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#### Height and well-being in Sub-Saharan Africa

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# Height and well-being in Sub-Saharan Africa

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## I. Introduction

Height is a multidimensional factor in a person's life and cognitively promotes well-being. Although the literature has addressed several aspects of well-being, its relationship with height is still a subject rarely touched by scientists. However, Vincenzo and Mari (2011) examined the effect of height on well-being through a survey and found that there is a correlation between a human's height and his or her socioeconomic and health conditions. Thus, this analysis on the African continent remains a subject of interest because the relationship between height and well-being remains a hot topic in the economic and health literature. It is with this in mind that it will be briefly approached in this paper which a focus on Sub-Saharan Africa.

This paper is structured as a literature review. The intention is to present the research done to date on the relationship between height and well-being in Sub-Saharan Africa. It will highlight the elements that contribute to adult height. It will also explain the different factors that could prevent an adult from reaching the height predetermined by their genetic code. These factors can be listed as follows: child health, environment, nutrition, inequality, income, morbidity and gender.

Many development economists have recently discussed the use of height as a measure of well-being, particularly when other economic indicators such as GDP per capita or morbidity and mortality data are not available (Deaton, 2007). For Sub-Saharan Africa, in the absence of income data, height is a valuable indicator for measuring the well-being of the region's population. Using height as a measure may have its limitations, but it has proven useful because of its ease of access and can reflect the overall health and well-being of a society. Data on human height are more readily available in the African context than other reliable socioeconomic information (Joerg Baten, 2021).

Genetics aside, research has established that the most critical stage of childhood for determining adult height is the age of two to three years (Bozzoli, 2007).

For Sub-Saharan Africa, little research has focused on the relationship between height and well-being and its overall impact on economic growth. In the course of my research, I have found that this topic is widely discussed on other continents, but very little to date on Sub-Saharan Africa. Thus, in order to approach this study in depth, we took a look at previous studies that provide the anchor for this topic.

The main purpose of this paper is to discuss in general terms what height data can tell us about well-being in Sub-Saharan Africa. In theory, have we learned from height studies about the evolution of well-being in Sub-Saharan Africa? To answer this research question, three specific questions will allow us to clear up the grey areas about the topic.

- 1) *Why and how can height be a measure of well-being in Sub-Saharan Africa?*
- 2) *How is height inequality determined in Sub-Saharan Africa and does gender affect nutritional status in childhood and therefore height in adulthood?*
- 3) *Historically, how have heights evolved and how have they affected well-being in sub-Saharan Africa?*

This study will successively address three chapters in the context. First, it will explain the measurement of height by well-being through health and income (section 1). Then, a second part will examine this relationship based on inequality and gender (section 2). Finally, the third section will provide an overview of the long-term trends of heights in Sub-Saharan Africa (section 3).

## II. Health and Income

On the research on health and income being related to height, in particular as a measure of well-being, there has been some analyses arguing its potency and limitations. This section of this paper will focus on the reasons why health and income could be used as measures of well-being in Sub-Saharan Africa.

On the grounds that nutrition, health, and the economic environment and other indicators are associated to wellbeing (Perkins, 2016), this section of the paper will discuss their overall connection with height in the context of Sub-Saharan Africa.

***Determinant of height and the usefulness of its use.*** In historical work, height has been a valuable indicator of health due to its ease of availability when data is lacking on morbidity or mortality (Deaton, 2007). Height can be a good proxy to measure the standard of living of an individual when lacking information on income per capita (Weil, 2007) and can be used as an indicator of health status in modern societies (Yoko Akachi, 2010) in addition to life expectancy, ability to work and provide cognitive capabilities (Weil, 2007). To assess general population health and development, adult height may be a better measurement than some typical measures, such as child mortality.

According to several authors, the main height determinants for height are nutrition, disease environment, and to some degree, labor intensity (Yoko Akachi, 2010). Moreover, height is determined by genetic likelihood and by net nutrition, typically in early childhood (Deaton, 2007).

Indeed, the main height determinants were described here above, but there also are many *proximate* socioeconomic determinants of height: those determinants can be income, inequality,

public health (including water and sanitation), healthcare access, hygiene, health technologies, labor organizations, cultural values, and food prices (Yoko Akachi, 2010).

**Genetics.** Another aspect that could determine heights are genetics. It influences the height of a person and can be manifested through the difference of individual heights in a group of people that were raised in similar conditions (Moradi, 2010). Weil reminds readers that Steckel (1995) had argued on how genetics could affect differences in average heights and may be due to environmental factors (Weil, 2007). A twin study explained how genetic factors linked adult height and intelligence (cognitive aptitude). The results of the study showed that the taller twin was better educated and earned more money (Perkins, 2016).

**Nutrition.** The assumption exists and is perceived on the idea that adult heights is dependent of good nutrition and health conditions in infancy and in adolescence (Akachi, 2007) (Yoko Akachi, 2010). Research has shown how better nutrition (Weil, 2007) and a higher consumption of protein intake across developing countries contribute to improved heights (Yoko Akachi, 2010). Other indicators such as wages or IQ are also relevant for tall stature. Not only does better nutrition has a positive effect on height, it also contributes to school completion and intelligence (Weil, 2007).

Net nutrition is defined as the difference between food intake and the losses to activities and to diseases (Deaton, 2007). Nutritional needs and food intake determine overall nutritional status (Moradi, 2010). Therefore, nutrition can be considered as a partial indicator of the health component of well-being (Deaton, 2007). Nutritional intake and losses over time, in particular during the growth periods determine adult height (Perkins, 2016). Moreover, Moradi explained how a decrease in height may show an extended period of problematic nutritional circumstances and that stagnating heights could be perceived as an indication of nutritional problems (Moradi, 2010). Nutrition is the most significant exogenous factor impacting growth and growth delays is often a sign of a limited supply of nutrition. Nutrition distresses growth more in the postnatal period than in the prenatal period. A study from the Gambia showed no difference in late adolescent height following supplementary maternal feeding during pregnancy and maternal supplementation during lactation (Perkins, 2016).

As one knows, dietary consumption depends on food availability. Proper nutrition is beneficial in the reduction of child mortality and supports increase in heights, health improvement and human capital for future adults (Yoko Akachi, 2010).



**Health environment.** The environment (health) of a child in infancy is essential in determining his or her adult height. This is emphasized by nutrition intake and accessibility and being disposed to diseases. Adequate nutrition and health lead to welfare due to their positive contribution in reducing child mortality, as it has been mentioned that childhood status contribute to adult height.

Parental social class, deprived socioeconomic conditions and maternal education are all elements that can provide an understanding of adult height. These elements characterize access to resources, exposure to risk factors, and health actions of the mother (Perkins, 2016). Numerous scientists as well as the World Health Organization have come to the conclusion that environmental condition is a key explanation for height differences globally (Moradi, 2010).

**Child mortality.** In Africa, child mortality is positively associated with heights (Deaton, 2007) but the risk of mortality has been shown to increase with decreasing height (Perkins, 2016). Sub-Saharan Africa has experienced a lower reduction in infant mortality than the rest of the world, and slightly increased underweight prevalence, on average, while all other regions saw improvements (Akachi, 2007). Global health, considered in mortality rates, explain the correlation between adult height and adult mortality, as demonstrated by Fogel (1994) (Weil, 2007).

In their research, Akachi and Canning (2007) concentrate on the proximate determinants of height and describe adult height by the child mortality rate, GDP per head, and the intake of protein and calories during infancy (Akachi, 2007).

Alter (2004) believed that food consumption and disease environment were two variables affecting height and infant mortality (Yoko Akachi, 2010). While child mortality has its limitations in studies, it has been recognized to be the best proxy for the disease environment (Moradi, 2010). As there have been observations in deviating trends in infant mortality and adult height in Sub-Saharan Africa, the effect of a decline in child mortality could lead to more short children surviving (short due to nutrition aspects) and hence lower average heights (Yoko Akachi, 2010) which should be a cautionary measure in interpreting height trends.

**Health.** Adult height has been shown to be a useful measurement to establish the connection between height and health outcomes. Adult height could potentially explain population health over time through nutrition. Lack of adequate nutrition contribute to illnesses which affect growth (Perkins, 2016) while illnesses prevent the immersion of nutrients and indisposes children's bodily growth (Yoko Akachi, 2010).

When tracked over an adequate period of time, average adult height can be a valuable element that could display the evolution, or lack thereof, in health, well-being, and also socioeconomic inequalities in populations (Perkins, 2016).

As health is being discussed in relation to height, further research has shown that taller people smoke less, have lower blood pressure, and better diets. For tall women, they are shown to display more worry, and both genders are also more likely to report stress and anger. In general, taller individuals consistently report better health and less diseases and better results on numerous welfare measures, including enjoyment, happiness, sadness, physical pain, and social activity (Perkins, 2016). This research demonstrates the positive relationship with taller stature and better health. Consequently, the fact of being tall may contribute to overall well-being in terms of physical and mental health as well.

In addition, there has been research demonstrating the positive correlation between adult height and numerous cancers such malignancies of the colorectum, breast, head and neck, ovaries, skin, endometrium, central nervous system, blood, liver, thyroid, brain (gliomas), and lymphatic system. On the other hand, being tall could shield from neoplasms of stomach, esophagus, and mouth, but these results have been inconsistent. Modern adult height could provide an important opportunity to comprehend improvements in population health, nutrition, and development over time (Perkins, 2016).

**Income.** Adult height is strongly related with both higher income and higher level of education in modern societies and can interpret economic productivity, taller individuals have higher incomes (Perkins, 2016), are more likely to be in the job market and are physically more capable of work or alternatively, because height is an indicator of higher cognitive reach (Deaton, 2007). There are strong positive correlations between adult height and household wealth and education across many countries (Perkins, 2016) as well as income/salaries (Yoko Akachi, 2010).

Income is unquestionably associated with health as represented by indicators such as child mortality rates and life expectancy. Africa being the exception, as women are tall relative to their national incomes, there is at least an interregional connection between height and income. As incomes have increased over time, so have heights (Deaton, 2007). A different point of view comes from Moradi's research where he states that there is no connection between heights and income in the sample of Sub-Saharan that he studied in his research. An example highlighted are the case of Burkina Faso and Mali, two countries with very low per capita income rates, but the average heights in these countries could indicate that nutrition may not have been meager. Height corresponds to enhanced social and economic development and therefore impacts current and future population health and welfare (Moradi, 2010). Conditional

on income, which has the expected positive effect, children in countries with the highest disease burden turned into the tallest adult women (Deaton, 2007).

***Contribution to adult heights.*** There are two essential growth periods in an individual's lifespan: the first occurs during early childhood and the catch-up growth could vary. The first growth period in early childhood mostly determines adult height if nutrition is adequate and the second growth can contribute to catch-up growth. Both Perkins et al. and Moradi explain that adolescence being catch-up growth period might not be adequate enough to compensate for the deficits held in early stages of life in terms of nutrition (Moradi, 2010) to attain full growth potential (Perkins, 2016).

The health environment in childhood may be the most crucial determinant of adult height, assuming that the population is stable (Weil, 2007) instead of income per capita (Deaton, 2007).

***Discussion.*** Deaton elaborates on the fact that tall people live longer, and living long would be ascribed to well-being. Another point that may explain the global differences in height is the possibility that income per capita is not representative of the indication of nutrition. Africa is vast relatively to its population and nutrition could be relatively abundant for the population although people may struggle to feed themselves due to low incomes. In light of this, one may wonder that could determine this variation in heights at the global level and a possible idea may be that income per capita is not a good measure of nutrition (Deaton, 2007).

Deaton's point of view on adult heights in Sub-Saharan Africa relate to the fact that the indicators 'income per capita' and 'illnesses in childhood' should not be considered as determinants of adult heights (Deaton, 2007). Deaton states several times how African women are relatively tall compared to other regions, but does not emphasize on the possible explanation why this is the case, which may not have been the objective of his research but perhaps an observation. As he acknowledges that there is a lack of explanation for their tall stature, he stated that it may have occurred even if there was a 'slow adaptation of heights to nutrition'. He comes to the conclusion that due to the fact that they are tall, one should not take into account the relationship between heights and income as central when doing research and to be careful using anthropometrics as a link to living standards. In my view, what the author may have omitted: migration aspects, staple food characteristics and dietary diversity across the continents. For instance, a staple food linked to one region of Sub-Saharan Africa that could be beneficial to growth, might not be the same staple food consumed in another region of Sub-Saharan Africa. If one assumes that these nutrition food items, full of vitamins and proteins that positively affect the population that consumes it, in terms of stature, although considered a 'poor

person's food', could be an important element in the understanding of why women in Sub-Saharan Africa are tall. This would be an important factor to take into account. Adding to this idea, if migration occurs to a region in which the staple food consumed is beneficial for growth, this would lead to an increase in growth overall on the continent.

Moradi argues that the tall heights observed in Sub-Saharan Africa could be connected to an improvement in nutrition during the catch-up growth phase (adolescence). He points out that this period of growth would not be captured in measurements like child mortality for instance (Moradi, 2010). Regarding catch up growth, I would highlight the contradictory's point of views from two articles: one elaborates the possible explanation for tall population in Sub-Saharan Africa due to catch-up growth (Moradi, 2010) while (Perkins, 2016) stated from a study from the Gambia, that there seemed to be no difference between heights in puberty – even if supplementary maternal feeding in utero and post-birth was given.

In addition, the author (Moradi, 2010) discusses the dependency on agriculture for food, and the impact of climatic shocks for the provision of food for populations. As we know, this affects food security and the quality of harvests. He mentions droughts as trigger points and the countries affected by this natural phenomenon. Other climatic shocks that he may have omitted would have been floods, cyclones and locust infestations which are found in the region discussed. In terms of conflicts, civil wars were mentioned as disturbing nutrition and health as it relates to agriculture. However, through his discussion, the elements contributing to poverty through conflicts were not mentioned, such as unemployment, lack of infrastructure and access to services, inflation, etc. The aspect of epidemics was not discussed neither and how various epidemics on the continent could impact the trend of heights to a decline in health.

When phases of high revenues occurred, a larger percentage of short children would be dead but survived. Moradi offers a new theory of why African populations are taller than projected based on their per capita income (Moradi, 2010).

Akachi and Canning explain that for macroeconomic studies, in order to observe the link between health and economic growth, the indicators of life expectancy rates are usually used to analyze populations health with the assumption that this measure is connected to adult height. They also address the use of mortality rates indicators to measure population health and how one of Millennium Development Goal (MDG) was to reduce mortality but within that 'nutrition has been the forgotten MDG' that if the focus was on this, it would have been beneficial for not only the reduction of child mortality but the increase of heights and human capital (Yoko Akachi, 2010). Nonetheless, I would disagree with nutrition being perceived as the forgotten

MDG as it is included in the first MDG ‘eradicate extreme poverty and hunger’ and the Sustainable Development Goals (SDGs) address it in its second goal as ‘zero hunger’.

Regarding genetics, generally speaking, Moradi explained that genetics have a role in determining heights (Moradi, 2010) but other authors were doubtful on the true importance and impact of genetics on adult heights (Deaton, 2007) and its effect on variations between heights among populations (Perkins, 2016). In terms of genetic aspects, Akachi and Canning (Akachi, 2007) mentioned that the effect of genetic features is small in well-fed populations and is part of a debate on genetic variation. Unlike the authors mentioned above who doubt the impact of genetics, Akachi and Canning address the skepticism and elaborate the discussion by explaining that the variations in height (and body shape) across populations may be a result of climatic influences and progress in technology. Since Perkins et al. 2016 stated that genetics are unlikely to contribute to average heights, one may wonder why the conclusion of their article discusses the impact of adult heights on future generations, unless they meant to make the connection to socioeconomic conditions in their article. This part of the conclusion was a bit ambiguous. We can assume that there is a possibility that the future generation may not suffer from chronic malnutrition and have taller stature.

The fact is that Africans are tall despite the shortcomings encountered does not explain their height (Deaton, 2007). Due to the fact that Africans populations are lacking in some socioeconomic aspects, but are taller than less deprived people in other regions, the possible genetic difference in population stature comes into question. It is observed that women in many African countries had poor parents, were undernourished, were prone to diseases, and had mothers poorly educated, yet were tall (Deaton, 2007). Perkins et al. 2016 (Perkins, 2016) state that the tallest countries are found in Western Europe while the shortest are centered in Sub-Saharan African and Southeast Asia and that these two regions have the lowest average adult heights and the greatest prevalence of undernutrition. This would contradict Moradi’s (Moradi, 2010) claim that African populations are tall. Perkins et al. 2016 acknowledge that adult height (in these modern times) creates an opportunity to understand the evolution of health and nutrition over time (Perkins, 2016).

We understand from the article that with higher incomes, better health and nutrition follows, which would lead to increased heights. Therefore, unless these populations are in chronic poverty (which may be the case for Sub-Saharan Africa), then these inter generation aspects would not change and heights would not change. The authors did mention that continuous augmentation of heights is not the ultimate objective, it is understated through the conclusion

that the real aim is for population to live out of poverty and have better health. A possible point that could have been elaborated or could be looked into in future research is the gender difference through well-being and happiness the connection with heights. The authors discussed it but there was a lack of explanation in the gender differences in terms of happiness.

Akachi and Canning argue that health is multi-dimensional and that variation in child mortality rates and adult stature (even if there is a co-movement between the two variables) could diverge majorly in certain regions and conditions. These diversions limit the understanding of the changes in populations' health (Yoko Akachi, 2010).

As the section of this paper discussed various factors linking heights to health, nutrition and income, the authors have argued on several interesting points. For instance, Deaton's position on the determinant of adult heights in African countries is that it cannot be measured by income per head (Deaton, 2007) nor illnesses in childhood as the existing data is not sufficient nor consistent to validate the hypothesis while on the contrary, while Perkins and others (Perkins, 2016) strong positive correlations between adult height and household income and education. Akachi and Canning (Akachi, 2007) find an important link between income per head and adult height due to its bearing on nutrition and health. Deaton reiterates on how Africa is one of the poorest regions globally, has the highest disease burden yet is the tallest of the regions. From his point of view, income or the disease environment to predict mean adult height comes almost entirely from Africa, particularly the contrast between African countries on the one hand and the rest of the world on the other hand. Additionally, children originating from African are conclusively the tallest adult women. The link between population heights and income is unreliable and that population average heights are mostly determined by economic and sanitary environments (Deaton, 2007).

The importance of the environmental conditions in childhood have been emphasized by various authors. The variation in modern adult height is majorly reflected in the differences in environmental conditions who have an effect on net nutrition (Perkins, 2016), and health environments have an impact on ultimate growth (Moradi, 2010), especially for infants (Deaton, 2007) and the effect on child mortality also (Yoko Akachi, 2010). Weil found height as an imperfect indicator, as the environment in childhood may be different from the living condition in which the adult resides. In the cases where the health environments are changing rapidly, adult height is not considered to be a good indicator. The explanation lies in the fact that there is a stretch of a period between from childhood malnutrition taking place and its consequences in adulthood in terms of illness. From the research, it has been shown that adults who are short in stature caused by their poor childhood conditions, have the tendency of having many chronic

illnesses in middle and old age (Weil, 2007). The mystery on the reason for the tall stature of Africans remain. There is substantive poverty and the disease environment experienced in childhood is considered an important determinant of adult height, not income per capita (Deaton, 2007).

An addition to what other authors may have stated on the link between nutrition and height (Yoko Akachi, 2010) (Moradi, 2010), primarily being important in early childhood, Perkins and al. (2016) add to this claim that not only postnatal periods are critical but in utero also. On the articles reviewed in this section of this papers, these were the only authors to highlight the importance of maternal health, thus in uteri's nutrition.

**Well-being.** For the most part, it has been observed that individuals who are taller generally have better health and are less affected by diseases. These same individuals also tend to score with better ratings on well-being indicators, for instance, enjoyment, happiness, sadness, physical pain, and social activity. Equally, tall people are more prone to report stress and irritation and, for women, anxiety. Income and education contribute to these well-being measures. But overall, in terms of socioeconomic conditions, adult height is inversely connected with less risk of depression and suicide and shows a positive association with psychological welfare, even if the gender results may differ (Perkins, 2016). For health and nutrition, height can be considered a good indicator of well-being. When considering the health environment, that it was an imperfect indicator. Because heights are strongly connected to health, while nutrition and health go hand and hand together, stature would be a good measure to assess an individual or a population's welfare. For income, some authors found a strong correlation between heights and income, while another author argued that there was a lack of relationship between income and height. The next section will discuss inequality and gender issues in relation to height and well-being.

### III. Inequality

There are several approaches to measure height inequalities. Various tools will be discussed in this section and the researchers' point of views on the utilization of these measures. Inequality of height is also affected by wages, ethnicities, intra and interregional aspects, and also nutrition inequality which affects heights. This section of this paper will focus on the reasons the ways to determine inequality and issues relating to it for the well-being of populations in Sub-Saharan Africa. Gender height inequalities will also briefly be addressed.

**Inequality determinants/indicators.** The indicators of inequality utilized for least developed countries (LDCs), where reliable data has been available are real wage or real GDP per capita

(Moradi, 2014) (Baten, 2005), instead of utilizing income distribution (Baten, 2005) and has been found useful as from the point of view of biological aspects of income inequality (Blum, 2014). Height inequality might be a good complement to conventional indicators, and perhaps an even better indicator in some respect (Moradi, 2014). Anthropometric measurements not only highlight income variations but also unofficial earnings such as subsistence farming and illegal trade. Such data has been highly utilized by economic historians and development economists for the following two reasons: conventional statistics from the past, mostly originating from less developed countries, have tended to be less reliable and difficult to gather (Blum, 2014). There have been issues using wage inequality as an indicator due to the fact that many populations of LDCs work in the informal sectors (Moradi, 2014) or are self-employed unemployed (Baten, 2005) and thus are not recipient of salaries (Baten, 2005). For the wage inequality indicator, it is also important to take into account that the wage earner transferring money to the rest of the household varies (Baten, 2005) (Moradi, 2014). Additionally, wage data are often focused on urban areas, while inequality between rural and urban regions is associated as one of the main contributors of total inequality within countries (Baten, 2005).

In addition, chronic malnutrition or stunting is considered as a convenient anthropometric measure for children due to its positive correlation with social and economic deficiencies. Stunting is now recognized as one of the best proxy indicators for child health inequalities. Research also indirectly reaffirms that the prevalence of stunting is an adequate proxy for socio-economic inequalities (Wamani, 2007).

The general determinants related to height inequality are the following:

- Farming method such as subsistence farming to production of crops for markets; this can increase mean income and improvement in nutrition. When this occurs, increasing inequality follows, with an imbalance of populations who gained from these farming methods and the ones who lagged behind.
- Accessibility to high-protein food production is connected to augmenting average height and lower height inequality according to Baten (2005).
- Through education, average heights of regions are raised according to Loaiza (1997) and in addition, primary schooling seemingly decreases height inequality within a region (Baten, 2005).
- Natural resources have been perceived to reduce mean regional well-being due to its adverse effect on human capital. It increases inequality within regions as only a minor



percentage of the population profits from natural resources according to Sachs & Warner (1995).

- Industrial activities influenced by the government only benefits part of the population. Contrarily to industrial regions, light industries areas (market-oriented) tend to have higher mean heights and less inequality.
- Ethnicity affects Africa in terms of inequality with: (a) discrimination through ethnic fractionalization and unequal subsidies (b) the fact that African's ethnic clusters have diverse genetic height aptitudes.
- Geography and location have an impact on inequality as peripheral regions within a country are inferior economically, as governments attempt to reduce inequality in regions near the capital for political reasons according to Bates and Lipton (Baten, 2005).

***Height as a measure of inequality.*** There is a partial correlation between unequal distribution of income and heights (Baten, 2005). Deaton (2001) and Pradhan, Sahn and Younger (2003) claimed persuasively that health inequality indicators have significant value by themselves, not only in connection to wages (Moradi, 2014). New understandings on inequality can be generated from the height indicator (Blum, 2014) (Baten, 2005), although it is not established as the only accurate measure of inequality, but considered beneficial to disprove other measurements, thus bringing better estimates all in all (Baten, 2005). Height inequality includes significant biological features of inequality, and it can corroborate the results obtained by using conventional methods (Blum, 2014).

The advantage of using this indicator is that it allows the inclusion of other variables such as the jobless, the self-employed, black market workers, housewives, and offspring. Nevertheless, the authors are aware that height inequality shouldn't be used solely.

Real income is considered an input indicator to human utility while the height variable is perceived as an outcome indicator (Moradi, 2014).

In order to attain a certain height level, a level of income would be expected for individuals to buy food and medicine. Yet, if these inputs turn out unequal, this would consequently affect heights to be unequal as well (Baten, 2005).

When income affects nutrition, it will have an effect on the distribution of height of the population. Since public health and education actions have equal effect, those are not measured through income inequality but are considered in the inequality of heights (Moradi, 2014).

***Anthropometric inequality measures.*** In the past, economic historians have used the measurement ‘height difference’ to assess (inter) regional inequality. In addition to height difference, the coefficient of height variation for intraregional and the overall country’s inequality is utilized. Coefficient of Variation (CV) is very useful to gain better knowledge on inequality (Moradi, 2014). More and more anthropometric research use has shown to use the coefficient of variation (CV) as a measure of socioeconomic inequality where usual inequality measures are unavailable (Blum, 2014). Anthropologists discuss the fact that biological variance augments with mean height, therefore the standard deviation is not an accurate measure of inequality, according to Schmitt & Harrison (1988). However, the coefficient of variation (CV) considers this fact and consequently is a reliable and robust estimate of inequality (Baten, 2005). While on the other hand, the coefficient of variation (CV), in contrast, is a robust approximation of inequality, if certain elements of homogeneity are respected (specifically: no combination of still growing and adult individuals) (Moradi, 2014). Researchers that use height inequality have a preference towards using the coefficient of variation (CV) in lieu of standard deviation (SD) values, as anthropologists have argued that the biological variance rises with average height (Blum, 2014). What can be considered as a benefit of height CVs is the unnecessary dependency on employment and social classifications (Moradi, 2014). The CV considers it and is consequently a more dependable and robust approximation of inequality (Blum, 2014). Nevertheless, the very high correlation between CV and the standard deviation (if average height is not too unsimilar) makes a comparison with the more intuitive standard deviation possible. As CV and the standard deviation are strongly correlated, it can help distinguish an improved intuitive standard deviation. Generally, standard deviations, coefficients of variation or centimeter distances can be used to measure height inequality for working and income groups (Moradi, 2014).

The contrast between CV and the income-based Gini coefficients shows a close correlation for Sub-Saharan Africa. The authors looked into possible limitations of height CVs as inequality indicator, and found no sign for important irregularities (Moradi, 2014).

There are only eight gini coefficients of income for Sub-Saharan Africa for the period before 1980 as produced by the reputable Deininger and Squire data set (1996) and these were categorized as “acceptable”. Atkinson and Brandolini (2001) persuasively noted the serious defects in the income inequality data collected by Deininger and Squire, stating the lack of consistency across countries and over time (Baten, 2005).

In the aspect of inter and intra-regional inequality, it has been demonstrated that height inequality is an adequate and useful indicator for further knowledge on topics such as cash

cropping argument and various others which are linked to wellbeing and inequality issues (Baten, 2005). It occurs that in certain instances the national coefficient of variation (CV) is mostly determined by high interregional inequality (Moradi, 2014).

On the subject of inequality in nutrition, researchers have shown that it could be measured through anthropometric approaches: historically, evaluations were done between the average heights of different occupational or income groups. The degree of inequality in nutritional status and health is shown on the way that the average heights of some groups vary from each other and it displays. For this method to be accurate, the classifications of social or occupational status must be comparable and non-random which is not easily achievable for least developed countries. The average nutritional status of a population can be estimated through its height distribution, and equally display and indicate the nutritional inequality of this population (Baten, 2005). One point of view is to consider two measures. First, the CV of the region that specifies nutritional inequality within the administrative unit (intra-regional inequality). Second, the region's height difference compared to the national average height. An average height which is less than average indicates inferior nutritional and health conditions worse in comparison with the rest of the nation. This second measure will display inequality between regions (interregional inequality) (Baten, 2005). Another point of view and doubt from the author is that there is still some thinking on the close the question remains how close link between nutritional inequality and income inequality, particularly the gini coefficient for income. Due to lack of other information, Deininger and Squire's (1996) gini coefficients are the best instruments available (Baten, 2005).

As it related to wages, there will not be a perfect correlation between income and height inequality if deprived populations are able to access public health assistance, received food distribution (which is not recorded) and any other forms of privileges (Baten, 2005).

***Relationship between height inequality and income inequality.*** It has been shown that difference in stature are the results of more factors than just financial income inequality. The link between height inequality and the equivalent financial income that demonstrates financial inequality impacts anthropometric inequality. Elements such as access to public support, subsistence farming and black markets are highly influential on the height variation. Does income inequality influences height inequality? The availability of elements that affect height variation such as the availability of food and medical support will be disposed to influence the stature of a person. Height inequality will reflect the availability of such elements within a household. For example, conventional statistics only include the transfer of revenues of a

household's unique wage earner to his family unit while disregarding other types of support and the benefits to these family members are not considered (Blum, 2014).

There are several aspects that affects height inequality as listed below:

- A. **Cash cropping/Agriculture.** In Sub-Saharan Africa, cash cropping is significant as source of revenue, in particular for exports, but has been shown to raise inequality. In 1965, agricultural cash crops good was associated with 74% of Sub-Saharan Africa's export profits. Since cash cropping is instrumental to acquire income which provides populations the opportunity to buy foods or other items that is not easily acquired, it demonstrates the imbalance between regions where cash cropping is used against the regions that used farming goods for subsistence farming. Accordingly, cash cropping regions have the lead in comparison to subsistence farming areas, but it is difficult to quantify the benefits of cash cropping in reality.
- i. Research has argued the *inequality that comes from cash cropping* and how the existence of one cash-crop commerce can reduce a region's average height by almost one centimeter and increases intra-regional inequality (Baten, 2005). Despite its advantages, cash cropping is known to increase height inequalities. In a complex way, cash cropping increases inequalities between regions because the regions which has more advantage are usually the ones with more skill sets, has agricultural adaptation and profits from commercial buyers. Once they gain enough assets, they advance their farming techniques and invest in better lands. This is how the majority of subsistence farming progressed to commercial farming and the rise of inequalities between the regions (Moradi, 2014).
  - ii. However, *varying a cash-crop* approach reverses the effect as heights rises nearly by three millimeters and the CV declines by 0.10 for each additional cash-crop commerce, whereas inequality is consistently inferior (Baten, 2005). Diversified cash crops regionally have higher average heights comparatively to the country average (Moradi, 2014).
  - iii. These results can *impact policies*. It shows that cash crops can help an economy in terms of growth and development and through exports, help this economy in towards globalization and will help diminish inequality (Baten, 2005). Dealing with cash cropping of foods is a form of debate instead of a one-sided discussion and facts. On one hand, cash cropping is considered to contribute to better

nutritional circumstances and is known to be a crucial source of income, notably the earnings from exports in Sub-Saharan Africa.

- iv. Although ***cash cropping is a great source of livelihood***, especially for families who cannot farm or cultivate their own foods, the profits or benefits are a bit ambiguous. The numbers are not so clear, hence the evidence of cash cropping promoting equality is not a reality. There is a dependency on food prices when dealing with cash cropping. Whenever there are seasons of bad harvests, the deficiency of the credit markets in Africa makes it nearly impossible to compensate the income of the farmers with savings, if any. Ultimately, the prices increase on food crops (Moradi, 2014).

Although the effects of cash cropping on inequalities are still debated, studies have shown that having diverse cash crops have a positive influence on the increase in heights versus single cash who tends to raise height inequality and leads to a decline in heights. **Agriculture.** In regards to agriculture in the 1960's, it was the source of income for 85% of the African population (Moradi et al. 2005). Herding cattle and other animal farming are imperative when considering the highest source of proteins. Thus, having a good quantity of cattle, for example, symbolizes availability of plenty of proteins. Agricultural exports are important in association with the region's GDP. There are many African nations which have illustrative advantages in exported crops. For instance, Senegal's production and export of groundnuts, gives the nation an advantage in gaining huge revenues and able to import any other food crops for its nation. On the flip side, the inequality of one region gaining huge revenues out of cash crops, which can be exported and another region which does not have the capacity of cash cropping, because of lack of exposure, education, environmental factors, to name a few, could cause social conflict (Moradi, 2014). This section on agriculture recapitulates the inequalities that can be found in agriculture, though not directly linked to height.

- B. **Industrialization.** In regards to industrialization, light industries such as textiles, footwear, printing functioned competitively which allowed laborers to be paid regular salaries of African economies, likely higher wages than in rural areas in order to attract workers (Baten, 2005) (Moradi, 2014). Thus, it could be expected that there would be taller statures in areas where light industries were widespread (Baten, 2005). Due the competitiveness of these markets, taller regional average heights and lower inequalities were noticed. In the 1960's most industrial firms in African regions were taken over or

founded by the state, to make sure the industrial production was prominent due to its important role in the economy. The consequence of such monopolies with the rise of a small percentage of high-income groups still affected the majority of the region who remained poor or with even less income than before (Moradi, 2014). This explains how industrialization leads to height inequalities and how populations in rural areas could have shorter heights.

- C. **Distance/location.** Geographic location also plays an important role in regards to inequality (Moradi, 2014). The provinces or peripheries in Sub-Saharan African may suffer from inequality due to the fact that urban centers or capitals thrive economically. (Baten, 2005). As the market gets further from the capital, it may decrease in profits and earnings (Moradi, 2014). The further one is from the capital, the more difficult it is to compete in markets. For political reasons, governments tend to attend to inequalities near capitals and direct resources in terms of public good or subsidies to ensure future political status. This can lead to higher average height and less intra-regional inequality in areas closer to the capital. There are ambiguous views on inequalities within regions; distance to the urban center suggests that inequality is less abundant in distant regions as the coefficient of variation (CV) has negative impact on regions. Nonetheless, when looking at the changeable size of African countries, the view may be different: notwithstanding the distance of the furthest region, distance has affects inequality positively (Baten, 2005). Access and closeness to protein products leads to taller stature and less inequality.

There are two contradicting views:

- a) There is a robust negative bearing on the regional CV with the simple distance to the capital which insinuates that inequality is lower in remote areas with understandably less access to markets (Moradi, 2014).
- b) Yet, there are difference in sizes of African countries (some are vast, others small), which shows a different picture: regardless of the distance to the farthest region, distance still impacts inequality. This indicates that remote areas of large countries have a smaller inequality, but remote regions of small countries have a higher inequality (Moradi, 2014).

Rising height inequality occurs within urban environments due to the economic and cultural profile of metropolises which attract high earners and the poor equally. This effect

is explained from the availability of employment opportunities for all social classes (Moradi, 2014).

- D. **Education.** Education enhances the health and nutritional habits of the most deprived and this should affect positively the average heights. Regional heights have been positively affected by light industries and education (Baten, 2005). As one would expect education to impact average heights positively, it could also have an egalitarian effect due to the fact that education ameliorates the health and nutritional behavior of the poorer individuals correspondingly. Education helps to decrease inequality within regions and provides better welfare comparatively to the country average (Moradi, 2014).

These four factors summarize how they can be linked to height inequalities. There may be other forgotten elements that were missed, but in terms of effect on inequalities, these were the main ones addressed.

***Ethnicities aspects.*** Ethnic alignments are usually instrumental when it comes to political support which influences politicians to attend to infrastructure measures, education, health, or employment (Baten, 2005) while harming other ethnic groups by taxing their economic activities (Moradi, 2014). In African environments, societies at large pay the cost from the maneuvers that politicians use to acquire political power. There is a U-shaped effect on inequality with ethnic diversity: a rising percentage of the biggest ethnic group decreases inequality initially, but once this group becomes too significant, inequality rises again (Baten, 2005) (Moradi, 2014). Furthermore, maternal linguistic distance also has strong and robust negative effects; it has been shown that the children of mothers who are ethnically distant from their neighbors face a higher probability of dying before reaching the age of five and that those who survive are shorter in stature (Gomes, 2014).

***Governance/institutional issues.*** The political economy aspects explain how high inequality in areas close to the capital could lead to political discontent and eventually cause rebellions from these populations. In light of this knowledge, the government tends to direct resources in zones near the capital. This situation also occurs when institutional or governmental structures are weak and control distant zones with difficulty. Higher average height and less intraregional inequality would be expected regions near the capital (Moradi, 2014).

***Intra household allocation of resources (linked to gender).*** The imperfect correlation of height inequality and gender is explained by the intra household allocation of resources, which can

also vary over time. One of the sexes may profit from better foods and medical attention (Moradi, 2014). Firstborns have been shown to be taller in comparison to their siblings at the same age at different phases of life, for instance in childhood, teenage years, and as adults. The hypothesis that children who are born later usually have older mothers, who are exposed to more possibility of chromosomal and congenital defects also and can have premature births. From the author's view, it is understood that the theory of 'later-born children being shorter' is justified. Gender comes into play if for example the male is a favored gender and the firstborn is a girl, parents may proceed to have more children until the child is a male. In those instances, parents tend to invest more in later-born children. On the contrary, the opposite will happen if earlier-born children are males, and the later born children will be 'neglected'. While male preference is widely documented in East and South Asian countries, Other regions may have a male preference but there is less information for this preference in Sub-Saharan Africa. According to Rossi and Rouanet (2015), it seems that for Sub-Saharan Africa, females are preferred or a mix of both genders. Instead, evidence in sub-Saharan Africa seems to indicate female preferences or a preference for mixed genders. The birth order can also be explained with through intrahousehold mechanisms and the parents' comportments towards favoritism of one gender over another (Villa, 2018). Nevertheless, research has also shown favoritism towards of sons at the disadvantage of daughters, including dietary unfairness, leading to conclusions of a nutritionally disadvantaged status of female over male children (Wamani, 2007).

From gender-related research, intra-household allocation has been shown to be a disadvantage to women in cash-cropping areas. Women lose their wages from commerce from agricultural outputs that are usual for subsistence farmers. This may have a consequence on lower expenditures for education, nutrition and health care of children and thus a lower adult height (Moradi, 2014). Transfers within households affects height inequality. If the single wage earner of a family transfers money to his or her relatives, only that income is included in official statistics – the utility profiting family members are not considered (Blum, 2014).

The coefficient variation is likely a more sensible and dependable measure of inequality as the elasticities are perhaps higher for females. During crises, poorer families tend to keep the expenses for boys the same, while they diminish the care for girls (Moradi, 2014).

**Summary.** This section discussed the importance of height inequality indicator and how it could be a good complement to usual economic indicators. The gini coefficient and coefficient of variation of heights were discussed and several authors prefer the idea of using the coefficient



of heights instead of the standard deviation as it is a more approximation of inequality. Several factors were shown to be connected with height inequality such as cash crops, geographic location, industrialization, intra-allocation within households, agriculture and education. Ethnicity aspects were reviewed and explained for its relevance to height inequality. Inequality is valued as an important indicator of well-being (Moradi, 2014). Through his analyses, Blum demonstrates empirically how height inequality and average height observations as well as economic inequality are determinant of well-being (Blum, 2014). A safe assumption is that genetics are not a significant determinant of inequality when the population is considered in its entirety (Baten, 2005). In sub-Saharan Africa, male children under five years of age are more likely to become stunted than females, which might suggest that boys are more vulnerable to health inequalities than their female counterparts in the same age groups (Wamani, 2007).

According to Svedberg regarding gender bias in undernutrition in Sub-Saharan Africa, he proposed in his research that there was a minor anthropometric advantage shown by girls, women, which could indicate favoritism towards pattern of females linked to their participation in agricultural labor (Wamani, 2007).

In addition, inequalities in adult height within and across countries show the intergenerational elements that affects health and well-being (Subramanian SV, 2011).

The provision of public goods can lead to changes in consumption and purchases of an individual and thus lead to height-based inequality measures. Additionally, income completely disregards transfers within households which argues in favor of height-based measures: heights are results indicators, while income characterizes input to human utility (Baten, 2005). Average height (and well-being) could increase by redistributing resources from the wealthy to the poor because gains of the poor outweigh those of the wealthy (Blum, 2014).

The studies on height inequalities have demonstrated that the measure of height inequality can be a valuable tool in relation to cash-crop and agricultural issues which is linked to the welfare of population. Geography, education, access to protein products and whether an individual lives in a rural or urban zone affects heights. Industrialization also has shown to affect height in an unequal manner.

#### IV. Long-term trends

**Height trends.** The trends in height are also quite perceptible. Heights overall have been decreasing in Sub-Saharan Africa. In the research on the health trends in Sub-Saharan Africa done in 2010, the results showed that the cohort born in 1985 is about 0.5 cm shorter than the cohort born in 1961 (Perkins, 2016). Several authors share the same point of view on the fact

that adult heights have not increased in Sub-Saharan Africa in full; there has been seen substantial declines in height (Yoko Akachi, 2010) and Perkins also mentions that research has shown that average adult heights have been stagnating or actually decreasing, particularly in Africa and in relation to Western European countries (Perkins, 2016). While there have been large reductions in infant mortality and nutrition intake, adult stature has not gotten better (Yoko Akachi, 2010). Deaton also corroborates the pattern observed in Sub-Saharan Africa and the fact that heights have been plummeting since the mid-1960s and seem to continuously fall (Deaton, 2007).

The declines in heights were occurring in most of Sub-Saharan Africa, conspicuously in comparison to the rest of the world which was experiencing an opposite effect (Moradi, 2012). Sub-Saharan Africa appears to be the only region to encounter a reduction in average heights (Moradi, 2005) (Baten, 2014) (Subramanian SV, 2011).

Since the 1960s, the African continent has been exempted from the global demographic trend (Perkins, 2016); instead of experiencing increasing heights, it has been contrary to the global trend and adult height diminished or stagnated by approximately 5 centimeters for many countries (eLife, 2016).

For instance, from information gathered from World Health Surveys, Western Europe possesses the tallest populations (Grasgruber, 2014) while the shortest are found in Sub-Saharan Africa and Southeast Asia (Perkins, 2016). These declines may have been linked to debt and monetary complications of the mid-1970s and 1980s in the African region which caused the reduced average adult height of cohorts born during those time periods (Moradi, 2012). Furthermore, the positive effect of the industrial revolution may be linked to the increase of stature in the developed world. The late 18<sup>th</sup> century and around 1830, there were observed decline of body size which possibly may have been caused from overpopulation, worsening in income distribution, and a decrease of food availability per capita (Grasgruber, 2014). Though the trend of the decline in stature is observed in Africa, populations in some areas of Sub-Saharan Africa have somewhat a larger stature than 100 years ago (eLife, 2016). In contrast with relative income earned in African populations, they are found to have a larger stature that would be expected from their income (Moradi, 2012). The inconsistency in Africa in relation to heights is that Africans are comparatively tall despite negative settings such as a high degree of poverty and diseases (Bozzoli, 2007).

There is no certain explanation for the divergence in height trend in Africa (Moradi, 2012).

There are inexplicable variations between regions such as Sub-Saharan Africa and South Asia which both comprise of high mortality rates, but despite the similarities Africans are taller,

and South Asians shorter than would be expected as well as notable differences across nations within continents, mostly within Africa and Latin America (Bozzoli, 2007).

In 1953, D.F. Roberts studied how African heights would incline with temperature and would decline with relative humidity. His argument related to the fact that climate had an effect on heights through the channel of nutrition and diseases (Moradi, 2012).

From the research in Côte d'Ivoire and Ghana, both countries had experienced growths in heights in the late colonial period, as a consequence of urbanization and cocoa production. However, after 1960, the following evolution occurred: the growth trend in Côte d'Ivoire slowed down and Ghana experienced a shift, leading to a decline (Cogneau, 2011).

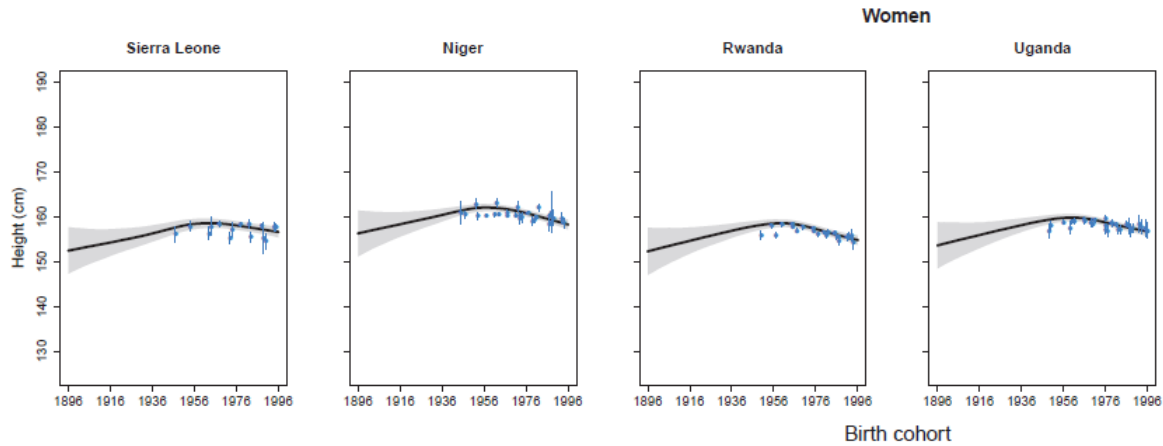
Regarding South Africa, towards the end of the Apartheid, there was a variation in heights between white and black men. For the black population, there were typically at least 7 cm shorter than the white population. This has been shown as an illustration of within country variations although the emergence of this variation is unknown. While assessing the welfare of black populations in South Africa by utilizing height measures, the results showed a slight improvement during the 20<sup>th</sup> century, in contrast to other Africans in other countries, who had shown substantial growth in stature. As there isn't any precise measure to assess the evolution of the welfare of black populations in South Africa in the 20<sup>th</sup> century, the direct comparable indicator to support the research is the height indicator (Mpeta, 2017).

***Height trends for women.*** In the 1950s, there seemed to be a rise in female stature in numerous African countries (Yoko Akachi, 2010). Moradi (2010) researched the trend in heights considering the years between 1950 to 1980. The outcome from his research was that females in Africa were tall in the 1960s and 1970s (Bozzoli, 2007) (Moradi, 2010), when compared to other developing nations who generated higher incomes. The theory that could explain the tall stature of these women related to the adolescent period which allows catch up growth. It is possible that if the health environment improved during young years or early adolescence, it would influence the final adult height (Moradi A. , 2010). Perkins et al. (2016) also observe that in comparison with the other developing countries, women adult heights rose by roughly 1.2 cm on average during the 24-years study period (1961-1985) (Perkins, 2016). Klasen (2006) formerly noticed the puzzle of tall women in Sub-Saharan Africa especially due to the high rates of stunting (Bozzoli, 2007).

The authors above mentioned the upward trend for women after 1950s. The information from 'Our World Data' states otherwise, as depicted graphically below in Figure 1. Figure shows that

generally, with the four countries in the sample from different regions from Sub-Saharan Africa (West, Central and East), the trend is downwards. The trends in women heights in Africa is reversed (eLife, 2016).

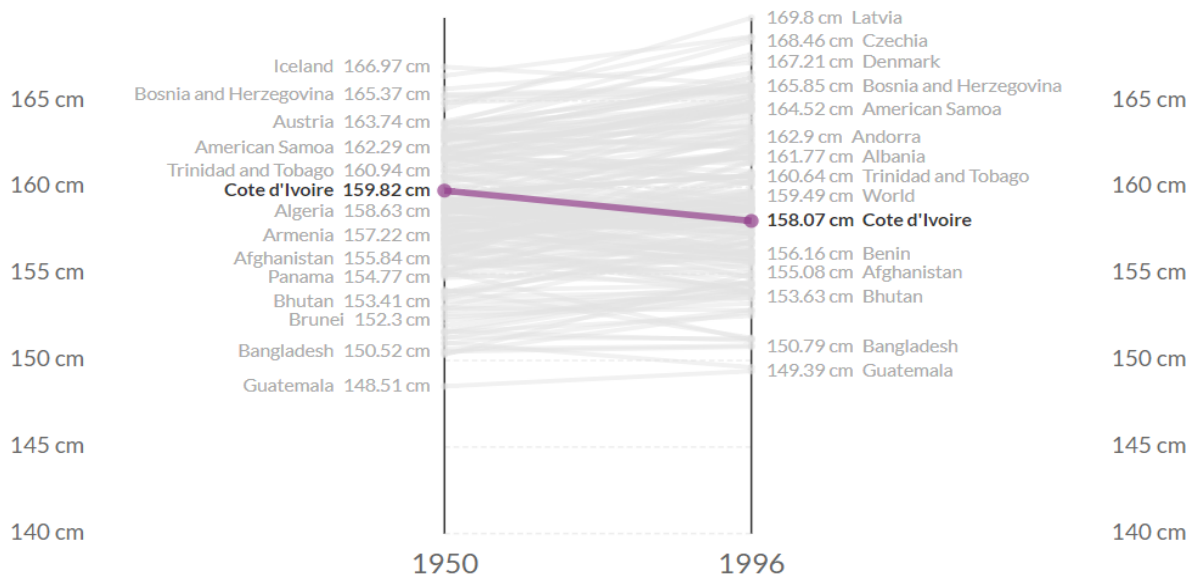
**Figure 1: Trends in height for adult female; 4 countries sample from Sub-Saharan Africa**



Source: e-life publication, *elifesciences.org*, article “A century of trends in adult human height” (2016). Trends in height for adult female, four countries Sub-Saharan Africa; solid line and shaded areas how estimated height at 18years of age

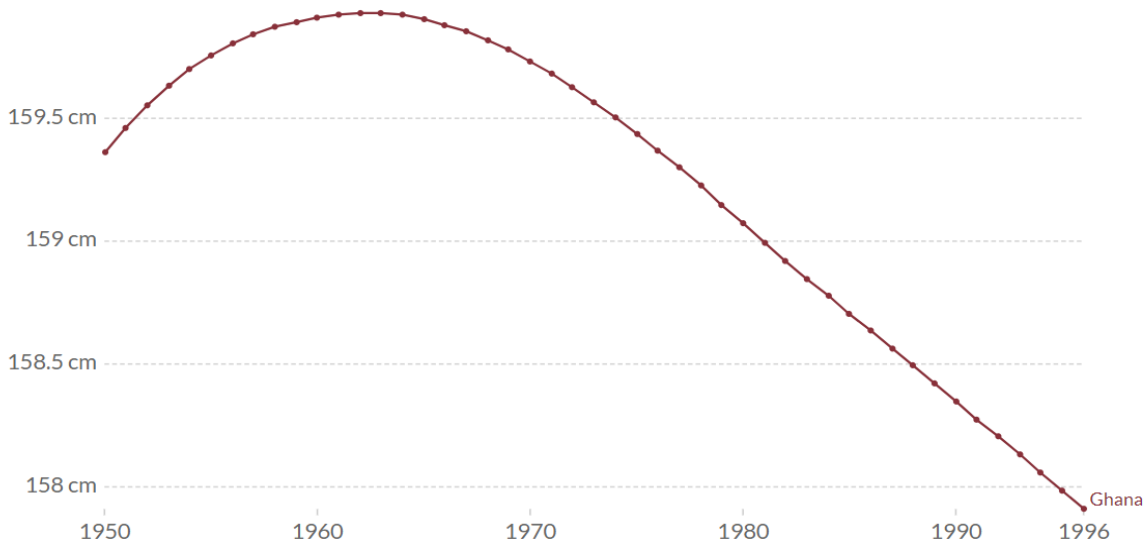
Even though, Moradi (2012) and Perkins et. al (2016) did not specify the countries with the increase in stature for women, Cogneau et al. (2011) had contradictory results for Côte d’Ivoire and Ghana. In their study, women (mothers) in Côte d’Ivoire, after 1960, did not increase in stature as noticed in the Demographic Health Surveys. And for Ghana, a decline of approximately 1.5 cm was observed for mothers born in the mid-1980s in comparison with women born in the 1950s (Cogneau, 2011). The results for Côte d’Ivoire from Cogneau et al. do not corroborate with the data from ‘Our World in Data’ as can be seen in Figure 1 below. The observed trend for Côte d’Ivoire from Figure 2 is downward and not stagnant. Nonetheless, for Ghana, the results from Cogneau et al. (2011) support the results from Our World in Data (see Figure 3).

Figure 2: Average height of women aged 18 or older by year of birth – Cote d'Ivoire: 1950-1996



Source: <http://www.ncdrisc.org/data-downloads-height.html>

Figure 3: Mean height of women aged 18 or older by birth year, extending from 1950 to 1996



Source: <http://www.ncdrisc.org/data-downloads-height.html>

There are explaining factors in the changes of heights for women over time. For instance, when it comes to the average change in height for women, economic growth has been found to be the best interpreter of variations (Moradi, 2012). In addition, to differentiate gender differences in trends, age at menarche is associated with adult height in young women and demonstrates important variations over time which can be an explaining factor for the divergence between male–female height ratios (Perkins, 2016).

Furthermore, while examining the trends for women in Sub-Saharan Africa, Moradi (2012) discusses the link between heights and climate. He explains how tall women can be found in “tsetse fly free areas from the Sahel region, areas around Lake Victoria, Namibia, Zimbabwe and southern parts of Zambia”. He further explains how the tsetse fly is lethal for cattle and how these cattle are an important source of protein nutrition. His study further explains how women in forest regions tend to be smaller in stature (Central Africa, in West Africa in between the coast and the Sahel zone) and how climate in the tropics eases the contamination of diseases (Moradi, 2012). Although his study acknowledged the tall stature of women in these specific regions of Sub-Saharan Africa, he did not elaborate on whether they had grown or decreased in heights over time. He simply observed that climate may be an explanation for women stature due to humidity and tropical weather.

**Urbanization.** Regardless of policies implemented, Sub-Saharan Africa will continue to urbanize speedily (Collier, 2017). The drawbacks of urbanization are connected to weak infrastructures resulting in meager public health due to overpopulation and inadequate water supply, hygiene and sanitation (Moradi, 2012). The effects of these inadequate investments have strained living situations and contributed to the impact on population height in much of Africa (Collier, 2017). Nonetheless, with the medical progress of the 20<sup>th</sup> century, the situation reversed and modern-day survey data showed that urban inhabitants were taller than rural populations throughout Africa (Menon et al., 2000) (Moradi, 2012).

In Côte d’Ivoire, a noteworthy percentage of the rise in height stature may be connected to the beginning of urbanization. For Côte d’Ivoire, a one centimeter increase in height growth is explained by the expansion of the urban population density over 30 years, from 0.1 to 5.7 people per square km. For that country, it is assumed that the effects of urbanization followed by cocoa production impacted height increases during the late colonial time period. A plausible explanation regarding the slowdown of height evolution is due to decreasing returns of urbanization after Independence in Côte d’Ivoire. In Ghana, the recession and the failure of the cocoa sector can directly describe the height losses of cohorts born in the 1970s and 1980s. Limitation in the research gives an explanation as to why urbanization and cocoa expansion are found to have little impact in the case of Ghana in terms of effects on height. The authors stated the limits of the research to find explanations for the discrepancy (Cogneau, 2011).

With the overpopulation and harmful environments, urbanization is a direct connection to the disturbing height demographics. When comparing rural and urban areas, the decline in heights is better explained by the differences in urban and rural zones instead of assuming that rural

areas are distanced from urban centers. As a matter of fact, child heights provisions are generally higher on average in urban zones irrespective of the time needed to access urban centers (Collier, 2017).

***Industrialization.*** The positive effect of the industrial revolution may be linked to the increase of stature in the developed world. Paradoxically, the late 18<sup>th</sup> century and around 1830, there were observed decline of body size which possibly may have been caused from overpopulation, worsening in income distribution, and a decrease of food availability per capita (P. Grasgruber, 2014).

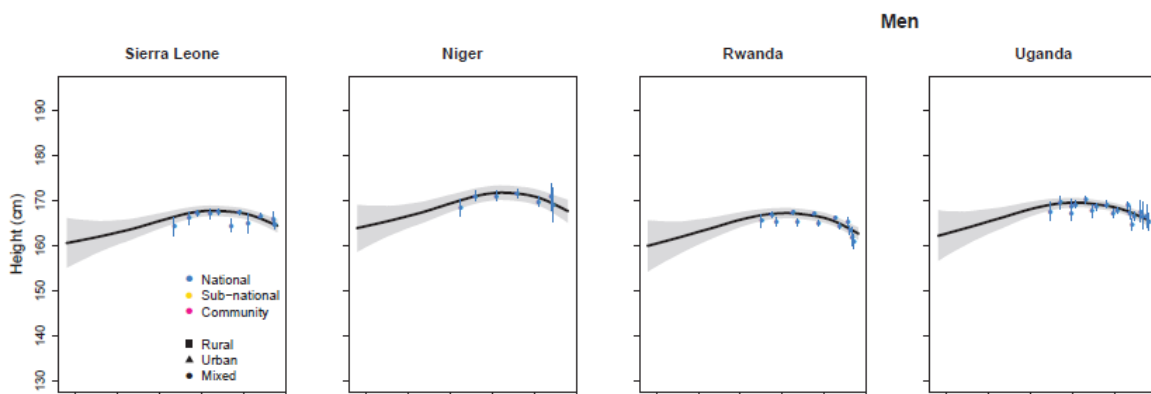
Regarding cocoa expansion, in the case of Ghana and Côte d'Ivoire, there are differences observed between the two countries. Ghana production begun at a superior rate compared to Côte d'Ivoire. Cocoa production brought an average increase of 0.42 tons of cocoa per square km which was relatively equal to a height gain of 0.4 centimeter. It has been apparent that the initial stages of cocoa production growth had an important effect on height growths (Cogneau, 2011).

***Colonialism.*** It has been assumed from historical works that the standard of living of colonized populations was reduced through colonialism. Colonialism was harmful and its overall effect led to an important height decline of at least 1.1 cm. These results support several hypotheses that would explain the probable mechanism of how development was negatively affected by colonialism, for example through land appropriation, forced labor, epidemics, conflicts during colonial times that reduced populations' well-being, negative effects on economies and population growth that ultimately had a role in the height decline. Research outcomes validate the understanding that colonization was harmful on the heights of native Africans during the colonial times. The observations showed that the decrease was the sharpest in the Democratic Republic of Congo, the Central African Republic, Somalia, Eritrea, Egypt, and Guinea. The exceptions were Niger, Cameroon and Togo had positive growth during the two periods of pre-colonialism and colonialism. The Democratic Republic of Congo encountered a very important decline of roughly 1.6 centimeter (from 165.7 to 164.1). In addition, a colonial height decline of between 1.0 and -1.5 centimeter was also found in Tanzania, Burkina Faso, Congo-Brazzaville, Mali and Libya, and a moderate decline of less than 1 cm was observed in six other Sub-Saharan countries. All in all, from the analysis, the pertinent colonial height decrease was detected in all regions of Africa (but not necessarily all countries) (Maravall, 2021).

When highlighting two important outcomes for West Africa, Cogneau (2011) presented in their paper about Ghana and Côte d'Ivoire how there was a steep increase in the height stature of populations born during the late colonial period (1925–1960) (Cogneau, 2011). The conclusion was that for the countries of Côte d'Ivoire and Ghana, heights improved during the colonial period (also Moradi et al., 2013) (Maravall, 2021). However, for both countries, the trend changed in the post-colonial period: a slowdown of height increases in Côte d'Ivoire and yet a deterioration in Ghana. The puzzle also remains as to why the trend varied for Ghana and Côte d'Ivoire. The authors questioned whether Ghanaian cities were in poorer situations than Ivorian ones. An obstacle preventing the authors to explain adult mortalities in Côte d'Ivoire and Ghana is the lack of information on vast epidemics during the beginning of the colonial period. The early period of urbanization may account for the important share of rise in heights in Côte d'Ivoire (Cogneau, 2011).

As described above, Maravall (2021) and Cogneau (2011) have different points of views in terms of trends during colonial times.

*Figure 4: Trends in height for adult male - for four Sub-Saharan countries*



*Figure 4: Trends in height for adult male, four countries Sub-Saharan Africa; solid line and shaded areas how estimated height at 18 years of age; source e-life publication, elifesciences.org, article "A century of trends in adult human height" (2016)*

Furthermore, in the example of Kenya, results of the study showed that the heights of military recruits were continuous (Moradi, 2009) and proceeded to rise during late colonial times (Maravall, 2021).

**Slavery.** Height information on slaves and freed African (previously enslaved) was used in research to provide an overview of the trend. It is assumed that height was not a determining factor in the purchase of slaves. Eltis (1982) discussed that the height inconsistency between



freed Africans and the people from the origin countries they came from was probably not considerable due to the fact height was not an important pricing factor. It should be noted that slaves' stature differed from zone to zone and regional costs did not consider this change (for example, the cost of slaves in Senegambia were not distinctively different from those in other regions. Although there is a lack of proof regarding the slave markets, with the idea of the Alchian-Allen effect, the argument could stand that foreign slave buyers would still pursue to select the slaves with the largest stature (in this case high would presumably implicate quality). The slave trade demanded robust workers (Maravall, 2021).

Eltis (1982) discussed the slave trade and Africans in route to the Americas with data for the study coming from courts in Sierra Leone deposited in a London public office. It is questioned in the research regarding the Atlantic slave trade that the Africans sold would have tended to be taller and heavier than average. In the last century, two significant trends have come out from the last century: (1) there was only a minor variation between principal zones of importation in the mean heights of Africans entering the New World (2) existing modern height data related to black populations in the Americas pointed out to the fact that all black populations are considerably taller than Africans living in the regions of importation. The age of these adult slaves was assumed to be between twenty-five and forty years old. It is also acknowledged that most of these Africans had most likely completed most of their growth before the slave journey (Eltis, 1982). It has been suggested from several studies that the stature of slaves is an adequate (yet imperfect) measurement of the population's welfare (Maravall, 2021).

For Sub-Saharan Africa, the range of mean heights varies across countries. These variations could also be interpreted from nutrition, environments and diseases (Bozzoli, 2007).

The general understanding is that the trend is declining for Sub-Saharan Africa for both genders. In the section for women, the trend in height from the research is that for women, heights have inclined due to better health conditions and environments as well but there are conflicting views as elaborated in the section "height trend for women".

In the case of South Africa, Mpeta et al. (2017) explained how the slow rise in heights of black men during the second half of the 20<sup>th</sup> century puts forward the theory of how economic growth, urbanization, and public health led to better welfare conditions for black populations.

Subramanian et al. (2011) discuss the changes in height over time across countries for women and give important understanding into the changes in childhood living situations across Sub-Saharan countries.

Cogneau (2011) stated that “colonial height growth is found to reflect long-term structural changes across the whole economy and society”. Another conflicting point of view from the same authors Cogneau et al. (2011) who stated that height increase was impressive during the colonial era but this idea was contradicted by Maravall et al. (2021) who presented in their research how the colonial era was damaging to growth in stature.

## IV. Discussion

### **Health**

We retain from this study that in a country where well-being is a main objective, the population benefits in one way or another from good health and consequently an improvement in height. When individuals are healthy, they tend to eat better. They have may have access better nutrition, and their average height increase. It is understood that chronic malnutrition affects statures for children, their adult height is affected and this situation stems from a poor health environment. Their futures are affected, as they may have difficulties learning in school, which affects employment, and hence respective contribution to GDP, and so forth. As a result, one would say that tall stature (hence good health) is visibly connected to overall well-being. It is important for countries to have well-balanced health policies that will include nutrition policies which will benefit the upkeep of the overall well-being of populations, all linked to future of generations.

It is remarkable that some countries have a reputation for a bad disease environment and yet still display tall heights. People are sometimes tall in countries and regions with problematic disease environments or high poverty. Senegambia is a region of Africa with taller than average regional stature but still encounters high rate of poverty (the African Sahel zone region is also another example). The Nilotic tribes in South Sudan, the Dinka population were also known once upon a time to be among the tallest in the world, but due to unreliable to date, there is no recent information on their stature’s status. They were found in refugee camps and may have lost stature due to famines and conflicts from the region (Grasgruber et. al 2019) (Anitei 2007).

### **Inequalities**

As discussed in the section on height inequalities, these can be perceived several different ways. For instance, while discussing the inequality in stature by ‘geographic location’ or rural versus urban, there is some ambiguity. Various authors argue that height inequality may be lower in rural areas because there are less businesses or market, hence less competition; while the flipside of the coin, is that in urban areas, similarly, due to so many different markets, only a certain group of people (educated, business-oriented, etc.) increases inequality in urban areas.

It also includes access to employment opportunities in urban areas that attract poor and rich people equally, hence the link to inequality. It is implied that urban individuals would have higher incomes, therefore access to better staple and nutritious foods, which would give them a taller stature. Studies also usually focus on wage information more concentrated on urban areas (assuming that access to these data are easier found for urban zones). Because research also highlights interregional inequality, and how it is connected to heights, the height distribution of a population would give an overview of the average nutritional status of the said population, explaining height inequality and nutritional inequality of this population. The definiteness of this shows that for Sub-Saharan Africa, it is not quite clear. It is evident that more research is required to have a conclusive answer.

Because research also highlights interregional inequality, and how it is connected to heights, the height distribution of a population would give an overview of the average nutritional status of the said population, explaining height inequality and nutritional inequality of this population. Through this literature review, one topic that I have not reviewed or found was the link between indigenous people and height inequalities. There are a concentrated group of people in Sub-Saharan Africa, particularly located in the central African region of the continent. As it is known, indigenous people tend to be quite short in stature, residing in tropical forests which can be an explanation of their lack of vitamin D and small height (Tokin 2012). In this specific case, and for the indigenous people of Central Africa, one could say that short height contributes negatively to their welfare as they have a short life expectancy. In addition to that, they are often expelled from societies (in the case of Africa), seen as an error from God or a linked to witchcraft and other form of superstitions.

Other forms of height inequalities have been addressed regarding education. Somehow the connection is understood, have the better educated one is, the better the chances are to obtain an employment with an adequate income and access better foods, which would lead to an increased height.

### **Gender**

In the literature research on height inequalities regarding gender, I did not find the research conclusive. Several authors such as Wamani (2007) explained how in in Sub-Saharan Africa, boys tend to be more stunted than girls. Indeed, girls are valued due to their contribution in the agricultural sector and may therefore access more nutritious foods. On the other hand, we can also discuss household intra allocation of resources, when boys are more accepted than girls and receive preferential treatment in comparison to girls. However, for Sub-Saharan Africa, I found that it was not necessarily linked to gender but more of the order of birth; firstborns are

found to be taller compared to their siblings, perhaps due to more attention to breastfeeding (Villa, 2018).

## V. Conclusion

This project includes 27 references. The articles chosen for the literature review are focused on research on Sub-Saharan Africa. The majority of the themes linked to heights are categorized in this paper as: (i) health, (ii) inequality, (iii) economic growth/income.

While reviewing studies on the connection between health and height, it is clear that adequate nutrition is beneficial to tall stature in Sub-Saharan Africa as the effects of chronic malnutrition in childhood prevents the desired adult height eventually. The importance of the disease environment in childhood has been highlighted by several authors as a major factor contributing to expected average height and perhaps one of the most important when we discuss health.

The results on the research on income and height was discussed and perceived from two angles: the first one whereas several authors underline the strong correlation of the two in terms of education, productivity, labor and health and the outcomes of income on tall stature; the second viewpoint negates the correlation of the link between income and height, as reviewed in the research, height corresponds to improved social and economic development for future generations, but no directly linked to income.

What was learned from the evolution of heights in Sub-Saharan Africa was ambiguous. The general understanding is that during post-colonial times, heights increased in that region, but later on stagnated or even decreased. Statures have not evolved in recent years in that part of the continent and even have been shown to decrease. Sub-Saharan Africa is filled with populations in need but are still taller than expected despite economic conditions. African women are relatively tall compared to other regions, but there is no precise explanation for it. It seems that for women, the trend on increase in heights is debated by several researchers: some have argued an increase while others, the opposite. Men experienced an increase during urbanization and industrial times, then stagnated and some countries declined altogether.

In comparison to other regions in the world, Sub-Saharan Africa falls short in research in heights and well-being. By addressing the matter of well-being, I would agree that it is an appropriate measure of well-being and that many factors help us identify how heights can be an indicator of well-being. Good health which promotes stature is without compromise a measure of well-being. Height assesses the effect of well-being for Sub-Saharan Africa. Gender and income are a bit more complicated to prove. From the research, more arguments defend the fact that being tall affects one's life positively rather than the opposite, and that short people are affected more

by inequalities and illnesses. When a nation strives economically, the height distribution of its population increases and living standards are improved.

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