Assessing the effects of autarchic policies on the biological well-being: analysis of deviations in cohort male height in the Valencian Community (Spain) during Francoist regime

Abstract

This article aims to assess the impact of autarchic policies on the biological dimensions of human well-being during Francoist regime in Spain. This is done by examining the nutritional status of the population through the study of male adult heights. Our case study is the Valencian Community with the focus on the period 1940-59 which witnessed the implementation of such policies. The heights of 21-year old draftees born between 1900 and 1954 from nine municipalities (N=87,510) were analyzed in the light of inter-cohort deviations from a secular trend established for cohorts that were not exposed to autarchy-related hardships. Height was regressed on infant mortality as a way to control for infection and therefore approach the net effect of nutrition on height outcomes.

Contrarily to what was displayed by cohort height trends in themselves, the results reveal a significant worsening of the nutritional status of the male population at the time. Deviations from the expected height trend across municipalities ranged between -.5 and -3.4 mm per year. The effects of malnutrition are found to be larger among cohorts born in the period 1920-34 in coherence with a longer exposure to autarchy hardships during adolescence. Pre-autarchy nutrition levels observed among the cohorts of 1900-14 were not regained until the cohorts 1945-49. The results also show that malnutrition had an unequal impact with the large industrial towns of our sample experiencing the poorest height outcomes. Overall, these results invite to revise conclusions obtained from the sole evidence of height trends and they question the efficiency of intervention policies implemented in Spain during the 1940s.

Keywords**:** biological well-being, food insecurity, food policies, nutritional status, cohort height, infant mortality, autarchy, Spain

1. Introduction and objectives

The use of human height as a proxy for biological dimensions of well-being is based on proven auxological hypotheses that relate human growth to environmental conditions (Tanner, 1981). Height is a sensitive indicator of well-being as it captures a number of socioeconomic determinants which influence on nutrition and, eventually, on the physical growth process (e.g. income, education and their social differentials; Akachi and Canning, 2015; Perkins et al., 2016; Grasgruber and Hrazdíra, 2020). For instance, it is accepted that nutritional deprivation can cause disruptions in the normal

pattern of physical growth until this ends at the start of adulthood (McGovern et al, 2017). Although the human body is able to develop compensatory mechanisms so that catch-up growth can occur after episodic energy deficits, chronic malnutrition often results in cumulative effects causing stunting (low height for age) and, eventually, the loss of some centimeters of height with respect to the genetic programming of each individual (Martorell, 2010). This implies that variations of mean adult height over time and/or across populations can be analyzed in the light of socially and economically-determined environmental factors.

War, autarchy, rationing policies and a number of other related human-operated environmental scenarios, are of special interest for anthropometric studies as these circumstances are exceptional and often involve extreme conditions affecting the proximate determinants of stature (e.g. Komlos and Kriwy, 2003; Pak et al., 2011; Blum, 2013; Akbulut-Yuksel 2017; Portrait et al., 2017; Cox, 2019; Zwarte 2020). For instance, Pak et al. (2011) reveal that Northern Koreans were taller than their Southern counterparts before the war whereas this was reversed among cohorts born after 1948. Authors conclude that, despite the strong interventions of North-Korean governments in public health, the poor diet during the subsequent decades caused the worsening of the nutrition status with respect to South Korea. Similar conclusions about the implications of structural scarcity on the stagnation of adult height during the communist rule in Eastern Europe have been drawn in previous studies (Komlos and Kriwy, 2003; Cvrcek, 2009). Baten and Wagner (2003) reported the decline of mean height and life expectancy, and the rise of morbidity during the first years of the Nazi rule in Germany (1933-37) which was likely related to the restrictions in some foodstuffs high in nutrients. Also recent studies have documented the impact of war-related shortages in terms of net nutrition, either due to economic lockdowns (Cox, 2019; Zwarte, 2020) or

simply to war-related spin-offs such as declining imports of commodities, which affected anthropometric parameters of early childhood related to adult height (Butie et al., 2020).

Spain experienced a civil war between 1936 and 1939 that was followed by two decades of autarchic policies (1940-59) headed by Franco's dictatorship. Autarchy was especially severe during the 1940s. Over this decade, Spain remained under a rigid policy of food rationing which lasted until 1952. Although such policy was officially addressed to mitigate scarcity and to improve the supply of basic hygiene products and foodstuffs, it resulted in the halt of the process of nutritional transition in this country.

Previous studies have underlined that the last decades of the 19th century and the first third of the twentieth witnessed the first stage of the nutritional transition in Spain which was characterized by the regularization of supply in basic foodstuffs and the progressive increased in consumption of basic nutrients through three main products: cereals, potatoes and legumes. Although the diet did not meet nutritional needs properly and it did not reach the level of other Western European countries at the time, authors coincide that the first decades of the twentieth century were of clear improvement (Cussó, 2005; Cussó and Garrabou, 2007; Pujol and Cussó, 2014). For instance, milk consumption (per year/capita) increased from 23 l. to 56 l. between 1906 and 1933 (Hernandez-Adell et al., 2019).

This process came to a halt between the middle of the decade of 1930s and the decade of 1950. Over this period (Civil War and post-war autarchy), famine and chronic malnutrition are well documented for broad segments of the Spanish population. Nutritional lacks were especially associated with deficiency in the intake of micronutrients such as calcium, A-vitamin, and folic acid which are largely contained in milk and dairy products as well as in some fruits and vegetables. The declining intake of

calories, proteins and lipids was very significant between 1936 and 1947 (Cussó, 2005; Cussó and Garrabou, 2007). In concrete the consumption of dairy products became residual for broad segments of the population and milk consumption fell to 46 l. (annual average of the period 1943-49). To this regard, the level recorded in 1933 was not regained until 1954-55, still being notably lower than that of other European countries (i.e. 56 l. in Spain compared to 100-150 l. in countries like the United Kingdom, France or Germany; Collantes, 2014).

Since 1940 monthly official reports from provincial authorities insisted on the extreme and alarming lack of foodstuffs which notably included the Valencian Community. (Molinero, 2014). Not for nothing the 1940s are known as the 'famine years' in Spain, a period characterized by malnutrition and general scarcity of basic supplies together with the spread of deficiency diseases (Del Arco, 2020).

The anthropometric outcomes available to date do not seem to correlate with this socioeconomic picture as, apparently, the impact of autarchy on the biological well-being of Spaniards born at that time is tenuous or non-existent in some areas (Quiroga, 2001). Actually, some other sociodemographic indicators followed a positive trajectory during the 1940s (Maluquer de Motes, 2007). For instance the secular decreasing trend in mortality was vividly resumed during that decade (Pérez-Moreda et al., 2015). Also, the Human Development Index which combines *per capita* GDP, primary education and life expectancy improved notably between 1940 and 1950 (Escudero and Simón, 2010) despite the drop in the country's GDP (Prados de la Escosura, 2017) and also despite the increase in hygiene and malnutrition-related morbidity (e.g. enteritis and typhoid fever; Del Cura and Huertas, 2009; Castelló, 2011). Taken together, this evidence suggests that the expected negative consequences of autarchy-related

hardships were somehow mitigated which has fueled a debate on the actual nature of living conditions in Spain at the time.

On one hand, some previous research claim that the worsening of the nutritional situation was not widespread across the country, being experienced only during the last stages of the civil war by the Republicans (the losing side). Just after the war, State intervention in food trade and supply (e.g. price regulation and rationing) could have contributed to mitigate the effects of food scarcity (Payne and Palacios, 2014). Other studies also suggest that some social interventions of the State (e.g. the promotion of maternal education), together with medical advances, played an important role in the positive evolution of the above mentioned indicators (Reher, 2003).

This article aims to examine the biological well-being of Spaniards during the autarchic period by using cohort adult height as a proxy of the net nutritional status of the population. This is done through a large sample of heights from males born between 1900 and 1954. These birth cohorts developed their growth process prior to, during and after the decade of 1940 which was the most severe period in terms of material living conditions for the population. We have taken the period 1936-49 as the reference to measure the contextual exposure to war and autarchy-related hardships during the two first decades of life. Our analysis will consist of exploring the deviations in mean cohort height with respect to what would have been expected in absence of war and post-war autarchy. In good logic, the longer the exposure, the larger the expected downward deviation from the trend. To be noted, the first half of the 1940s was harder in terms of material living conditions and also, auxology has pointed out that environmental stressors have greater impact on physical growth when they occurred during its critical periods (i.e. infancy or adolescence). Thus, in order to ease the interpretation of results there are three premises to bear in mind: 1) cohorts born prior to 1920 were merely or

not exposed to those episodes, 2) on average, the longest exposure to hardships prior to adulthood was experienced by cohorts born between 1930 and 1944 and 3) the longer exposure to hardships during the critical periods of physical growth was experienced by the cohort group 1920-24 (ages 15-19) and the cohort groups 1940-44 and 1945-49 (ages 0-4). Importantly, no cohort group involved in our analysis was exposed to autarchy hardships during both critical periods of physical growth. As a major episode of potential influence for anthropometric outcomes among the cohorts born during the two first decades of the twentieth century, the 1918-20 flu pandemic is taken into account for the interpretation of the results (see Fig. 1 and Table 1)[1].

Fig. 1. Lexis diagram illustrating the time and duration of exposure to post-war autarchy during pre-adult life. Spain, birth cohorts 1900-1954.

Table 1. Duration of potential exposure to autarchy by age. Birth cohorts 1900-54.

2. Data and methods

2.1. Height data

The draftees whose height was recorded were born between 1900 and 1954 and they were all examined by medical personnel when they were 21 or would turn 21 in the

[1] Though minor in relative terms, the impact of the flu pandemic extended to 1920. In concrete, in Spain, its fourth (and final) wave happened over winter between 1919 and 1920. The official numbers of deaths reported in Spain were 147,114 in 1918, 21,235 in 1919, and 17,825 in 1920 (Trilla et al., 2008; estimates based on excess mortality rise those numbers to more than 250,000 deaths in total). The fact of including the year 1920 in a cohort group encompassing 1915-20 did not change the results obtained in this work at all (analysis not shown and available upon request).

course of the corresponding year of enlistment. This means that the oldest cohort (1900) was measured in 1921 and the youngest cohort (1954) was measured in 1975.

The heights that were included in the analyses amount to 87,510 and all of them correspond to native males from each of the nine municipalities chosen (see Table 2). These municipalities were chosen aiming at representing diverse socioeconomic contexts and physical environments. To do this a first random exploration of municipal archives was carried out across the three provinces of the Valencian Community to subsequently collect and tabulate the information on draftees from military records. After data screening, we discarded some municipalities with incomplete height series, few cases by birth cohort (due to very small population size) or high proportion of missing heights. Thus the final sample is made of those municipalities with full coverage of the time span under research and enough quality and robustness of anthropometric data. The reason to exclude non-native draftees is that a varying (and unknown) period of their pre-adult life occurred under different environmental conditions from those of the native draftees.

Our height data are not truncated as medical examinations preceded the final verdict (*fit*/*unfit* for service). The resulting height distribution is roughly normal although it displays a typical heaping effect caused by 0-5 digit attraction. This effect is symmetric for the most part (i.e. it is observed on both tails of the distribution) so that no significant bias on the mean is derived from it (see Fig. 2). Standard deviations from the mean remain fairly constant (between 6 and 7 cm) in all the cross-tabulations tested (e.g. 5yr-cohort groups by municipality; not shown).

Table 2. Description of the height sample

Fig. 2. Histograms and normal curve for height samples

2.2. Infant mortality data

Nutrition in itself (i.e. the amount and quality of nutrient intake) is not the only proximate determinant of adult height which specifically applies to populations exposed to highly prevalent infections. A vast body of previous research has shown that energy intakes and energy expenditures such as those associated with infection interact through a number of complex pathophysiological mechanisms which influence key health dimensions and their corresponding outcomes and/or biomarkers (e.g. morbidity, height, or mortality; see Crimmins and Finch, 2006 for a review). The trade-off between energy intake and expenditure is usually called net nutrition.

As with foodstuffs, usually we lack precise information on factors driving energy expenditure at the individual level. Alternatively, the infant death rate (m_0) which indicates the incidence of mortality upon a given birth cohort during the first year of life, can be used as a proxy for sanitary and hygienic conditions as it is assumed that breastfeeding partly prevents or moderates the effects of malnutrition that are derived from food deprivation (Crimmins and Frinch, 2006; Scherbaum and Srour, 2016). As the background of food insecurity (i.e., the efficiency of the policies implemented to mitigate it) is at the core of this research, we have controlled the other principal component of net nutrition (illness-related energy expenditure) by using the incidence of infant mortality as a proxy for general morbidity over the period analyzed (see similar approaches in Crimming and Frinch, 2006; Quintana-Domeque et al., 2011).

The annual infant death rates (per thousand live births) for the period 1900-54 in the Valencian Community are taken from Gonzálvez (2003) and were aggregated in coherence with the interpretation of adult height outcomes (this is to say, as a cumulative net result of energy accounting during the two first decades of postnatal life). The left panel in Fig. 3 displays the annual data on which such conceptual-methodological approach rests on whereas the right panel depicts the result of data aggregation (the 5yr-averaged m_0 is not used in our analysis but shown for illustrative purposes). For a better understanding of the result section it is worth paying attention to the relationship between height and infant mortality which, for the most part, has a highly negative correlation except for the period-cohorts 1919-30 (shaded area in Fig. 3, right panel). In this period, infant mortality decreased steadily whereas cohort height slightly decreased or stagnated.

Fig. 3. Height and mortality in Valencian Community, 1900-54.

2.3. Study context

The empirical evidence used in this paper comes from the Valencian Community, a Spanish region located to the East of the country. On the eve of the civil war (1936-39), it was among the most industrialized regions of Spain, its per capita GDP being close to the national average (Martínez-Galarraga et al., 2015). Also, previous anthropometric studies showed that the average male height in Valencia was in the range closest to the Spanish average (Martínez-Carrión and María-Dolores, 2017).

Our height sample is made of industrial towns (2), service-oriented towns (2) and agrarian towns (5). Among the latter we find diverse productive contexts in terms of farming systems (e.g. irrigated vs. traditional dry farming) and/or the degree of

commercialization. We would expect our results at a regional level to resemble the picture obtained for urban-industrial towns as these comprise a high proportion of cases.

2.4. Methods and techniques

Birth cohorts were grouped into five-year intervals for analysis (N by cohort group and municipality always amount to more than 100 valid cases and there are over 500 valid cases for the vast majority of cohort-municipality combinations; not shown). Two cohort groups were chosen as height references (i.e., cut-off points for establishing a linear trend): 1900-04 and 1950-54. These birth cohorts grew up without being exposed to the first decade of autarchy (1940-49) which was no doubt the most severe in terms of living conditions (rationing ended officially in 1952). This is not to say that the cohorts born prior to the 1940 did not face a variety of environmental stressors. For instance, virtually all birth cohorts born during the two first decades of the twentieth century were exposed to the effects of the 1918-20 pandemic prior to the completion of physical growth. In concrete, the reference cohort group 1900-04 closed its physical growth under the influence of that event and the cohort group 1915-19 was exposed at pre-natal time as well as early in infancy. Both groups, nevertheless, completed their physical growth prior to any potential influence of autarchy. The same applies to the cohort group of 1950-54 as they not only enjoyed their infancy in a context of food security but, especially, they lived their adolescence during Spain's great leap forward of the 1960s and the first years of the 1970s. Based upon these two cohort groups (1900-04 and 1950-54), we have applied a straightforward technique which consists of depicting a linear trend by interpolating the corresponding height means. This trend represents a constant increase in mean height across the cohort groups between 1900

and 1954 (i.e., as if the civil war and autarchy had had no effect on the biological well-being of the population).

We have compared the linear trend with the actual mean height across cohort groups in order to capture the (hypothetically downward) deviations associated with autarchy. Also, we have regressed cohort height on m_0 aiming to control the effect of hygienic and sanitary conditions (i.e., infection environment). For instance, if adult height exclusively depended on hygienic-sanitary conditions we would observe a perfect lineal correlation between the average height of a given cohort group and its 20yr-averaged infant death rate. Downward deviations would indicate a nutrition deficit (i.e., a given cohort group should have grown taller according to the cumulative sanitary conditions over its growth cycle but did not due to the lack of adequate nutritional inputs). By contrast, upward deviations would indicate that people grew taller than expected; this is to say, food inputs met the requirements of physical growth despite a relatively deficient infection environment as proxied by infant mortality.

3. Results

Fig. 4 displays the evolution of mean height aggregated into three broad 15yr-cohort groups: Municipalities are ranked according to the mean height of the cohort group 1900-14.

First, with few exceptions, municipalities with higher height averages in 1900-14 continued to be so for generations. These 'taller' municipalities were invariably smaller towns with economies that depended mainly on agrarian activities. By contrast, the poorest anthropometric outcomes are found among larger towns either specialized in manufacturing or service provisions, regardless the period analyzed.

Second, it is apparent that inter-generational progress in height was unequal across the groups analyzed whereby cohorts of draftees born in the period 1920-34 exhibit the lowest rate of change with respect to the preceding cohort group.

Third, there is no association between the two former points in that the discrepancies in the rate of growth across cohort groups do not follow an economic or demographic pattern. This is to say, municipalities behaved in a very erratic manner, regardless of their population size or prevalent economic sector. This said, all but Alcoy recorded higher rates of inter-generational growth during the second interval analyzed.

Fig. 4. Mean cohort height by municipality

Fig. 5 shows the linear vs. the actual height trend (left panel) and the absolute difference between the two (right panel), the latter indicating height loss with respect to what would have happened if the rate of inter-generational growth had been constant.

It is apparent that the deviations from the expected trend depicted is not fully related to the context of autarchy as it affected to cohorts whose physical growth developed entirely or almost entirely prior to autarchy. This is the case of the groups 1910-14 and 1915-19. On this point, the potential scarring effect of the 1918-20 flu pandemic on survivors should not be overlooked and it will deserve some specific comments in the discussion section. However, and importantly, downward deviations among those cohort groups are minor if compared to the groups of cohorts that were exposed to autarchy. In particular, cohorts born between 1920 and 1934 display the largest deviations from the linear trend (see Fig. 5). The accumulated deviations from the trend throughout the period analyzed sums up almost -7 cm.

Fig. 5. Male mean cohort height (mm) in Valencian Community (1900-54). Actual trend vs. linear trend (left); deviations from the linear trend in historical context (right).

Fig. 6 shows the relative distribution of such total deviation (-68 mm) across birth cohorts. The results from this analysis confirm that deviations from the trend exacerbated, coinciding with the first group of cohorts that was exposed to war-autarchy related environmental stressors, that is, cohorts born in the period 1920-24. At the time when the Spanish Civil War started (1936), these cohorts were aged between 12 and 16 years old and most of these individuals had not finished their physical growth when autarchy commenced. It can be observed that the magnitude of height deviations do not correlate exactly with the duration of the exposure. To this regard, it must be remembered that our approach does not operationalize the intensity of hardship but just considers the age at the time of exposure and the potential duration of exposure. Despite this limitation, it is worth noting that the trend observed at the beginning of the century was not resumed until 1945-49. To be noted, the exposure to autarchy-related hardships as depicted in the pre-adult life trajectories of the cohorts analyzed would account for more than 90% of the total height deviations from the trend.

Fig. 6. Distribution of height deviations from the linear trend by birth cohort (%).

Table 3 replicates the former analyses for each municipality in order to gain an insight into the magnitude of the impact of the autarchic regime as a function of environmental and socioeconomic contexts. These analyses reveal diverse situations. For instance, in some small (at the time) towns such as Gandia, we did not find any evidence of a worsened situation that may be strictly associated with the autarchy; in a larger town like Castellon, the height deviations from the trend could be traced back to before the population was exposed to warfare and autarchy which is also true for Sueca. This said, seven out of the nine cases analyzed (all but Gandia and Villarreal) point to the central implications of the autarchy as the height deviations from the linear trend either started or notably increased, coinciding with the cohorts that were exposed to such context. For instance, in the town of Alcoy, an important industrial hub, the mean height of the draftees born prior to 1920 increased at a rate of 1.8 mm per year above the trend whereas the height of those born after this year decreased by -.5 mm (cohorts of 1920-34) and -.8 mm (cohorts of 1935-49) per year below the trend.

Table 3. Sum of height deviations from the linear trend by cohort group and municipality (mm).

Fig. 7 and 8 portray the situation experienced in the two most industrialized towns in our sample, Elche and Alcoy (labelled as “industrial”) compared to the municipalities with economies mostly based on agriculture at the time (Villareal, Gandia, Requena, Sueca and Pego; this group is labelled as “agrarian”). It must be noted that the impact of postwar autarchy on the industrial towns was greater than in rural areas as autarchy put an abrupt end to the positive trend in height which was in progress in the industrial towns during the first decade of the twentieth century. The values of the

deviation fell from +6 mm (cohorts of 1915-19) to a minimum of -11 mm (cohorts of 1925-29) in industrial towns whereas in areas specialized in agriculture the variation was between -9 mm (cohorts of 1915-19) and a minimum of -13 mm (cohorts of 1925-29). In other words, in the agrarian municipalities, the worsening of the net nutritional status preceded the potential exposure to the autarchic regime and the latter might be associated with an absolute loss of only about 4 mm with respect to the linear trend. By contrast, in the industrial towns of our sample (Elche and Alcoy), the worsening is fully identifiable with the commencement of the exposure to the postwar autarchy and this worsening amounted to 15 mm which is actually almost four times the impact registered in agrarian municipalities.

Fig. 7. Mean cohort height (actual vs. expected) (mm). Industrial and agrarian municipalities of Valencian Community. Male cohorts 1900-54.

Fig. 8. Deviations from the height trend (mm). Industrial vs. agrarian municipalities. Male cohorts 1900-54

Finally, Fig. 9 depicts the expected height (i.e. modelled mean height) once hygienic-sanitary conditions proxied by infant mortality rates are controlled for. This model specifies height as the dependent variable and it specifies the 20yr-averaged infant death rate (proxy of hygienic-sanitary conditions) as a predictor. The corresponding equation is displayed in the figure together with the determination coefficient R^2). The expected height (straight line) is plotted against the actual height mean of each cohort group (dots). The corresponding vertical distances from each dot to the line are interpreted as the relative performance (over-performance vs.

underperformance) of nutrition as a factor of nutritional status (i.e. net nutrition). The results of this analysis indicate that food intake values either in quantity or quality were in line with or slightly higher than the expected values according to infection exposure among cohorts born until 1919. Subsequently, this pattern was reversed among cohorts born since 1920. Then we see that nutrition tended to underperform with respect to the corresponding potential infection exposure. There are three cohort groups which have particularly negative results in this regard: 1920-24, 1925-29 and 1940-44. Again, this seems to be coherent with the burden of exposure to the context of postwar autarchy prior to adulthood. By contrast we can observe that the cohort group 1950-54 recorded an average height significantly higher than expected as a function of hygienic and sanitary conditions. This is not surprising as these were the first birth cohorts of Spaniards that developed their entire physical growth in a context of food security and substantial progress during the nutrition transition.

Fig. 9. Scatter plot of mean height and 20yr-averaged infant death rate by cohort group. Valencian Community, 1900-54

4. Discussion

A number of anthropometric studies in Spain have shown that male cohort height increased moderately, yet steadily, after the end of the Civil War (María-Dolores and Martínez-Carrion, 2011; Spijker at al., 2012; Cámara, 2015) coinciding with the implementation of autarchic policies by the fascist regime. This is also the case of the Valencian Community. This increase together with the positive outcomes displayed by other sociodemographic indicators, has puzzled historians in the light of both the poor performance of economy (Prados de la Escosura, 2017) and the picture of severe

deprivation that was documented at the time (Del Cura and Huertas, 2009). This paradox invited to ask whether social policies (food provision policies in particular) during the context of economic autarchy contributed to buffering or even neutralizing the effects of scarcity on a key component of the biological well-being of the population such as nutrition. In this study we have coped with such paradox by 1) analyzing deviations from a cross-generational linear trend in height and 2) controlling infection-related environmental factors which interact with nutrition in explaining height outcomes.

At the regional level, the deviations from a linear trend reveal negative effects of the autarchic regime on the nutritional status of the Valencian male population. Large deviations from the trend occurring across cohorts born during the first half of the twentieth century persisted until the end of rationing (mid 1950s). Therefore, although male mean height increased steadily among cohorts born during the 1930s and 1940s in the Valencian Community, it did so to a much lesser extent than would have been expected in normal conditions at the time. This said, our results reveal that downward deviations, though smaller in magnitude, preceded the exposure to the hardships associated with autarchy. On this point, the potential scarring effects from a major episode of environmental stress like the Spanish flu (1918-19) must be taken into account.

According to our results, male cohort height analyzed into 5yr-cohort groups was invariably increasing over the two first decades of the twentieth century. Importantly, this trend traces back to the final decade of the nineteenth century in this and other Spanish regions. Certainly cohort height and mortality paralleled occasionally in the short term (for instance both peaked in 1918 and dropped in 1919 as depicted in Fig. 3). This could be due to a mortality-related selection effect in that potentially

weaker and/or poorer nourished (thus potentially shorter at adulthood) segments of the population could have been removed at early infancy (e.g. Waaler, 1984; Bozzoli et al., 2009; Havari and Perachi, 2017). However, if really existent, such effect is largely buffered when analyzing 5yr-cohort groups. What is likely evidenced in the results is the cumulative deleterious effect of the pandemic on the survivors. To be noted, virtually all cohorts born during the first two decades of the twentieth century were potentially exposed to the pandemic prior to physical growth completion. Actually, it is interesting to observe that the improvement of male cohort height trend slowed down among the cohort groups that were exposed to the pandemic as adolescents or during the years preceding the end of their physical growth. Yet in absence of longitudinal data for the individuals involved in the analysis, our reflections on the former point are necessarily speculative to a large extent. In light of the bulk of the evidence obtained in this work we tend to believe that the pandemic-related scarring prevailed over any potential mortality-driven selection which is in line with the conclusions obtained by a number of previous works based on either adult and pre-adult heights (Lin et al., 2014; Ogasawara, 2017 and 2018) or other health and human-capital related outcomes in later life (e.g. Almond, 2006; Almond and Currie, 2011). In words, it seems quite reasonable to hypothesize that the loss of momentum of inter-cohort height trend might have initially had to do with the scarring effect associated with the pandemic while such effect would have intensified dramatically among the cohorts that were exposed to war and/or post-war autarchy. Nuances to this regard have been observed at the sub-regional level which would deserve specific attention in the future.

Overall, it must be noted that in most areas sampled in this study, the large industrial towns in particular, the worsening of the nutritional status was principally related to the environmental conditions that prevailed in the autarchic context that

followed the Spanish Civil War. This turns the focus of the discussion towards the efficiency of the socioeconomic intervention and social policies undertaken by the fascist regime in Spain, especially those related to health and nutrition.

Illustratively, in terms of health policies, the budget addressed to public health from the State remained at very low levels between 1943 and 1958 (Comín and Martorell, 2013: 945-946). This is assumed to have impacted negatively on the provision of health infrastructures and medical-sanitary equipment as well as on the training of qualified personnel (Bernabeu et al., 2006; González and Ortíz, 2017). In particular, these deficiencies affected the rural areas of the regions that were most affected by hunger and infectious diseases. Despite this, it is apparent that such limited health intervention ought to count among the explanatory factors for the sustained decline in mortality experienced since 1942 in Spain. To this regard, previous research has pointed to the influence of some measures in the field of childcare and obstetrics. For instance, the extension of child hygiene services to rural areas, the implementation of maternity insurance as well as the social work developed with mothers regarding the preparation and conservation of food and other maternal cares (Arbelo-Curbelo, 1962; Bernabeu, 2002; Reher, 2003).

Also, and principally in our opinion, the progress in the fields of therapeutics and pharmacology against infectious diseases, such as antibiotics, sulfa drugs and the gradual diffusion of new vaccines could contribute to the reduction of fatal outcomes from infection, which applies to a number of European societies at the time (Barona, 2014; Pérez-Moreda et al, 2015). To this regard, the key role played by antibiotics has been underlined in the case of Spain and other European countries. For instance, penicillin was introduced in Spain in 1944 after a trade agreement with the United States although its massive use and, particularly, its spread to rural areas will not take

place until some years later. Not before 1949 Spain started to produce it (González-Bueno, 2012). Moreover, vaccination programs were an official priority for the Francoist regime given the high prevalence of infectious diseases among children as well as the rise of infant mortality after the Spanish Civil War. In 1944 vaccination against smallpox and diphtheria became compulsory although the abovementioned lacks in terms of health infrastructures hampered the expected progress on this point noticeably (Pachón del Amo, 2004).

The former arguments must be taken together with the food policies implemented by the Spanish dictatorship. Rationing was officially established from 1939 to 1952. The objective was to guarantee a constant and fair supply of basic foodstuffs and to avoid cornering and speculation (Barciela, 2015). "*Not a home without fire, not a Spaniard without bread*" was the famous Francoist slogan. Nevertheless the 1940s are known as the 'famine years' in Spain, and the period is actually considered by some as one of the greatest food catastrophes in 20th-century Europe (Del Arco, 2020) whose prevalence was among the highest across European countries (Havari and Perachi, 2017). Some studies revealed that the ration amounts were rarely met and what the population received was well below the official figures throughout the whole of the 1940s (Molinero and Ysás, 2003). With respect to the evidence available for the Valencian Community, in 1944 (when harvests resumed normal levels), bread rations were actually around 40% of the officially established amount. Other basic products did not exhibit better results. This means that for the bulk of basic products, the black market was the only available option. In the province of Valencia as well as in other regions of the country, uneven access and discretional distribution was criticized even by the local authorities belonging to *Falange* (the regime's party) (Molinero, 2014; González and Ortíz, 2017). Thus, among other factors, the state intervention in agrarian

prices led to scarcity and an increase in the volume of products accessed through the black market due to the lack of economic incentive for either growing or trading these products legally (Christiansen, 2012; Barciela, 2015).

In sum, the rationing system implemented by the Francoist State would not only have failed in their goals (to ensure food supply at low prices) but would have generated the opposite effect: scarcity, high prices of basic foodstuffs and, consequently, the spread of deprivation and malnutrition. Foodstuffs were the products that fueled the black market the most: bread grains, olive oil, potatoes and legumes. Even in the light of this evidence, no measures were taken by the authorities who insisted that rationing and price intervention were the way to ensure supply and low prices. In turn, the extension of poverty and hunger and the general worsening of living conditions derived in many families to implement behaviors and survival strategies that used to consist of the participation in clandestine food markets and, importantly, of the use of children as labor force.

Although our data does not permit to cope with this issue, it seems to us a suggesting point that should deserve specific attention in future research given its potential implications on net nutrition. Actually, this factor, together with some insights on age-mortality patterns could contribute to clarify and explain the contrasts observed in our results at the sub-regional level. Francoist's labour regulation was scarce, allowing a large number of boys and girls to be employed in domestic and agricultural tasks. Previous works outline that during the first third of the twentieth century, the incidence of child and youth labour in Spain was gradually reduced. The impact of the Civil War and the autarchy on the living conditions, however, reversed the achievements made in this field until then. More importantly, despite the fact that working age was established at 18 years, the application of certain assumptions often

allowed working at 14 years (Amich, 2008: 170-171). This invites us to bring attention on the influence of this factor on net nutrition during puberty and the years that preceded the end of the physical growth process. Moreover, though the evidence obtained is indirect so far, we can hypothesize that one of the factors that influenced the greater or lesser incidence of pre-adult labour was the different productive specialization of each area. To this regard, some studies suggest that where agriculture was more intensive and labour-demanding, as was the case of irrigated areas in the Valencian Community, child labour participation began earlier (Borrás, 2002: 505-506). Also, during the Spanish Civil war and post-war autarchy, the available data on draftees' occupation reflects the halt of the economic modernization process so that the productive structure of this region returned to its former agrarian prevalence to a good extent. This, according to previous works, could be associated with an increase of child labour in the Valencian agrarian sector during this period (Ayuda and Puche, 2014: 107).

5. Conclusions

In our opinion, there is no paradox between the positive male height trend and the negative environmental conditions documented in this and other Spanish regions during the decade of 1940. As physical growth must be interpreted as the cumulative result of living conditions during the first two decades of life, therefore, Spanish cohorts born during the war and the first postwar decade were able to partly catch up in height growth once the most severe environmental stressors were partly overcome. This, according to economic and sanitary indicators, occurred since the mid-1950s. Previous research found that food security for most of the Spanish population was achieved during that decade thus retrieving the path of the nutritional transition that was

interrupted by the Civil War and postwar autarchy. Significantly, the birth cohorts born in the 1950s will close their physical growth during the decades of 1960 and, especially, the decade of 1970. To this, some public health interventions together with medical advances, though limited, must be mentioned as contributors that diminished the impact of infection on the energy expenditures that influence net nutrition. Thus we are in front of converging factors which likely interacted for the recovering of the nutritional status of Spaniards born since the decade of 1940s. Our results also invite us to believe that the 1918-20 flu pandemic was not a key determinant of the main trends and deviations found although it is likely that it provoked deleterious effects on the physical growth of cohorts born prior to 1920. Actually, we hypothesize its scarring effects to lie behind the beginning of height deviations which actually preceded the exposure to autarchy. Disentangling the magnitude of scarring and mortality effects on height is virtually impossible in absence of life-term individual panel data (see Alter, 2004 for a review). Tentatively, according to the results obtained in this work at both regional and sub-regional level, we believe that the flu pandemic could have affected negatively the nutritional status of the survivors thus deriving in shorter-than-expected mean cohort height. This would be reflected by the slight downward deviation observed within the cohort group 1915-19.

To be sure, it can be concluded that the nutritional status of the Valencian male population worsened –dramatically in some cases- among birth cohorts born since 1920. It is important to note that the 1920-24 cohort group was the first to be exposed to warfare and autarchy prior to completing their physical growth. Overall, nutrition levels among the cohorts born at the beginning of the century, after controlling for infection, were not recovered until four decades later, among cohorts born after 1945 (which in common terms is more than one generation).

Clearly, the magnitude of downward deviations from the trend (nutrition underperformance) was greater among cohorts born during the 1920s which raises another interesting conclusion of this study. In auxology it is recognized that there are two critical periods during which structural deprivation and/or exposure to infection are particularly deleterious in terms of growth: early infancy and puberty. There is often uncertainty when interpreting height outcomes as cycles with highs and lows may be associated with one or another economic or sociopolitical episode affecting the basic components of nutritional status. The evidence obtained in this work indicates that the most affected cohorts (those born during the 1920s) were mainly exposed to environmental stressors after infancy which has important implications for the consolidation of the underlying mechanisms determining adult height (at least in Spain for the period analyzed). In conclusion, if we had to point to any critical period for physical growth within the context analyzed in this work, it would be puberty and/or the years preceding growth completion. Likewise, this would explain because subsequent cohorts analyzed grew taller on average despite of early exposure to autarchy hardships. Recent findings point in the same direction thus assessing this elementary auxological premise, that is, that children may experience a catch-up in growth and/or postpone both their pubertal spurt and the end of their physical growth process when the environmental conditions during infancy are not favorable but these improve subsequently. For this reason it is the entire physical growth process, including the years preceding its completion, what should be bear in mind when analyzing the potential impact of environmentally-related growth disruptors (Schneider et al, 2020; Beeking and Kok, 2017).

While the explanation of disparities across municipalities does not form part of the objectives of this study, they seem worth mentioning to us as they open new paths

for further research. For instance, evidence of an urban and/or industrial penalty as such is tenuous. In essence, our results indicate that height trends differed substantially across municipalities regardless of whether they were more or less urbanized/industrialized.

Finally, it is necessary to remind that this research is restricted to the male population so that these conclusions must be nuanced. The scarce evidence on female heights (obtained from health interview surveys at national level in Spain) has uncovered diverging trends with respect to males among several cohort groups which, very likely, would reflect both a different degree of eco-sensitiveness in front of environmental stressors and diverse social implications related to the socioeconomic and historical contexts occurred in this country during the twentieth century. Spanish women born during the 1920s would have coped better with the environmental stressors related to war and post-war autarchy which could be the result of greater biological resilience. Abnormally low values of sexual size dimorphism would point in that direction (Cámara, 2015). By contrast, their inter-generational progress in terms of height slowed down during the 1940s and the 1950 with respect to that found among males. This could be interpreted as the result of some gender bias, that is to say, girls would have suffered from some sort of neglect with respect to boys during the period of autarchy (Costa-Font and Gil, 2008). That the social status of women worsened notably under Francoism is unquestionable. Yet we still lack of enough convincing evidence involving the determinants of nutritional status that could produce such physical outcome. Actually, other Western countries evidenced an identical transitory slowing down of cohort female height under diverse political and socioeconomic circumstances throughout the twentieth century (e.g. Cavelaars et al., 2000; Komlos and Lauderdale, 2007: 209). For the Spanish case, one possible explanation deserving further research could be the

gradient in the allocation of food which partook of the rationing policy during autarchy. To be noted, the allotment for adult females was 80% that of the (male) breadwinner and for boys and girls until age 14 it was 60% of the breadwinner's. No nutrition or examination survey of the various endorsed and supervised at the time by the Rockefeller Foundation pointed to gender bias during infancy, but certainly such factor could have operated since age 14 and, especially, once descendants started working.

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