describe the difference between male and female stature. Gender dimorphism is calculated in most of the studies as the absolute difference between male and female adult height (GD1). However some recent studies used the ratio between male and female stature (GD2). In this study gender dimorphism (figure 2) was calculated as the difference between the mean heights of the genders expressed as a percentage of male height.

$$GD1 = \text{maleheight} - \text{femaleheight}$$

$$GD2 = \frac{\text{maleheight} - \text{femaleheight}}{\text{maleheight}} \times 100$$

3. Gender dimorphism: Does it reflect gender inequality, female-robustness or default biological mechanism?

Biologically men and women have differences in the nature of growth, final adult size and behavior. Males tend to have a larger stature, more robust cranial and facial features, along with greater muscularity and strength (Fruyer and Wolpoff 1985). However, apart from these biological differences between men and women, other determinants like nutrition, health care, and disease might play an important role in determining stature differences between men and women. For example neglect of girl children in diet and immunisation against disease can

¹ Gender dimorphism in the formula is expressed as GD

create many hurdles for girls to attain their growth potential. If boys compared to girls are provided with better nutrition and medical facilities, then girl children will have a severe negative impact on their tempo of growth. In this context, how to really segregate socially induced gender inequality from biological stature differences?

Some biological studies emphasized a decrease in male-female height differences under conditions of nutritional stress (Wolanski and Kasprzak 1976; Gray and Wolfe 1980; Brauer 1982; Lieberman 1982; Stini 1985). According to these studies, dimorphism increases with the improvement in nutritional status. Based on these findings and their biological theorizing, they hypothesized that women are more 'resilient' during crisis periods. They argued that males are more susceptible to fluctuations in nutritional quality and show greater impairment in long bone growth compared to females facing the similar food crisis (Clutton-Brock and Harvey 1984). So a long term nutritional shortage would not only mean a reduced adult height size in both sexes and but also more impact on men. In this case, it is not possible to use height as an indicator in measuring gender inequality as crisis would mean lower gender dimorphism. However, we reject the argument of Clutton-Brock and Harvey in the later stages of the paper and argue for the use of gender dimorphism in studying gender inequality.

The female robustness argument based on the above studies suffers from lack of good data. The sample sizes of all the studies that studied sexual dimorphism are too small to be reliable. This concern is especially applicable to the studies for prehistoric periods covering North America (Hamilton 1982), Mexico (Nickens 1976), Europe (Frayner 1984), India (Kennedy 1984), China, and Southeast Asia (Brace et al. 1984). All these above mentioned studies mostly focus on prehistoric time periods and have small sample sizes.

Apart from the robustness hypothesis, the argument that the sexual dimorphism is a function of stature questions the use of gender dimorphism for studying gender inequality welfare. Some biologists argue that sexual size dimorphism is positively correlated with height (for example, Brace et al. 1984). This positive relation between height and dimorphism

implies that increasing height of males and females in general will see increase in stature difference between males and females. However, recent research does not support this hypothesis. For example, Moradi and Guntupalli (Forthcoming) found that the mean stature of both females and males increased with food supply generally at the same rate. Their research on the Indian population between the 1930s and 1970s does not support the hypothesis of increasing dimorphism with increasing stature. They also showed that during the food crisis period in the states of Kerala and Orissa, an increase in gender dimorphism was observed pointing to a rise in gender discrimination. Recently, Guntupalli (2007) using Indian disasters data from 1950-1975 confirmed that gender dimorphism increased during natural disasters rejecting the female resiliency robustness argument for India. Moreover, her result that Indians in South Africa had higher dimorphism compared to Africans and European South-Africans due to Indian cultural preference for male children supports the use of dimorphism indicators for studying welfare differences by gender.

Clearly, it is important to review the biological literature on this question. Recent biological research also rejects the argument that dimorphism is a function of height. Gray and Wolfe (1982) pointed out that dimorphism increases with increasing mean height. However, Gaulin and Boster (1985) have criticized that the findings of Gray and Wolfe are not reliable due to their small sample size. Recently, Gustafsson and Lindenfors (2004) tested if populations with larger stature were exhibiting more dimorphism using adult male and female data that are above 19 years from 124 population groups from the later part of the 20th century. They rejected the hypothesis of increasing dimorphism with increasing stature in humans using phylogenetic methods to correct for errors arising as a consequence of populations sharing a common ancestry. Phylogeny is the evolutionary history of a group of organisms and the modern phylogenetic investigations are based on molecular data, primarily nucleotide sequences. Basically, the more closely related two organisms are the more genes

they will have in common. Hence, Gustafsson and Lindenfors controlled for genetic ancestry to compare evolutionary dimorphism.

What were the explanations given by biologists about gender dimorphism? Holden and Mace (1999) tried to relate sexual division of labour and gender dimorphism by observing 76 aboriginal populations. By comparing gender gap in stature and sexual division of labour data from the 'Ethnographic Atlas', they concluded that sexual dimorphism in stature is negatively correlated with women's labour force participation. They argued that this negative association stems from sex-biased parental investment. Development economists, demographers and economic historians have frequently used relative indicators like mortality and height ratios to study gender inequality either in the pre 1950 developed countries or the recent developing countries and made similar arguments (Dyson and Moore 1983; Nicholas and Oxley 1993; Klasen 1998; Horrell and Oxley 1999; Boix and Rosenbluth 2004; Guntupalli 2007).

In sum, based on the evidence we have collected from previous research we conclude that there is not enough evidence to support the argument that dimorphism is a function of height (Holden and Mace 1999; Gustafsson and Lindenfors 2004; Guntupalli 2007; Moradi and Guntupalli forthcoming). However, more biological research is required to reject concretely the female resiliency argument. Besides, we can argue that reduction in female heights relative to male heights despite of existence of female resiliency is observable, simply because female discrimination is so severe that it outweighs the resiliency effect. Hence, female resiliency hypothesis supporters can still use gender dimorphism to study inequality by assuming that if women's height declines, this might even imply a stronger downturn of food intake and health care. We should mention the caveat that for the recent period, food consumption behaviour patterns are complicated to measure at higher income levels. For example, teenage girls in rich societies might consume less food in order to be slim to achieve the standard set by fashion industry. However, in the historical period food and health

resources were scarce goods, and there were gender-related allocation conflicts within the households.

4. Gender dimorphism from economic perspective

What views from economic theoretical perspective can be applied to the study of gender dimorphism? Apart from the biological stature difference between men and women, some other determinants like changing agricultural patterns play an important role. For example, before the 20th century in Europe and some other world regions, women were more often specialized in cattle farming and garden work, increasing their ‘advantage of proximity’ to milk and vegetables. In contrast, grain cultivation requires more male upper-body strength than herding cattle; hence a grain-oriented society might distribute more nutrition and health resources to male offspring. When agricultural patterns changed in the 18th and 19th centuries in Europe, for example, from cattle farming towards grain-based agriculture, we find declining trend in women’s height as Klasen (1998) argued assessing relative mortality. In grain based agriculture men play an important role and this devaluation of women’s labor by shifting from cattle farming to grain-based agriculture reduces relative female welfare. But those ‘rational’ distribution patterns are not that simple to study. Ogilvie (2004) argued, for example, that while this sounds plausible, in early modern Germany almost all occupations in which males had seemingly rational brawn advantages, there were also active women. Moreover, they were actually actively excluded from those occupations not because they were unsuccessful, but because male competitors succeeded in creating institutions (guilds etc.) to exclude them and limit their activity.

Apart from agricultural specialization, the expected income of girls which determines the relative parental investment in their female offspring could also be influenced by other labour market relations, such as the relative efficiency of female labour in factories, for example, or a labour market for female domestic services. In other words, parents develop a specific income expectation of their male and female children later in life. The later income of

their children will likely help them after retirement. Hence if women are likely to obtain substantial own income later-on, girls receive more resources early in life in order to increase their survival probability.

The relative mobility of marriage partners might also play a role. In this context, “mobility” is defined as the mobility to leave the partner and the family. Boix and Rosenbluth (2004) have argued that male brawn that can be used for grain production is a relatively mobile factor, whereas female specialization in child-rearing is an immobile, family-specific investment. Given that most societies have the traditional division of labour with women performing more of child-rearing, males have a better bargaining position by threatening to run away. Boix and Rosenbluth illustrated this with the empirical fact that in hunter gatherer societies, dimorphism tends to be relatively small. When these hunter and gatherer societies switched to sedentary lifestyle and grain cultivation, male brawn became relative more important for the grain harvest, and female gathering skills lost their importance. Hence the male bargaining position increased, and dimorphism grew.

Other than the biological and economic factors, disease and cultural factors can also play an important role in deciding welfare differences between genders. The relative exposure of women to disease also can play an important role in differential welfare of males and females. For example, if girls are kept isolated in a household, their infection risk might be lower, in spite of the otherwise deleterious effects. On the other hand, if they have to perform unhealthy tasks in the household or if cultural norms dictated unhealthy behaviour, their disease exposure might be higher. Nevertheless, it is difficult to measure exposure to disease. Culturally determined discrimination patterns play an important role and this was especially proved in case of some Asian countries like India and China. For example, Das Gupta (1993) argued that the relation between discrimination against girls and available resources has an inverse relation where acute scarcity results in gender bias. In other words, bad periods are particularly problematic for women, whereas with improving overall welfare, the

discrimination might decline somewhat ('better times are better for women in particular'). We can test this hypothesis with our historical data. In sum, the economic views on dimorphism focused on mobility-based bargaining patterns, agricultural specializations and other labour market factors that influence the expected revenue from female labour unlike biological theories.

5. Were the Middle Ages good for 'wise women', and the Early Modern 'witch hunting period' a transition to a more male-dominated society?

A relative new area of study has focused on male and female heights using human bones from archaeological excavations. Koepke and Baten (2005) have employed almost 10,000 height estimates from more than 300 sites all over Europe to estimate human stature by century, region, and gender. A large amount of their study focuses on strategies of minimizing measurement error, hence in this study we will not repeat those issues again, but refer the reader to the original Koepke and Baten's study.

What can we learn from archaeological study of bones about gender inequality? The most important aspect is probably the strongly changing distribution of biological welfare between the Middle Ages and Renaissance (Figure 1). Koepke and Baten (2005) found that the Dark Ages were really dark for women, whereas the Renaissance brought redistribution in favour of women. To be more specific, especially women in the 10th to 12th, and 14th centuries were particularly short in relation to men, whereas the 15th and 16th century women were actually quite tall. While the increase in female heights during the 15th century is supported by only small sample (18 observations), the positive trend of the 16th century relies on 118 cases, compared with much larger samples for male heights. However, 118 cases do not constitute a large sample and we need to check whether there were obvious regional or social biases which might have made those women look relatively taller than the average European women during this period. Fortunately, most women were from the Southern Rhine region in central

Europe (177), hence they came from a European region that had average height. In terms of social selectivity, they were of similar social origin as the males of those centuries (overwhelmingly of low or unknown status, as opposed to middle or upper social status). We conclude that women had better relative anthropometric values during the Renaissance period, compared with the Middle Ages. This stands clearly in contrast to the view in much of the historical gender literature that ‘wise women’ could have had a stronger position during the Middle-ages, before the start of ‘witch hunting period’ in the 15th century in order to increase male dominance.

[Insert figure 1 here]

6. Gender dimorphism during the 18th and 19th centuries

The economic historiography of relative heights mainly relies on prisoner records of female heights. The gender histories of England, Scotland and Ireland were the first studied with this type of source (Johnson and Nicholas 1995; Nicholas and Oxley 1993; Oxley 2004). A similar data set is available for Southern Germany (Baten 2000B; Baten and Murray 2000). Though doubts were raised about prisoners’ data – were they representative of the general population? -- , we argue that they provide some insights when dealt with caution. Also, it is difficult to locate records other than prisoners’ data for studying gender differences in welfare for the 18th and 19th centuries.

Using data on heights of English and Irish women and men that were transported to New South Wales, Stephen Nicholas and Deborah Oxley (1993) found that English rural women suffered the most – depicted by decline in stature – compared to urban and rural men, and urban women during 1800-1815 confirming the differential impact of industrialization on English women’s living standard. Declining labour market opportunities for women was one of the reasons for the differential welfare. Interestingly, during the same period the height of

Irish women increased – along with the height of men – suggesting that pre-famine Irish living standards were better compared to the famine period.

We argue that the increasing specialisation of some Irish regions on butter production for the English market could have caused this relatively positive development – after the fat had been removed, the remaining low-fat milk was a high quality food that could not be transported to urban or English consumers with high purchasing power. Hence the consumption of the low fat milk by the locals at very low cost improved their stature. This cross-sectional result of better Irish net nutrition is confirmed by Mokyr and O’Grada (1994) and can be explained by proximity effects to Irish milk (on this effect, see Baten and Murray 2000). Ireland had traditionally one of the highest cattle per capita ratios in Europe. This effect increased also the relative quality of female nutrition, as females had often more direct access to this perishable product. The ‘proximity-and-equality effect’ of local low-fat milk abundance is also visible in the more favourable mortality statistics of the English West Coast and North England (Klasen et al. 2005).

Johnson and Nicholas (1995) argued that both males and females born between the early 1820s and the mid 1850s in the UK suffered from nutritional stress. They found that men in England before 1850 suffered a major food, environment insult and the female height decline and its timing parallels that for men. However, the decrease in female criminal heights in 1820’s and in the 1850’s is greater than that for men. This reflects the differential impact of disease, work, and inter-household allocation during the mid-19th century crisis.

According to Horrell and Oxley (1999), gender bias in the treatment of children is expected to occur in the regions where there are few opportunities for women to work, especially at low income levels. They found that greater availability of work for children of one sex does not show in their well-being. For example, in the textile industry provided opportunities for female employment, whereas in metal manufacturing male labour dominated. In both industries, boys received more food than girls. They conclude

– based on other evidence – that a child’s well-being is decided by the expected economic returns: both the likelihood of a child being employed and the length of time for which parents might expect to be the recipients of the earning, as evaluated by the parents. The removal of employment opportunities for girls had deleterious consequences on the welfare of females.

The British studies found a height decline for both genders in the 1830s and 1840s. However, Coll and Komlos (1998) found a slightly earlier decline of female heights by comparing all the European studies. This is especially true in the study on Southern Germany (Baten and Murray 2000) and using this Southern Germany data, we study the gender dimorphism. We took neither the ratio of male and female heights nor the absolute difference between male and female heights. We have calculated gender dimorphism as the difference between the mean heights of the genders expressed as a percentage of male height.

We found that in Southern Germany, heights of men and women were less correlated compared to British Isles. The height dimorphism was relatively high in the early period right until the famine years of mid-century (Figure 2). However, gender dimorphism declined in the late 1850s and 1860s when the general situation improved, indicating that ‘better times are better for women’, quite opposed to the resiliency hypothesis.

[Insert figure 2 here]

7. Gender differences in the transition period from socialism to market economy in the 20th century

For the early 20th century, Bernard Harris will give a more detailed and well-informed review than we could do here (see also Harris 1994; Harris 1998B). For the late 20th century in contrast, anthropometric dimorphism has not yet been studied very well, partly because changing food habits could play a role in this period. However, one promising area of

research is the transition period from socialism to market economies between the 1980s and 1990s. Even if socialist countries were unsuccessful in providing a sufficient average standard of living (and political freedom), they promoted women's work and extended child care, which might have resulted in more gender equality. The hypothesis would be that gender inequality should have been lower in socialist countries, and increased during the transition phase towards market economies.

Komlos and Kriwy (2003) found, that gender differences were slightly smaller in the GDR compared both with Western Germany, and with East Germany after reunification. After reunification, the heights of male children and even military conscripts in the East converged rapidly towards the higher Western level (Hermanussen 1995; Hermanussen 1997; Komlos and Kriwy 2003), although the exact dimension of the previous gap is still debated (Greil 1998). Female heights appear to have converged less than male heights (Komlos and Kriwy 2003). Komlos and Kriwy (2003) note that male heights in Brandenburg improved more during and after reunification, as was the case in other areas of Eastern Germany (see also Schilitz 2001; Kromeyer et al. 1997). Zellner et al. (2004) postulate that the height of 7-year-old girls in Jena was 124.5 cm in 2001, whereas boys were 126.4 cm tall (Jena is situated in the *Land* of Thuringen, south-west of Berlin and Brandenburg). Also, heights in Kazakhstan – one of the former Soviet republics in Central Asia – have been stagnating or declining, with the height of girls developing even worse than boys' height due to religiously-induced discrimination in the labour market (Dangour 2003).

Further light is shed on this unresolved puzzle by the development of mortality rates in the years following German unification. Available data suggest that mortality rates deteriorated in Eastern Germany during this period, although mainly for those in the middle age groups around age 40. Eberstadt, and Riphahn and Zimmermann studied the determinants of this surprising demographic development (Eberstadt 1993; Riphahn and Zimmermann; 1997). They found that certain gender-specific age groups were most at risk. In general,

female mortality decreased in Eastern Germany after unification; only women in the age-group 35-45 experienced some increase in mortality between 1989 and 1991. Eastern German men in this 35-45 age-group also saw an increase in mortality. In the first few years after unification, younger Eastern German males also experienced increased mortality, but their death rates moved back to normal values relatively fast. By contrast, as late as 1994 Eastern German males around age 40 still had mortality rates 10-20 per cent higher than before unification.

One may speculate that younger people adjusted more easily to the new situation, while men of 35-45 years are typically in a life phase in which they want to apply the knowledge they have obtained up to that point. Not being able to do so and instead being faced with uncertainty and often unemployment, it seems likely that they experienced strong psycho-social stress. Riphahn and Zimmermann conclude that the increased mortality rates among Eastern German men of this age-group were mostly caused by over-consumption of alcohol and by circulatory and cardio-vascular problems which were also related to psycho-social stress (Riphahn and Zimmermann 1997).

It is interesting that women were much less sensitive to this development, even though they were the main victims of the high unemployment which emerged in Eastern Germany after unification. Only middle-aged women in Eastern Germany saw some increase in their mortality rates after unification. For Eastern German women as a whole, by contrast, life expectancy improved considerably, mostly because of falling mortality risks for elderly women and, to a lesser extent, for very young females. We interviewed a small sample of Eastern German individuals after unification who suggested that men suffered more than women from the psycho-social stress of unemployment, because – in accordance with traditional gender roles – males felt more loss in social status from losing their jobs.

For the period after 1994, Baten and Boehm (2008) argued also for the land of Brandenburg (East Germany) that boys of age 6 were taller than girls, which is not normally

the case in the age range between birth and the teenage growth spurt. In fact, none of the available growth reference charts for the U.S. and European countries suggests a height advantage for boys of this age (see <http://www.cdc.gov/growthcharts/>).

For the late 20th century, there are also some studies on Less Developed Countries and middle income countries. Conducting a worldwide comparison, Guntupalli and Schwekendiek (2006) investigate male and female malnutrition rates of children living in 117 countries at the end of the millennium (1995-2001). They found that a reduction of fertility rates and improvement in GDP lowers the malnutrition rates significantly for both male and female children. The Asian continent showed the highest female discrimination compared to the rest of the world.

8. Measuring gender differences in well-being: discussion

In all populations, mean male stature is greater than female stature. However, the interesting parameter is the size of stature differences between different populations and especially over time. We would argue that gender differences in stature can be used to answer some important questions: Which societies discriminate females more than others? Which effect does relative female labour participation have? Does the dimorphism increase or decrease during famine and crisis periods?

However, the current available anthropometric data are not sufficient to answer these questions in a systematic way. More countries need to be documented, for example for the 19th and perhaps early 20th centuries: all of Eastern, Southern, and Northern Europe is missing, within central Europe only Bavarian data is available. For Western Europe, the situation is somewhat better with existing studies on England, Scotland, and Ireland, and research on the Netherlands and Switzerland is currently proceeding. However, even within Western Europe, France and Belgium are clearly missing. It is likely that prison records of female and male convicts have survived as they did in other countries. Even for countries

such as Mexico, Brazil, and Argentina prison records have survived in the archives, hence we can expect the same from the ‘white spot on the map’ countries in Europe mentioned above.

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