



Growing taller unequally? Adult height and socioeconomic status in Spain (Cohorts 1940–1994)

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ABSTRACT

Socioeconomic inequalities and their evolution in different historical contexts have been widely studied. However, some of their dimensions remain relatively unexplored, such as the role played by socioeconomic status in the trajectory of biological living standards, especially net nutritional status. The main objective of this article is to analyze whether the power of socioeconomic status (SES) to explain differences in the biological dimensions of human well-being (in this case, adult height, a reliable metric for health and nutritional status) has increased or diminished over time. Educational attainment and occupational category have been used as two different proxies for the SES of Spanish men and women born between 1940 and 1994, thus covering a historical period in Spain characterized by remarkable socioeconomic development and a marked increase in mean adult height. Our data is drawn from nine waves of the Spanish National Health Survey and the Spanish sample of two waves of the European Health Interview Survey (ENSE) for the period 1987 to 2017 (N = 73,699 citizens aged 23–47). A multivariate regression analysis has been conducted, showing that, as a whole, height differentials by educational attainment have diminished over time, whereas differences by occupational category of household heads have largely persisted. These results indicate the need for further qualification when describing the process of convergence in biological well-being indicators across social groups. For instance, the progressive enrollment of a greater proportion of the population into higher educational levels may lead us to underestimate the real differences between socioeconomic groups, while other proxies of SES still point to the persistence of such differences.

1. Introduction and objectives

In the study of the biological dimensions of well-being, anthropometric parameters, particularly human stature, have gained unquestionable relevance in recent decades (Blum, 2013; Galofré-Vilà, 2018; Thompson et al., 2020). Since Tanner's groundbreaking work in auxology, human physical growth has come to be regarded as a 'mirror of health' (Tanner, 1986) and, as a result, adult height is widely accepted as a final output indicator of several determinants of health related to living conditions during pre-adult life. The height reached by an individual in adulthood is considered a reasonable measure of the influence

of environmental factors (i.e. physical, epidemiological and socioeconomic (Bozzoli et al., 2009; Steckel, 2012; Akachi & Canning, 2015)) on maximum genetic growth potential.¹ Basically, the interaction between these factors determines the balance between energy intakes (e.g. quantity and quality of food - Morgan, 2000; Puentes et al., 2016) and energy expenditures (e.g. burden of exposure to illness and infectious diseases and its interplay with malnutrition - Crimmins & Finch, 2006a, b; Perkins et al., 2016).

A number of factors associated with the socioeconomic status of individuals may mediate this basic relationship between energy inputs and outputs, giving rise to the possibility of using human height as an

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¹ The effects of the environment on height and health susceptibility in adulthood can be traced right back to the gestational period (Roseboom et al., 2006) and the predictive value of height in early childhood has been extensively demonstrated (Chen & Zhou, 2007).

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indicator of socioeconomic differentials and/or inequalities. On the whole, it is expected that a higher socioeconomic position has a positive influence on the equation of energetic inputs and outputs that we have defined based on auxology. On the inputs side, a higher SES would imply a greater possibility of accessing a sufficient and varied diet; on the outputs side, it would imply the possibility of living in healthier domestic contexts and of overcoming infectious processes that negatively affect growth (Cavelaars et al., 2000; Silventoinen et al., 2001; Subramanian et al., 2011). Furthermore, the socioeconomic status (SES) clearly determines the need to work (and contribute to household income) prior to adulthood, which is another potential factor of energy expenditure.²

The way SES and, consequently, SES-related differences are approached in anthropometric studies strongly depends on the availability of information. However, information on income is hardly available either due to the limitation of sources (e.g., for studies of past populations) or the reluctance of informants to provide these data (e.g., for studies of current populations based on survey data). For this reason, the most frequent and used proxies of SES are variables such as educational attainment and occupation. The two variables are related to one another to a greater or lesser extent. We know that prior to the implementation of welfare state provisions in Western societies, the possibility of following an educational path (i.e., the possibility of attending school and finishing primary and subsequent levels) was very limited (to only those from higher socioeconomic strata who could afford it). Needless to say, the SES was and still is partly associated with the occupational category of household heads. Therefore, the level of education is often taken as a derivation of socioeconomic position and, in consequence, as a valid proxy of SES. That said, we know that the synergies between education and the net nutritional status are actually more complex, as education in itself may be one of the determinants of the former in that it can prevent or enhance a good number of factors that, according to auxology, influence the physical growth process. For example, education promotes knowledge of hygienic-sanitary measures, leads to the adoption of lifestyles with less risky health behaviors and is also a determinant of diet choice, where possible (Gao & Smyth, 2010; Som et al., 2014; Viviani et al., 2020).

Over the course of the twentieth century, average adult height increased dramatically in most populations around the world with few exceptions, due to widespread improvements in living standards, nutrition and health (Cole, 2000; Grasgruber et al., 2016; NCD Risk Factor Collaboration, 2016). Western societies are a good illustration of this process from the end of the nineteenth century onwards (Hatton & Bray, 2010; Floud et al., 2011; Deaton, 2013). In light of the evidence, it is assumed that among different birth cohorts, environmental conditions will dictate the development of adult height and its trends within genetically similar populations. In the long run, therefore, we may expect increases in human height to mirror the general improvement in living conditions, coinciding with the evolution of other health and well-being indicators (Bogin et al., 2018; Fogel & Costa, 1997; Fogel, 2004; Grasgruber et al., 2014).

That said, progress in environmental conditions is not necessarily linear and, moreover, their impact on the different population segments varies considerably. There is extensive literature documenting drop cycles as well as periods of stagnation of inter-generational growth, correlating with diverse socioeconomic, political and epidemiological

² Child labor is considered another major source of energy expenditure and its deleterious effect on growth and development have been demonstrated in some studies (Ambadekar et al., 1999). Its negative effects on health are also well known. However, its impact on adult height is still a matter of some controversy (Cortez et al., 2007). Work during childhood, particularly in the case of females, increases the risk of illness, thus potentially interfering with the abovementioned balance between energy intake and energy expenditure (O'Donnell et al., 2005).

scenarios (e.g. Baten & Wagner, 2003; Cox, 2019; Komlos & A'Hearn, 2019). Furthermore, it is widely accepted that environmental factors are mediated by the socioeconomic status of individuals as both energy intake and energy expenditure are often socially determined. This leads us to consider height differentials across diverse social groups as potential indicators of inequalities in the biological dimensions of well-being (Blum, 2013; Carson, 2009; Gomula et al., 2021; Jaadla et al., 2021; Lopuszanska-Dawida et al., 2020).³

This paper seeks to examine the evolution of height differentials by SES in Spain over a period when major improvements in living conditions occurred: the second half of the twentieth century. To this end, we analyze the role of individual and household-level factors. In practice, this involves analyzing the variation in the level of impact on height of these factors in different socioeconomic and political scenarios. Spain is a particularly interesting case in this regard due to the accelerated pace and intensity of its transition towards high levels of development and standards of well-being (Prados de la Escosura, 2021; Carreras & Tafunell, 2021), which resulted in sharp contrasts in living conditions over the time span (i.e., among the birth cohorts) analyzed in this study. For instance, life expectancy increased from 50 years (decade between 1930 and 1939) to 66 years (decade between 1950 and 1959) (Human Mortality Database). Prior to the COVID-19 pandemic, this indicator in Spain ranked among the highest in the world (82.7 years in the period 2010-18; Human Mortality Database). As for adult height, this country recorded one of the highest rates of inter-generational growth over the second half of the twentieth century (Hatton & Bray, 2010). The involvement of various different factors in this trend has been broadly discussed at the macro level, e.g., the positive evolution of economic indicators (Prados de la Escosura, 2008; María-Dolores & Martínez-Carrión, 2011), the nutrition transition (Cañabate & Martínez-Carrión, 2017), the dramatic drop in the prevalence of infectious diseases and infant mortality (Galofré-Vilà & Harris, 2020; Quintana-Domeque et al., 2011) and, finally, the implementation of social provisions that reduced the inequality in terms of socioeconomic status and enabled regional convergence (Cámara et al., 2019; Martínez-Carrión & María-Dolores, 2017). Nonetheless, relatively little is known about the effect of these socioeconomic processes on specific segments of the population, or in other words, about the ways in which individual and household-level determinants operate on the trajectory of biological well-being.

This paper addresses two specific research questions. The first is whether the rapid increase in the cohort average height observed during the second half of the twentieth century was evenly spread across different social groups in Spain. In this regard, we seek to determine the degree of social convergence of biological living standards. The second question is how SES and the manner in which it is operationalized contribute to explaining height differentials in one socioeconomic context or another. In other words, the extent to which SES more or less influences height differentials depending on historical periods and their socioeconomic characterization and also the proxy that is used (for SES). Men and women are addressed separately in the analysis of these two questions, so as to establish (as a matter of additional interest) whether the key determinants operate similarly on both sexes over time.

The main hypothesis driving our research is that historical contexts of high environmental stress contributed to an increase in anthropometric inequality in the absence of significant institutionalized social provisions. In such contexts, socioeconomic status would condition access to an adequate diet in both quantitative and qualitative terms, as

³ Spain serves to illustrate this. Since the mid-eighteenth century, height differentials across socioeconomic groups (i.e. according to occupation, educational attainment, etc.) have been clearly documented by elite groups recording average heights of more than 1.70 m in the case of men Cámara & García-Román, 2010; Cañabate & Martínez-Carrión, 2018; Fuster, 2017; García-Montero, 2018).

would the burden of disease and physical labor in pre-adult ages. SES would gradually lose its ability to explain height differentials over time (i.e., across successive groups of cohorts) as welfare state provisions began to be more effectively implemented. Thus, the effects of SES on height would diminish for younger cohorts of Spaniards as a result of the overall improvements in nutrition and sanitation, as well as increased access to health services and a broader range of facilities. For older cohorts, however, we would expect SES to determine biological well-being to a greater extent due to the way it mediates access to basic resources and a healthier domestic environment.

Accordingly, height trends by social group should show a converging trend among younger cohorts of Spaniards who underwent their physical growth cycle in the context of both 1) the framework of a highly developed society and 2) widespread welfare provisions. Conversely, we would expect to observe higher social differentials and a greater influence of SES on height within historical contexts associated with high environmental stress and/or a low level of social provisions.

Our study covers Spanish cohorts born from the 1940s to the 1990s. We have grouped these cohorts into 10-year groups for analysis, except for one five-year group (1990-94). Clearly, the length of the growth cycle of any given cohort will exceed the decade of their group. This is a limitation of our study that we have opted to accept in the interests of parsimony in both our analysis and the interpretation of the results. As a rule, all cohort groups are made up of single cohorts who went through their growth cycle in progressively improving environmental conditions. By way of a brief overview, the socioeconomic and political conditions in Spain in the decades analyzed were as follows. In the 1940s, Spain was characterized by the adverse effects of the Civil War. Autarchy held back the economy until the end of the 1950s, although in this decade an economic recovery and an acceleration of the urbanization process took place (Prados de la Escosura & Rosés, 2012). During the 1960s, all indicators of human well-being improved (Prados de la Escosura & Rosés, 2021). The progress of the welfare state from 1975 onwards enabled inequalities to be reduced through the social redistribution of income. In the 1980s, the welfare state was broadened and strengthened thanks to a substantial growth in public spending on education and health. The new Historical Index of Human Development reveals that after three decades of progress in living standards, Spain closed the gap with Europe in around 1990 (Carreras & Tafunell, 2021; Prados de la Escosura, 2021). Nevertheless, the episode of economic recession in Europe in the early 1990s caused unemployment to rise to 20% in 1994 and slowed economic growth.

2. Data and methods

The study uses microdata from the adult samples of two health interview surveys: Encuesta Nacional de Salud de España (Spanish National Health Survey – ENSE) conducted in 1987, 1993, 1995, 1997, 2001, 2003, 2006, 2011 and 2017, and the Spanish sample from the European Health Interview Survey (EHIS) conducted in 2009 and 2014. Both are cross-sectional surveys (there is no follow-up of individuals) and use multi-stage stratified sampling techniques with proportionality criteria based on sex, age and place of residence. The interviews were held face to face and all the information provided was self-reported. For detailed information about criteria and general methodological aspects, see (Ministerio de Sanidad Online) and (Instituto Nacional de Estadística Online).

We proceeded by first, harmonizing the variables included in the analyses across the waves of these surveys and, second, by aggregating these data, thus obtaining one large database. The harmonization and aggregation of this large body of data allows us to construct long-term series of cohort heights and also provides the statistical consistency required to produce cross-tabulations of height as well as a number of key explanatory variables. To homogenize the respondent type, only direct informants were selected. Data provided by proxies were used in the ENSE of 2003 and 2006 but these were discarded for the analysis.

Table 1
Sample size of valid cases by variable of interest.⁶

| Information about | Valid cases |
|--|-------------|
| Height | 73,699 |
| Educational attainment | 72,905 |
| Educational attainment (household head) ^a | 34,844 |
| Social class (household head) | 32,551 |
| Region of residence | 73,741 |
| Age | 73,741 |
| Population size (municipality of residence) | 73,741 |
| Sex | 73,738 |
| Marital status | 73,665 |

Source: Own calculations from the abovementioned sources.

^a Respondents who headed households amounted to 35,178 whereas those who did not totaled 38,563.

Furthermore, only individuals with Spanish citizenship were selected.⁴ Age and/or year of birth were used to sort individuals into the cohort groups that formed the basis of our approach.

The age of the respondents selected for analysis was restricted according to two criteria: they had to be over 20 years old in order to have completed their physical growth process and they had to be under 50 years old in order to avoid distortion of the data due to age-related shrinkage.⁵ After the selection and grouping of birth cohorts, the age range of the respondents included in our dataset was 23–47 at the time of interview. The aggregation of the microdata from different waves of ENSE enabled us to obtain a good representativeness of cohorts born throughout the twentieth century. Furthermore, this allows us to observe the evolution of the key variables of the study for each group of cohorts in time. In this respect, it is important to note that previous studies based on the ENSE show that the mean height of a group of cohorts remains very stable once adulthood is reached (Spijker et al., 2008). Table 1 shows the number of valid cases according to each variable of analysis.

Height without shoes is self-reported in centimeters and the wording of this item is uniform across surveys (“Approximately, what is your height without shoes?”). It is well known that people tend to overestimate their height, which might be problematic for the use of this indicator in clinical practice at the individual level. However, at a population level, self-reported height has displayed very high correlations with measured height (Rowland, 1990) and it has been used as a valid measure in studies that investigate associations between anthropometric parameters, health predictors and health outcomes (Lipsky et al., 2019). In the case of Spain, the validity of self-reported height to depict general trends over time and socioeconomic differentials has been previously demonstrated (e.g. Spijker et al., 2008; Cámara, 2015). For the case at hand, it can be seen that the height distributions resulting from our sample roughly follow a normal distribution curve. While 0 and 5-digit preference in self-reports generally results in heaping, this occurs at the two tails of the distribution, which tends to remain

⁴ Immigration flows and the immigrant stock in this country prior to the decade of 2000–2010 were low. According to the 1991 population census, a mere 0.9% of the population was foreign-born, increasing to 1.4% in 1996 and 1.5% in 1998 (INE, online a,b). ENSE 2003 asked for citizenship but not for country of birth. For this reason, and given that the date (age) of arrival in Spain was not provided in any survey, we opted to use the variable citizenship. It should be noted that, within the age range of respondents used in this research, the proportion of foreign-born Spanish citizens sampled in the surveys was negligible in the cross-tabulations of cohort groups by the key variables of analysis: 3.3% in 2009 and below 0.5% in the rest of the surveys.

⁵ Shrinkage may occur gradually from age 40 onwards, but especially after 50 (Birrell et al., 2005; de Groot et al., 1996; Dey et al., 1999).

⁶ Sex and age of the household head are not included in the analysis because these variables only offer information for a limited number of observations. Furthermore, 93% of household heads were male and only 7% female.

symmetric for the most part. Moreover, the standard deviations are highly constant across cohort groups and subgroups and are very close to those found in normal distributions of measured heights (Cole, 2000, Fig. 1).

Missing height values (5% of the whole sample) were not randomly distributed across the control variables used in our analyses. For instance, missing heights are more frequent for older cohorts, less educated individuals and women. For these reasons, we imputed any missing values and contrasted the results of our analyses with and without imputed heights (not shown; available upon request). As the differences were negligible in terms of height trends and regression coefficients, we opted to keep the imputed heights in order to achieve statistical consistency for the diverse cross-tabulations implemented in the descriptive analyses. Table 2 displays the valid cases in the final sample by cohort group and sex.

As we can observe in Fig. 1 and Table 2, the final sample size differs noticeably across the cohort groups. This is an expected effect of both a) the available waves of the surveys used and b) the criteria for data selection (i.e., age/cohort restrictions). For instance, individuals who are included within the most recent birth cohort group (1990-94) may only be drawn from the latest available survey which was conducted in 2017. Coherently, this cohort group is made of individuals with a reduced range of ages (24–27 years old). Consequently, there are fewer valid cases for this cohort group (also because this is a 5-year cohort group). In contrast, the individuals of the cohort group 1960-are taken from the surveys carried out between 1987 and 2014 and their age range is complete (23–47 following the restrictions applied).

Aside from the age range, other sources of heterogeneity in the composition of these cohort groups exist. For instance, the cohort groups differ in terms of their share of educational levels. This is an expected result of the socioeconomic change in Spain (younger generations attained higher levels of education as discussed below). Both the sample size of cohort groups and the difference in their composition due to the covariates involved in the analysis may potentially affect the results of trends and differentials in height. For this reason, all the results that are commented and discussed in this paper are based on multivariate regression models that allow for the testing of the statistical significance of both inter-cohort changes in height and height differentials by SES-related variables once the sample size of each cohort has been taken into account and the effect of the remaining covariates has been controlled for.

We will now describe the main variables that are included in the analysis of this study.

Socioeconomic status: We have used educational attainment and occupational category as proxies for socioeconomic status (SES).⁷ To our knowledge, previous anthropometric studies in Spain only test the effect of SES as approximated by occupation and/or education level of the respondents. Although we may assume that the respondent's SES is related to parental SES to a certain extent, both the respondent's age and the process of social mobility could distort the interpretation of height differentials according to SES on the sole basis of the former. In other words, it is important to relate height reached in adulthood to the prevailing household socioeconomic conditions during the physical growth cycle. This can only be estimated by using information on the SES of the household head. In this study, we have included both educational attainment and occupational category of the household head in order to test their effect on height differentials across birth cohort groups.

Educational attainment had to be harmonized across surveys, as sometimes the person interviewed was asked for the number of years of education and other times for the highest level of education attained. Furthermore, the educational levels are not uniform in the response set due to changes made in the educational system over the last five decades

⁷ Income was ruled out in this study due to the large proportion of missing cases across surveys.

in Spain. We have used the abridged International Standard Classification of Education (ISCED) to harmonize this variable into four categories (the results are shown in Fig. 2):

1. *Less than primary:* individuals who did not complete the first level at school, which implies less than six years of schooling.
2. *Primary:* individuals who did complete the first level at school, thus receiving at least six years of schooling.
3. *Secondary:* individuals who completed the second level at school (old system), secondary school (under the new system), or who obtained a professional training qualification (under the new system; equivalent to secondary school in total years of schooling).
4. *University:* individuals who obtained a university degree, PhD, or any equivalent under the old system.

Primary studies have been taken as the reference category to analyze height differentials. The share of this category over time, though varying, is systematically higher than 20%, which contributes to a higher consistency of analysis among the younger cohorts analyzed.

Occupation has been harmonized into four ordinal categories following the simplest codification used for the different ENSE waves. The more recent waves of the ENSE provide much more detailed data on occupation (through the four-digit codes of the National Classification of Occupations: CNO79 in 2001, CNO94 in 2003 and 2006, and CNO11 in 2011, 2014 and 2017), whereas the early waves only include occupation in broad categories (i.e., skilled workers, non-skilled workers, etc.). Given that the more recent waves also include a variable referred to as "CLASS", obtained by classifying the occupations into seven broad categories that are roughly equivalent to the former response sets, we have been able to harmonize this variable into the following four categories:

- *Occupational category 1:* Unskilled workers.
- *Occupational category 2:* Skilled workers.
- *Occupational category 3:* Intermediate positions in public administration, freelancers and white-collar workers.
- *Occupational category 4:* High positions in public administration, businessmen, CEOs and liberal professions.

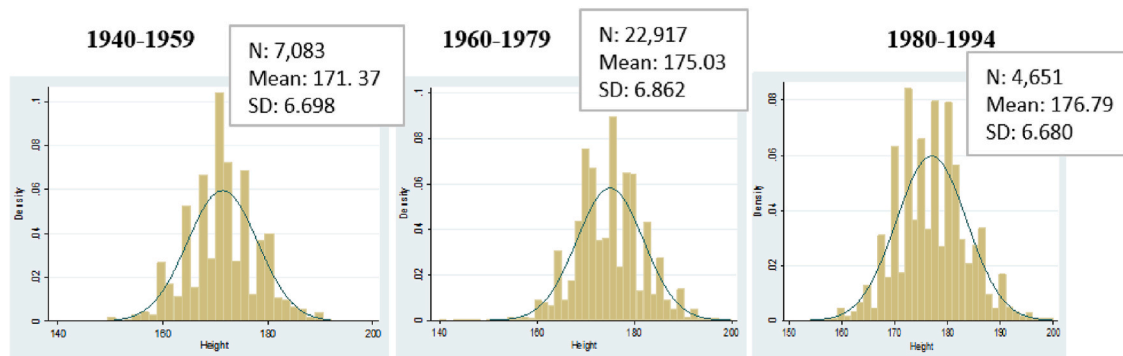
For the survey that did not include the variable "class", we were able to infer it using occupation at time of interview (or most recent occupation in the case of the unemployed or retired). Fig. 3 shows the resulting distribution of occupation according to the four categories described above.

Analyses: cohort series and regression model specifications. Height series are depicted for men and women separately using birth cohort as a time scale. For this purpose, birth cohorts have all been grouped into decades except for the youngest group, which covers a five-year period. These series according to the key variables of analysis can be found in the appendix of this study (Figs. 9 and 10).

Height differentials by SES over time are examined through multivariate linear regression models. This technical approach is addressed so as 1) to control for additional variables which might influence the trends and/or height differentials found and 2) to assess whether the trends and differentials obtained are statistically significant once the varying sample size and diverse source of heterogeneity across cohort groups are

⁸ We have compared the result of this harmonization with the distribution resulting from the 2011 Spanish census. Higher levels of education range very similarly across cohort groups between the two sources whereas the percentage of those with no studies is significantly lower in the surveys with respect to the census among the oldest cohorts. We tend to believe that this is due to the differences in the codification of the original categories of education between the two sources (surveys vs. census). Both the evolution of the distribution of educational categories over time and gender-related differentials display a very similar and coherent pattern between these two sources.

Men



Women

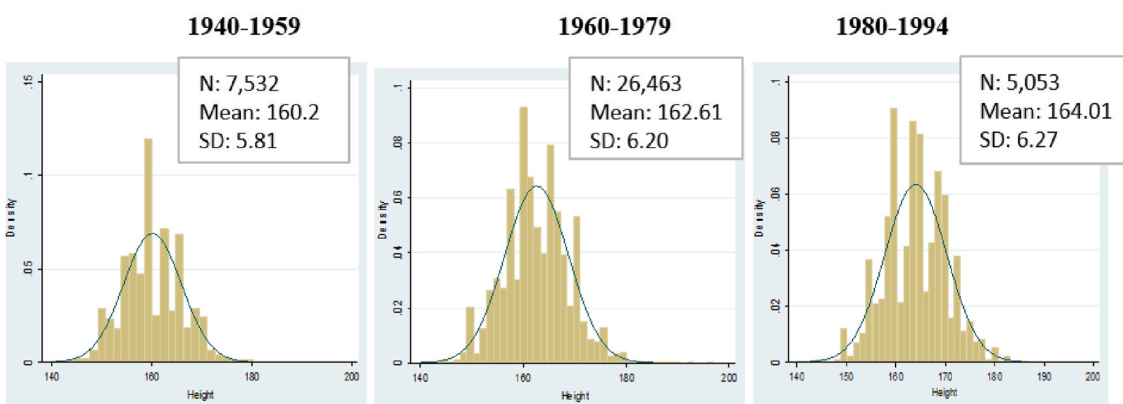


Fig. 1. Height distributions by broad cohort groups (1940–1994)
Source: Own calculations based on the above-mentioned data sources.

Table 2

Valid cases (final sample used in regression models) by cohort group and sex.

| Cohort | Men | Women | Total |
|--------------|---------------|---------------|---------------|
| 1940-1949 | 2,214 | 2,376 | 4,590 |
| 1950-1959 | 4,869 | 5,156 | 10,025 |
| 1960-1969 | 11,131 | 13,170 | 24,301 |
| 1970-1979 | 11,786 | 13,293 | 25,079 |
| 1980-1989 | 4,153 | 4,506 | 8,659 |
| 1990-1994 | 498 | 547 | 1,045 |
| Total | 34,651 | 39,048 | 73,699 |

Source: Own calculations based on the above-mentioned data sources.

controlled for.

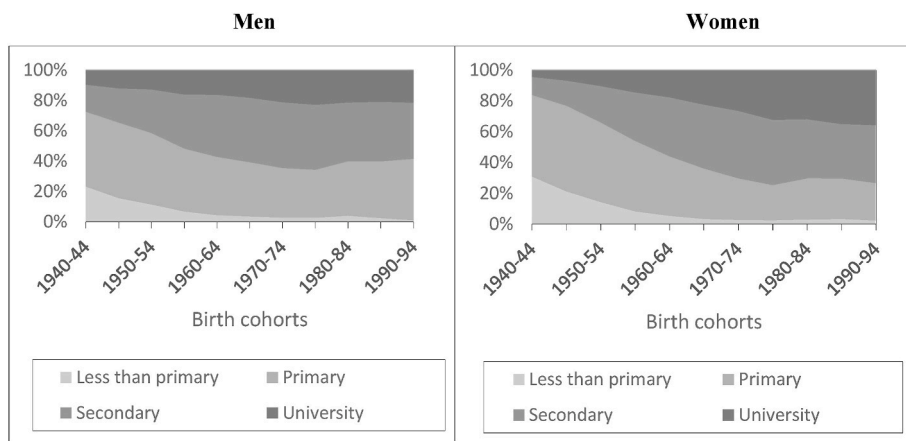
As for the main explanatory variables used in this study (educational attainment and occupational categories), we have tested their correlation across cohort groups as well as potential interactions in order to specify our regression models. The level of correlation was examined through the Spearman correlation coefficient (ρ) which is considered the most adequate statistic for ordinal variables. Regarding the association between the educational attainment and the occupational category of household heads, $\rho = 0.541$ (sig = 0.000; all cohorts), $\rho = 0.525$ (sig = 0.000; cohorts 1940-49) and $\rho = 0.636$ (sig = 0.000; cohorts 1980-94). Regarding the association between educational attainment (of those who are not head of the household) and the occupational category of the head of the household, the coefficient reported the following values: $\rho = 0.349$ (sig = 0.000; all cohorts), $\rho = 0.366$ (sig = 0.000; cohorts 1940-49) and $\rho = 0.330$ (sig = 0.000; cohorts 1980-94). These are all expected and coherent results. A higher correlation is found when the

variables refer to the same individual (the household head). Also, the correlation between educational attainment (of those who are not HH) and the occupational category of HHs decreases, though slightly, between the two cut-off points of our analysis (1940-49 vs. 1980-94). These levels of correlations can be considered as moderate (for the first relationship) and relatively low (for the second relationship)⁹. Finally, a number of interactions between these variables were tested with no significant effects.¹⁰

In light of the former tests and also considering that the models did not exclude any of the SES-related variables of the household heads due to collinearity effects, they were both included, together with the individuals' educational attainment in the series of models that close the

⁹ These results are also coherent with our research hypotheses. On the one hand (first relationship analyzed), and due to the change in the economic structure of Spain and other European countries, the share of skilled and semi-skilled jobs has increased over time. This is necessarily associated with an increase in formal education in order to access the labor market. On the other hand (second relationship analyzed), educational attainment becomes less and less dependent on SES (as approached by the occupational category of the head of the household) as welfare state provisions (democratization in access to education in particular) rise in a given society.

¹⁰ The interaction between the educational attainment and the occupational category of HHs (upper education*upper occupation) was tested and it was not significant in any of the cohort groups analyzed. No substantial change was detected in the coefficients of the main explanatory variables applied to both men and women. The interactions between each educational level of individuals and the two broad categories of education of HHs were also tested with no significant effects.



Source: own calculations based on the above-mentioned data

Fig. 2. ISCED-harmonized educational attainment in Spain among individuals aged 25+. Birth cohorts 1940-94⁸
Source: own calculations based on the above-mentioned data.

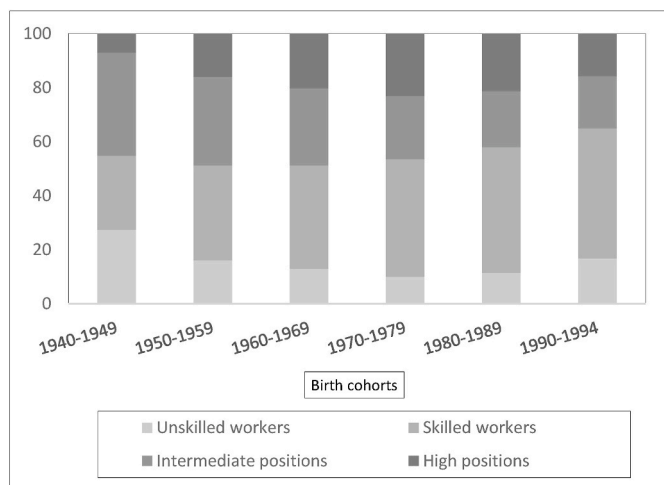


Fig. 3. Distribution of occupation (%) by birth cohort
Source: own calculations based on the above-mentioned data.

results' section of this study.

All the covariates listed below are also included in the models following the usual norms and protocols. Categorical variables are introduced by means of dummy variables whereby one category/variable is excluded, thus serving as the reference category when interpreting the regression coefficients. The models include the following control variables:

- Age (which technically produces the effect of including a time-trend, thus helping to illustrate the improvement of environmental conditions across single cohorts included in a given cohort group).
- Region of residence (in total, there are 18 regions, the 17 Spanish Autonomous Communities and the two Northern African Autonomous Cities of Ceuta and Melilla that are considered as a single region).
- Population size of place of residence (up to 10,000 inhabitants; from 10,001 to 50,000; from 50,001 to 100,000; more than 100,000).
- Marital status of the respondent. The latter, together with age, are instrumental variables which serve to indirectly control for the actual role of the respondent within the household. Ideally, the influence of the household head's SES on biological well-being should be tested on the height of their descendants. In practice, however, such an approach is not possible as kinship within households is not

provided in the surveys, but we can at least distinguish between the head and non-heads of any given household.

Finally, for the models based on the household head's SES, cohort groups 1980-89 and 1990-94 were merged for the purpose of statistical consistency. The results section presents several graphs summarizing the main regression results. We only graphically represent those coefficients that are statistically significant. The complete regressions results can be found in detail in the Appendix.

3. Results

Fig. 4 (Table 3 in the Appendix) displays the trend in mean cohort height for individuals aged 23-47 (in this analysis we use all heights available irrespective of whether the individual is the household head or not). Control variables do not include the SES of the HHs. Average stature shows a marked upward trend for birth cohorts born from the 1940s to the 1980s in the case of men. For women, this upward trend started two decades later. In the case of men, there is evidence of a considerable increase in mean height of about 5 cm among these birth cohorts. Among women, the upward trend is less pronounced, representing an increase of around 2 cm over 40 years. For both sexes, the upward trend stagnated and even descended in the 1990s.

Figs. 5 and 6 (Table 4 in Appendix) show height differentials according to educational attainment, using primary studies as the reference category. As before, we used all valid heights, regardless of whether an individual is a household head or not. The general picture obtained points to a decrease in height differentials over time although the difference in favor of those with tertiary studies noticeably persists among cohorts born between the 1960s and 1990s. That said, men born in the 1940's cohort with a university degree were estimated to be around 4.5 cm taller than those with primary studies, whereas this difference is about 3 cm among the youngest cohorts analyzed. Height differences between other educational categories exhibit a clear decreasing trend across birth cohorts or even disappear as indicated by the absence of statistically significant results.

The above analysis is replicated for women in Fig. 6. We found that the height differentials between the educational categories follow the same general pattern but are noticeably smaller than those among men and, moreover, they remain more constant over time. For instance, women with university studies are estimated to be 2 cm taller with respect to those with primary studies for all birth cohorts analyzed except for the oldest cohort group where no significant difference is found (probably due to the fact of the very low proportion of women who went to university within that generation). Women with secondary

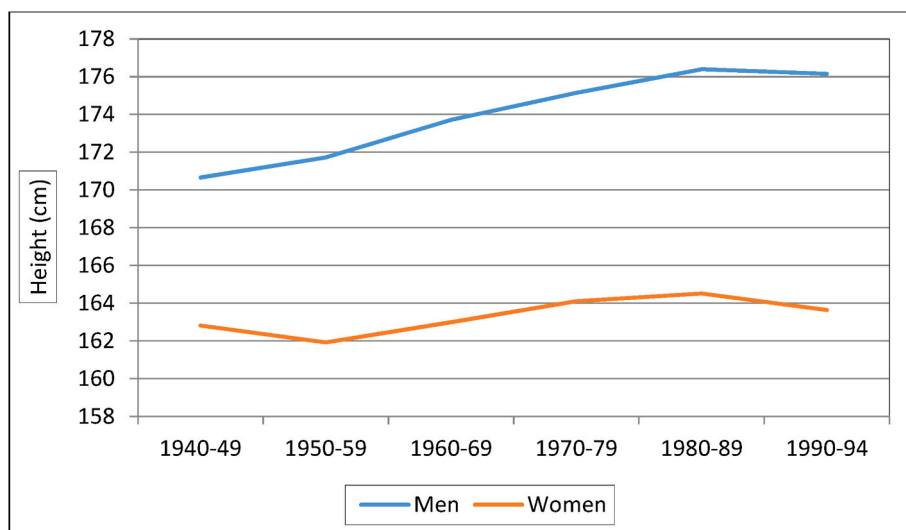
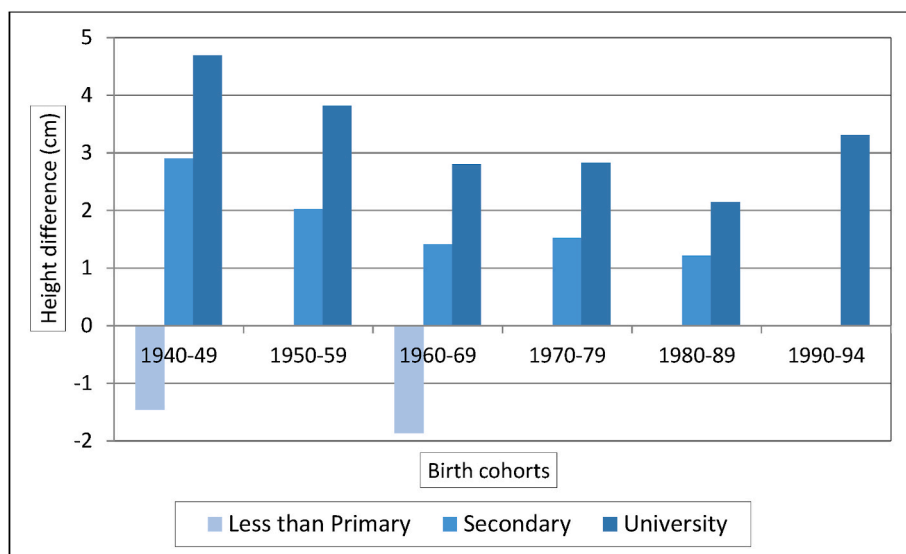


Fig. 4. Average height (cm) by sex and birth cohort. Spain, 1940-1994

Source: own calculations based on the above-mentioned data.

Note: the women's coefficient for the cohort group 1960-69 is not statistically significant (Table 3 in Appendix).



Source: own calculations based on the above-mentioned data

Fig. 5. Average height difference (cm), by educational attainment (males). Reference: primary studies

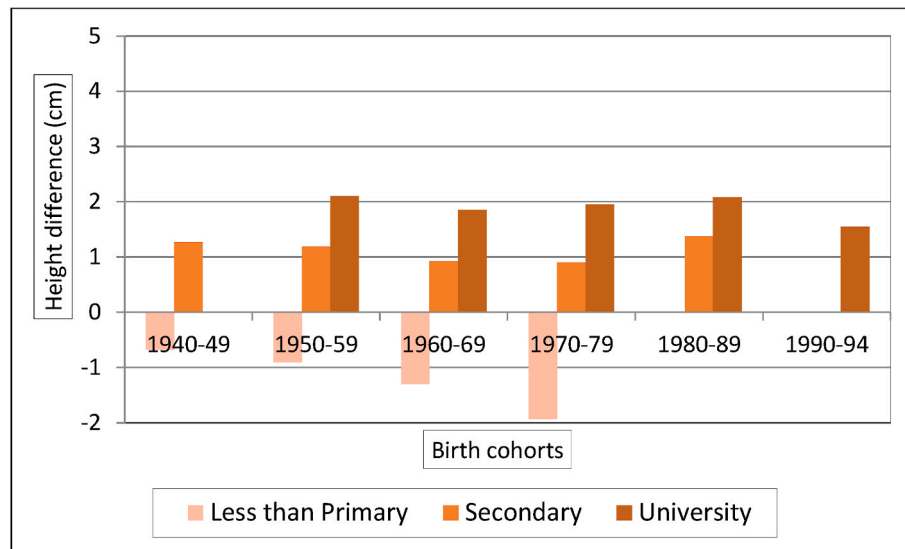
Source: own calculations based on the above-mentioned data.

studies born between the 1940s–1980s are around 1 cm taller than those with primary education. And finally, women with less than primary studies are estimated to be shorter than those with primary studies for the cohorts from the 1940s to the 1970s. It is interesting to note that this negative height difference almost tripled among these birth cohorts. This is most likely due to the changing socioeconomic profile embodied by these women with no studies. During a period of strong growth in female schooling, the still significant percentage of women who did not finish primary studies would probably represent the most impoverished sectors of Spanish society.

Figs. 7 and 8 (Table 5 in Appendix) show the significant coefficients when the educational attainment of the head of the household (HH) and the occupation category of the HH are both introduced in the set of models together with the individuals' educational attainment. In these models we only include individuals who are not household heads. In order to maintain a good statistical consistency, the variables containing the information on household heads (education and occupational

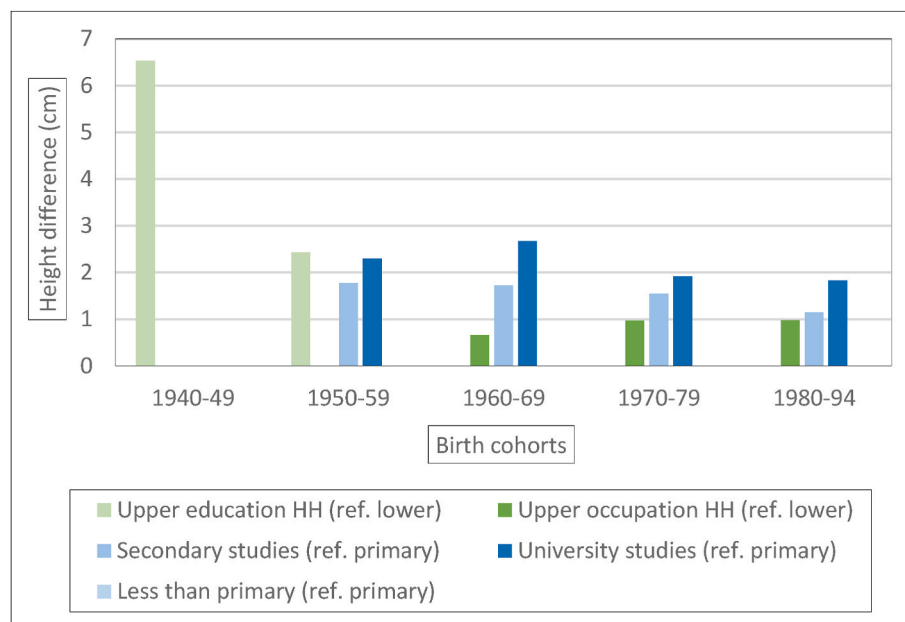
category) have been grouped into two categories: lower (no studies or primary; unskilled or skilled workers) and higher (secondary or university; intermediate and high positions). As a rule, either one or another of the SES variables for HHs is significant but not both of them. This in itself is an interesting finding, as are the differences observed between the effects on men and women.

Among men (Fig. 7), the only and strongly significant effect for those born in the 1940s was that represented by the educational attainment of the household head (more than 6 cm taller than their counterparts from the lower educational segment of households). During subsequent decades, such a strong differential is not observed again, although we can appreciate a diversification of significant effects and its persistence over time. For instance, since the 1960s, individuals from higher SES households (as proxied by the occupational category of HHs) have maintained a height difference of between 0.5 and 1 cm over those from lower SES households. As expected, the differentials captured by the educational attainment of individuals are lower in this approach, but



Source: own calculations based on the above-mentioned data

Fig. 6. Average height difference (cm), by educational attainment (females). Reference: primary studies
Source: own calculations based on the above-mentioned data.



Source: own calculations based on the above-mentioned data

Fig. 7. Male height differentials (cm) by educational attainment and household head SES.
Source: own calculations based on the above-mentioned data.

they maintain the pattern observed in the former analysis (Fig. 5). For instance, those individuals born in the 1980s and 1990s who attained university studies are, on average, almost 2 cm taller than those with primary studies, once the HH's occupation has been controlled for.

Fig. 8 reports the results for women, showing that those belonging to households where the HH had a higher occupational category and educational attainment are estimated to be taller. This effect is highly constant over time and systematically above 0.5 cm. In fact, it is the only effect that persists among the younger women cohorts analyzed.

4. Discussion

The dynamics of inequalities in biological well-being during periods of intense advances in living standards, particularly after the Second World War, have already received attention in previous studies (e.g. Bann et al., 2018; Cavelaars et al., 2000; Deaton, 2008; Silventoinen, 2001). In Spain, the life course of birth cohorts born between 1940 and 1994 have undergone profound economic, social, and political transformations, yet little is known, so far, about how such changes have

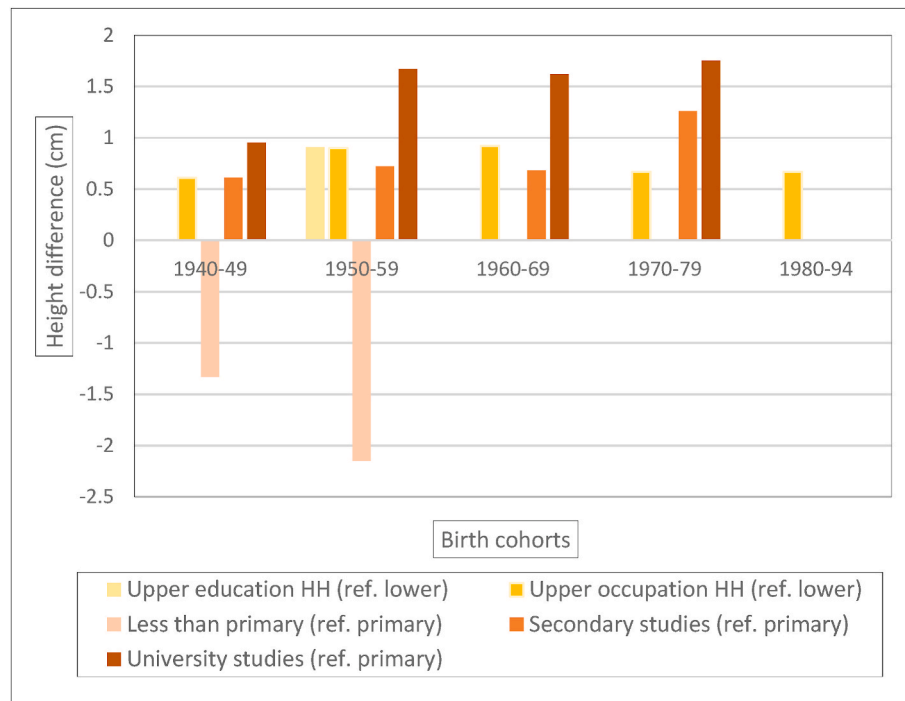


Fig. 8. Female height differentials (cm) by educational attainment and SES of household head
Source: own calculations based on the above-mentioned data.

shaped SES-related differentials in health and nutrition.

Our research hypothesis was that historical contexts of high environmental stress would be more prone to SES-related anthropometric differentials in the absence of significant institutionalized social provisions and that the SES would gradually lose its ability to explain height differentials over time (i.e., across successive groups of cohorts) as welfare provisions became more effectively implemented. The results of this paper only partially confirm this hypothesis. For the most part, our results confirm the convergence of trends in adult height by educational attainment and occupational category in Spain over the second half of the twentieth century. However, the overall reduction of anthropometric differentials is mainly related to the overcoming of the most negative effects of the Spanish civil war and the autarchic period. From the 1960s, SES-related differentials were mostly stable.¹¹ At least they did not decrease as had been expected within a context of major improvements in terms of social provisions (it should be noted that Spain has been a democracy since 1978).

As for educational attainment, the convergence may be partly related to the spread of access to basic levels of education for the bulk of the Spanish population. In other words, the SES-related effects that are initially visible in educational levels relaxed or partly diluted when access to higher levels of education became democratized. In short, the gap in height between the higher and lower educated segments of the Spanish population has indeed decreased but our results indicate persistent differences in favor of those with university studies with respect to those with primary education (2–3 cm among the male cohorts born from the 1960s and 1.5–2 cm among the female cohorts born from the 1950s).

Similarly, we can observe that the net effect of the occupational category of the household head on individuals' average heights has remained stable and statistically significant over the last decades analyzed (around 1 cm among males and more than 0.5 cm among

women). In fact, previous studies conducted on male height in Spain show that the gap between some occupational categories of individuals (semi-skilled non-manual workers and manual workers) widened during the central decades of the twentieth century. These authors suggest that this is a reflection of the general increase in inequality between socio-economic groups (Ayuda & Puche, 2014).

Previous research on other European countries reveals a decrease in height differentials between SES groups (e.g., Bann et al., 2018 by using the father's occupation as a proxy of SES). Other similar studies argue that such a convergence in terms of net nutritional status is most likely related to economic progress and the expansion of the welfare state in the final decades of the twentieth century (Bodzsar et al., 2015; Hauspie et al., 1996). Nevertheless, considerable inequalities in nutritional status are still present even in the most advanced industrialized societies, and to a greater extent in developing countries (Bredenkamp et al., 2014; Komlos & Baur, 2004). For instance, in Poland, although improvements have been made in living conditions over a period of almost 50 years, as reflected in the secular trend in children's height, there are still differences in height associated with social inequalities (Gomula et al., 2021, by using four factors to approximate SES: level of urbanization, parents' education and number of children). Furthermore, the evidence on the convergence of height trends by educational attainment is not conclusive either. Studies conducted of English children (Galobardes et al., 2012, using the mother's education as the key explanatory variable) find that differences in height, though probably smaller than in the past, persisted. In France, height inequalities associated with education remained virtually unchanged, and large, between 1970 and 2003: around 4.5–5 cm among men and around 2.5–3 cm among women (Singh-Manoux et al., 2011). This study shows that height differentials as a function of income were much more moderate than when examined in terms of education.

These and other evidence from previous research throws into question whether general improvements in living standards in Western European welfare economies always lead to convergence in terms of adult stature (Silventoinen, 2003; Singh-Manoux et al., 2011). A paper that analyzes the trends in physical stature of the Swiss population born

¹¹ Previous research on Spanish male cohorts born between 1840 and 1964 finds that height differentials by educational attainment increased during the autarchic years (Cámara et al., 2019).

between 1955 and 1985 concludes that the quality of the health care system and equal access to it seem to have a greater impact than other redistributive aspects of the welfare state (Kues, 2010). Other research papers question how state policies and practices may affect population health (Bhatta, 2021; Bird et al., 2019; McDonough et al., 2010) and there are some examples of the critical effect that public policies that promote income redistribution and universal access to education, health and sanitation services may have on nutrition and living conditions (Núñez & Pérez, 2021, Monteiro et al., 2010).

At this point, it is also worth commenting on the differences found between men and women. Height differentials by SES (regardless of the approximation used) among men are larger and they vary more over time with respect to women. These differences between the sexes could be related to both a higher eco-sensitivity (i.e., susceptibility to environmental conditions and changes in them over time) among men (Cámara et al., 2021, Zimina et al., 2019; Thurstans, et al., 2020a, b; Spake et al., 2022) and to the fact that access to higher education for older female cohorts was very limited in Spain (Ballarín Domingo, 2001; Heath & Jayachandran, 2016; Plötz, 2017). We are inclined to believe that the role of eco-sensitivity is more influential in this regard, given that the results of the analysis based on the educational attainment of the household head (mostly men) paint the same picture.

Finally, the results also reveal that the upward trend in intergenerational growth shows clear signs of having come to an end, at least temporarily, among Spanish cohorts born from the 1990s. This applies to men and women, and it seems that this interesting result is not related to any significant variations in the height differential by SES. This finding coincides with research from different European countries, suggesting that growth has virtually stopped in northern Europe and may have started to slow down in southern Europe. It is reasonable to assume that there might be an upper limit to average heights, especially in countries where living standards are already very high, such as Spain and a number of other European societies. Some studies relate the stagnation of cohort stature with the spread of obesity (Bann et al., 2018). Early studies of populations in Finland and Sweden show a slowdown in heights in the 1990s (Silventoinen et al., 2001). Using data from military recruitments, previous research finds that some European countries reached a height plateau in the 1990s, including Italy (Larnkjær et al., 2006; Gohlke et al., 2009), but not Greece, where recruits continued to grow (Papadimitriou et al., 2008). A study carried out in the Netherlands, the tallest population in the world, found that the long secular increasing trend in height has slowed down in recent decades (Schönbeck et al., 2013). Similar results have also been found in other European countries and in the United States (Komlos, 2007; Kues, 2010; Vinci et al., 2019).

After decades of intense growth, and similarly to the Dutch and other European and North American populations, the Spanish population may have reached a stable mean height in the 1990 cohorts, an issue that will require further research in the near future.

5. Conclusions

Overall, the results obtained in this study lead us to conclude that inequalities in the biological dimensions of well-being have tended to diminish over time among Spaniards born since the 1940s. However, this conclusion must be qualified in view of the evidence obtained from both the pace of the reduction of height differentials over time and the combination of the two approaches to SES (educational attainment and occupational category). First, our study shows that height differentials persisted during the decades of Spain's modernization process and the implementation of welfare provisions. Second, the results demonstrate that the way SES is operationalized matters in itself, as they indicate that height differentials according to educational attainment may be partly explained by the association of this variable with the household head occupation (i.e. SES-related occupation categories). Once this factor is controlled for, height differentials by educational attainment diminish

or even disappear in the case of women.

Thus, the variety of approaches used to address this issue prompt us to further qualify this apparent convergence. While differences in stature by educational level have mostly reduced over time, the differences by occupational category (that of household heads) largely persist. In general, height differentials decreased among the younger Spanish cohorts when compared with those cohorts born during the 1940s and the 1950s, thus prior to the implementation of welfare state provisions. This is particularly true in the case of men, for whom the education-related height differentials were very large in the 1940s. These differentials were smaller among women and remained more constant over time. These results should be interpreted taking two facts into consideration: the later access of women to education and the likely greater eco-sensitivity of men.

In summary, we find that the association between occupation and height differentials is much weaker than that of educational attainment, but it is persistent over time. This implies that education may play a more complex and diverse role in determining biological well-being, above and beyond acting as a sole proxy of SES. In addition, and most importantly, it indicates that height differentials by educational attainment may mask actual socioeconomic differences in biological well-being among younger generations. This could be due to the extension of education to lower classes in societies with high levels of welfare provision. Alternative approaches and indicators should therefore be contrasted with these results. In light of this evidence, the hypothesis that social provisions have led to a reduction in inequality is not fully confirmed. Instead, our results support the idea that, regardless of the level of social provisions, the household environment still appears to be a relatively significant mediator in access to certain basic resources and factors related to health and nutrition. Of course, the nature of this mediation and the specific factors involved are yet to be determined, given the limitations of the (mostly) contextual approximation we have performed through cohort groups.

It is clear that our results add meaning to conclusions on the evolution of inequalities in biological well-being reached solely on the basis of educational attainment. We have certainly been able to verify that in Spain, the differentials in adult height according to education level have, in general, reduced over time. However, in light of the contrasts revealed with the approach based on occupational categories of household heads, we are inclined to believe that education is a better proxy of SES in contexts where access to education is highly determined by economic factors. Conversely, its usefulness in the analysis of height differentials decreases as education becomes more democratized. This is not surprising since, for the most part, the opening of access to the lower classes of higher educational levels coincided, in Spain at least, with the implementation of a number of social provisions including access to health care and improved sanitation.

Authors contributions

Begoña Candela-Martínez: Writing - Original Draft, Data curation, Investigation, Formal analysis, Visualization. Antonio D. Cámara: Conceptualization, Writing- Original draft preparation, Methodology, Software. Diana López-Falcón: Writing- Original draft preparation, Supervision, Writing- Reviewing and Editing, Resources. José M. Martínez-Carrión: Supervision, Writing - review & editing.

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Ethical Statement

We do not declare any potential ethical conflict in relation to the data and methods used in this research. No experimental procedure was developed and the microdata used in the analyses was previously anonymized by the National Spanish Statistical Office (INE). These data are managed, preserved and released by INE and they were free-accessed online.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101126>.

References

- Akachi, Y., & Canning, D. (2015). Inferring the economic standard of living and health from cohort height: Evidence from modern populations in developing countries. *Economics and Human Biology*, 19, 114–128. <https://doi.org/10.1016/j.ehb.2015.08.005>
- Ambadekar, N. N., Wahab, S. N., & Khandait, D. W. (1999). Effect of child labour on growth of children. *Public Health*, 113(6), 303–306. <https://doi.org/10.1038/sj.ph.1900570>
- Ayuda, M. I., & Puche, J. (2014). Determinants of height and biological inequality in Mediterranean Spain, 1859–1967. *Economics and Human Biology*, 15, 101–119.
- Ballarín Domingo, P. (2001). *La educación de las mujeres en la España contemporánea (siglos XIX-XX)*. Madrid: Síntesis.
- Bann, D., Johnson, W., Li, L., Kuh, D., & Hardy, R. (2018). Socioeconomic inequalities in childhood and adolescent body-mass index, weight, and height from 1953 to 2015: An analysis of four longitudinal, observational, British birth cohort studies. *The Lancet Public Health*, 3(4), e194–e203. [https://doi.org/10.1016/S2468-2667\(18\)30045-8](https://doi.org/10.1016/S2468-2667(18)30045-8)
- Baten, J., & Wagner, A. (2003). Autarchy, market disintegration, and health: The mortality and nutritional crisis in Nazi Germany, 1933–1937. *Economics and Human Biology*, 1(1), 1–28. [https://doi.org/10.1016/S1570-677X\(02\)00002-3](https://doi.org/10.1016/S1570-677X(02)00002-3)
- Bhatta, T. R. (2021). Intercohort variations in the education–health gradient: Sociohistorical changes in early-life selection mechanisms in the United States. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 76(2), 330–342. <https://doi.org/10.1093/geronb/gbaa100>
- Bird, P. K., Pickett, K. E., Graham, H., Faresjö, T., Jaddoe, V. W. V., Ludvigsson, J., & Jennifer J McGrath, . (2019). Income inequality and social gradients in children's height: A comparison of cohort studies from five high-income countries. *BMJ Paediatrics Open*, 3, Article e000568. <https://doi.org/10.1136/bmjpo-2019-000568>
- Birrell, F., Pearce, M. S., Francis, R. M., & Parker, L. (2005). Self-report over-estimates true height loss: Implications for diagnosis of osteoporosis. *Clinical Rheumatology*, 24, 590–592.
- Blum, M. (2013). The influence of inequality on the standard of living: Worldwide anthropometric evidence from the 19th and 20th centuries. *Economics and Human Biology*, 11(4), 436–452. <https://doi.org/10.1016/j.ehb.2012.12.002>
- Bodzsar, E. B., Zsakai, A., & Mascie-Taylor, N. (2015). Secular growth and maturation changes in Hungary in relation to socioeconomic and demographic changes. *Journal of Biosocial Science*, 48(2), 158–173. <https://doi.org/10.1017/S0021932015000061>
- Bogin, B., Varea, C., Hermantussen, M., & Scheffler, C. (2018). Human life course biology: A centennial perspective of scholarship on the human pattern of physical growth and its place in human biocultural evolution. *American Journal of Physical Anthropology*, 165(4), 834–854. <https://doi.org/10.1002/ajpa.23357>
- Bozzoli, C., Deaton, A., & Quintana-Domeque, C. (2009). Adult height and childhood disease. *Demography*, 46(4), 647–669. <https://doi.org/10.1353/dem.0.0079>
- Bredenkamp, C., Buisman, L. R., & Van de Poel, E. (2014). Persistent inequalities in child undernutrition: Evidence from 80 countries, from 1990 to today. *International Journal of Epidemiology*, 43(4), 1328–1335. <https://doi.org/10.1093/ije/dyu075>
- Cámara, A. D., & García-Román, J. (2010). Ciclos largos de nivel de vida biológico en España (1750–1950): Propuesta metodológica y evidencias locales. *Investigaciones de Historia Económica*, 6(17), 95–118. [https://doi.org/10.1016/s1698-6989\(10\)70052-7](https://doi.org/10.1016/s1698-6989(10)70052-7)
- Camara, A. D., & Garcia-Roman, J. (2015). Anthropometric geography applied to the analysis of socio-economic disparities: Cohort trends and spatial patterns of height and robustness in 20th-century Spain. *Population, Space and Place*, 21(8), 704–719. <https://doi.org/10.1002/psp.1850>
- Cámara, A. D., Martínez-Carrión, J. M., Puche, J., & Ramón-Muñoz, J. M. (2019). Height and inequality in Spain: A long-term perspective. *Revista de Historia Económica - Journal of Iberian and Latin American Economic History*, 37(2), 205–238. <https://doi.org/10.1017/S0212610919000089>
- Cámara, A. D., Puche, J., & Martínez Carrión, J. M. (2021). 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. *Social Science & Medicine*, 273, 113771. <https://doi.org/10.1016/j.socscimed.2021.113771>
- Cañabate, J., & Martínez-Carrión, J. M. (2017). Poverty and stature in rural Inland Spain during the nutritional transition. *Historia Agraria*, 71, 109–142.
- Cañabate, J., & Martínez-Carrión, J. M. (2018). Crisis nutricional y brecha social en la España de la autarquía. Un estudio de caso a partir de la talla adulta. *Nutrición Hospitalaria*, 35(5), 108–115. <https://doi.org/10.20960/nh.2092>
- Carreras, A., & Tafunell, X. (2021). *Between empire and globalization: An economic history of modern Spain* (1st ed.). Berlin, Germany: International Publishing 473 Springer.
- Carson, S. A. (2009). Health, wealth, and inequality: A contribution to the debate about the relationship between inequality and health. *Hist Method*, 42, 43–56, 2009, 10.3200/HMTS.42.2.43-56.
- Cavelaars, A. E., Kunst, A. E., Geurts, J. J., Crialesi, R., Grötved, L., Helmert, U., ... Mackenbach, J. P. (2000). Persistent variations in average height between countries and between socio-economic groups: An overview of 16 European countries. *Annals of Human Biology*, 27(4), 407–421. <https://doi.org/10.1080/03014460050044883>
- Chen, Y., & Zhou, L. A. (2007). The long-term health and economic consequences of the 1959–1961 famine in China. *Journal of Health Economics*, 26(4), 659–681. <https://doi.org/10.1016/j.jhealeco.2006.12.006>
- Cole, T. J. (2000). Galton's midparent height revisited. *Annals of Human Biology*, 27(4), 401–405. <https://doi.org/10.1080/03014460050044874>
- Cortez, S. A. E., Barbieri, M. A., Pereira Saraiva, M. C., Bettiol, H., Moura da Silva, A. A., & Cunha Cardoso, V. (2007). Does child labour affect final height? *Occupational Medicine*, 57(2), 118–125. <https://doi.org/10.1093/occmed/kql155>
- Cox, M. (2019). *Hunger in war and peace: Women and children in Germany, 1914–1924*. Oxford: Oxford University Press.
- Crimmins, E. M., & Finch, C. E. (2006a). Infection, inflammation, height, and longevity. *Proceedings of the National Academy of Sciences of the United States of America*, 103(2), 498–503. <https://doi.org/10.1073/pnas.0501470103>
- Crimmins, E. M., & Finch, C. E. (2006b). Infection, inflammation, height, and longevity. *Proceedings of the National Academy of Sciences of the United States of America*, 103(2), 498–503. <https://doi.org/10.1073/pnas.0501470103>
- Deaton, A. (2008). Height, health, and inequality: The distribution of adult heights in India. *The American Economic Review*, 98(2), 468–474. <https://doi.org/10.1257/aer.98.2.468>
- Deaton, A. (2013). *The great escape: Health, wealth and the origins of inequality*. Princeton University Press.
- Dey, D. K., Rothberg, E., Sundh, V., Bosaeus, I., & Steen, B. (1999). Height and body weight in the elderly: A 25-year longitudinal study of a population aged 70–95 years. *European Journal of Clinical Nutrition*, 53, 905–914.
- Floud, R., Fogel, R. W., Harris, B., & Chul Hong, S. (2011). *The changing body: Health, nutrition, and human development in the western world since 1700*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511975912>
- Fogel, R. W. (2004). *The escape from hunger and premature death, 1700–2100*. Cambridge University Press. <https://doi.org/10.1017/cbo9780511817649>
- Fogel, R. W., & Costa, D. L. (1997). A theory of technophysio evolution, with some implications for forecasting population, health care costs, and pension costs. *Demography*, 34(1), 49–66. <https://doi.org/10.2307/2061659>
- Fuster, V. (2017). Variación regional de la estatura y diámetros transversales en universitarios españoles nacidos a finales del siglo XIX. *Antropo*, 37, 17–27.
- Galobardes, B., McCormack, V. A., McCarron, P., Howe, L. D., Lynch, J., Lawlor, D. A., & Davey Smith, G. (2012). Social inequalities in height: Persisting differences today depend upon height of the parents. *PLoS One*, 7(1). <https://doi.org/10.1371/journal.pone.0029118>
- Galofré-Vilà, G. (2018). Growth and maturity: A quantitative systematic review and network analysis in anthropometric history. *Economics and Human Biology*, 28, 107–118. <https://doi.org/10.1016/j.ehb.2017.12.003>
- Galofré-Vilà, G., & Harris, B. (2020). Growth before birth: The relationship between placental weights and infant and maternal health in early twentieth-century Barcelona. *The Economic History Review*, 74(2), 400–423. <https://doi.org/10.1111/ehr.13026>
- Gao, W., & Smyth, R. (2010). Health human capital, height and wages in China. *Journal of Development Studies*, 46(3), 466–484.
- García-Montero, H. (2018). La desigualdad en el estado nutricional en la España interior a finales del siglo XVIII. *Nutrición Hospitalaria*, 35(5), 26–30. <https://doi.org/10.20960/nh.2081>
- Gohlke, B., & Woelfle, J. (2009). Growth and puberty in German children: Is there still a positive secular trend? *Deutsches Ärzteblatt International*, 106, 377–382.
- Gomula, A., Nowak-Szczepanska, N., & Koziel, S. (2021). Secular trend and social variation in height of Polish schoolchildren between 1966 and 2012. *Acta Paediatrica*, 110(4), 1225–1230. <https://doi.org/10.1111/apa.15572>
- Grasgruber, P., Cacek, J., Kalina, T., & Seberal, M. (2014). The role of nutrition and genetics as key determinants of the positive height trend. *Economics and Human Biology*, 15, 81–100. <https://doi.org/10.1016/j.ehb.2016.01.005>
- Grasgruber, P., Seberal, M., Hrazdíra, E., Cacek, J., & Kalina, T. (2016). Major correlates of male height: A study of 105 countries. *Economics and Human Biology*, 21, 172–195. <https://doi.org/10.1016/j.ehb.2016.01.005>
- de Groot, C. P., Perdigo, A., & Deurenbert, P. (1996). Longitudinal changes in anthropometric characteristics of elderly Europeans. *European Journal of Clinical Nutrition*, 50(Suppl. 2), 9–15.
- Hatton, T. J., & Bray, B. E. (2010). Long run trends in the heights of European men, 19th–20th centuries. *Economics and Human Biology*, 8(3), 405–413. <https://doi.org/10.1016/j.ehb.2010.03.001>
- Hauspie, R. C., Vercauteren, M., & Susanne, C. (1996). Secular changes in growth. *Hormone Research in Paediatrics*, 45(2), 8–17. <https://doi.org/10.1159/000184841>

- Heath, R., & Jayachandran, S. (2016). *The causes and consequences of increased female education and labor force participation in developing countries*. Cambridge: National Bureau of Economic Research.
- Human Mortality Database (online). Life tables. Spain, Available at <https://www.mortality.org/cgi-bin/hmd/country.php?cntr=ESP&level=1>. (Accessed 1 September 2021) https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176783&menu=resultados&idp=1254735573175 [11/20/2020].
- Instituto Nacional de Estadística Online. https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176783&menu=resultados&idp=1254735573175. (Accessed 1 September 2021).
- Jaadla, H., Shaw-Taylor, L., & Davenport, R. (2021). Height and health in late eighteenth-century England. *Population Studies*, 75(3), 381–401. <https://doi.org/10.1080/00324728.2020.1823011>
- Komlos, J. (2007). Anthropometric evidence on economic growth, biological well-being and regional convergence in the Habsburg Monarchy, c. 1850–1910. *Cliometrica, Journal of Historical Economics and Econometric History*, 1(3), 211–237. <https://doi.org/10.1007/s11698-007-0013>
- Komlos, J., & A'Hearn, B. (2019). Clarifications of a puzzle: The decline in nutritional status at the onset of modern economic growth in the USA. *The Journal of Economic History*, 79(4), 1129–1153. <https://doi.org/10.1017/S0022050719000573>
- Komlos, J., & Baur, M. (2004). From the tallest to (one of) the fattest: The enigmatic fate of the American population in the 20th century. *Economics and Human Biology*, 2(1), 57–74. <https://doi.org/10.1016/j.ehb.2003.12.006>
- Kues, A. B. (2010). Taller – healthier – more equal? The biological standard of living in Switzerland in the second half of the 20th century. *Economics and Human Biology*, 8, 67–79, 2010.
- Larnkjær, A., Schröder, S. A., Schmidt, I. N., Jørgensen, M. H., & Michaelsen, K. F. (2006). Secular change in adult stature has come to a halt in northern Europe and Italy. *Acta Paediatrica*, 95, 754–755, 2006.
- Lipsky, L. M., Haynie, D. L., Hill, C., Nansel, T. R., Li, K., Liu, D., & Simons-Morton, B. (2019). Accuracy of self-reported height, weight, and BMI over time in emerging adults. *American Journal of Preventive Medicine*, 56(6), 860–868. <https://doi.org/10.1016/j.amepre.2019.01.004>
- Lopuszanska-Dawida, M., Kolodziejb, H., Lipowiczb, A., Szklarskac, A., Kopiczkoa, A., & Bielicki, T. (2020). Social class-specific secular trends in height among 19-year old polish men: 6th national surveys from 1965 till 2010. *Economics and Human Biology*, 37.
- María-Dolores, R., & Martínez-Carrión, J. M. (2011). The relationship between height and economic development in Spain, 1850–1958. *Economics and Human Biology*, 9(1), 30–44. <https://doi.org/10.1016/j.ehb.2010.07.001>
- Martínez-Carrión, J. M., & María-Dolores, R. (2017). Regional inequality and convergence in southern Europe. Evidence from height in Italy and Spain, 1850–2000, 74 *Revista de Economía Aplicada*, XXV, 75–103.
- McDonough, P., Worts, D., & Sacker, A. (2010). Socioeconomic inequalities in health dynamics: A comparison of Britain and the United States. *Social Science & Medicine*, 70, 251–260.
- Ministerio de Sanidad Online. <https://www.sanidad.gob.es/estadEstudios/estadisticas/encuestaNacional/home.htm>. (Accessed 1 September 2021).
- Monteiro, C. A., D'Aquino Benicio, M. H., Conde, W. L., Konno, S., Lovadino, A. L., Barros, A. J. D., & Gomes, V. (2010). Narrowing socioeconomic inequality in child stunting: The Brazilian experience, 1974–2007. *Bulletin of the World Health Organization*, 88, 305–311.
- Morgan, S. L. (2000). Richer and taller: Stature and living standards in China, 1979–1995. *The China Journal*, 44, 1–39. <https://doi.org/10.2307/2667475>
- NCD Risk Factor Collaboration. (2016). A century of trends in adult human height. *Elife*, 5. <https://doi.org/10.7554/eLife.13410>
- Núñez, J., & Pérez, G. (2021). The escape from malnutrition of Chilean boys and girls: Height-for-Age Z scores in late XIX and XX centuries. *International Journal of Environmental Research and Public Health*, 18, 10436. <https://doi.org/10.3390/ijerph181910436>
- O'Donnell, O., Rosati, F. O., & van Doorslaer, E. (2005). Health effects of child work: Evidence from rural Vietnam. *Journal of Population Economics*, 18, 437–467. <https://doi.org/10.1007/s00148-004-0197-y>
- Papadimitriou, A., Fytanidis, G., Douras, K., Papadimitriou, D. T., Nicolaidou, P., & Fretzayas, A. (2008). Greek men grow taller. *Acta Paediatrica*, 97, 1105–1107.
- Perkins, J. M., Subramanian, S. V., Smith, G. D., & Özaltin, E. (2016). Adult height, nutrition, and population health. *Nutrition Reviews*, 74(3), 149–165. <https://doi.org/10.1093/nutrit/nuv105>
- Plötz, J. S. (2017). *Gender gap developments in tertiary education: A cross-country time-series analysis on European level [Master's Dissertation, Universidade Católica Portuguesa]*. UCP Repository. <https://repositorio.ucp.pt/handle/10400.14/22361>.
- Prados de la Escosura, L., & Rosés, J. R. (2021). Accounting for growth: Spain, 1850–2019. *Journal of Economic Surveys*, 35, 804–832. <https://doi.org/10.1111/joes.12407>
- Prados de la Escosura, L., Rosés, J. R., & Sanz-Villarroya, J. (2012). Economic reforms and growth in Franco's Spain. *Revista de Historia Económica-Journal of Iberian and Latin American Economic History*, 30(1), 45–89.
- Puentes, E., Wang, F., Behrman, J. R., Cunha, F., Hoddinott, J., Maluccio, J. A., Adair, L. S., Borja, J. B., Martorell, R., & Stein, A. D. (2016). Early life height and weight production functions with endogenous energy and protein inputs. *Economics and Human Biology*, 22, 65–81. <https://doi.org/10.1016/j.ehb.2016.03.002>
- Quintana-Domeque, C., Bozzoli, C., & Bosch, M. (2011). Infant mortality and adult stature in Spain. *Social Science & Medicine*, 72, 1893–1903.
- Roseboom, T., de Rooij, S., & Painter, R. (2006). The Dutch famine and its long-term consequences for adult health. *Early Human Development*, 82(8), 485–491. <https://doi.org/10.1016/j.earlhumdev.2006.07.001>. Early Hum Dev.
- Rowland, M. L. (1990). Self-reported weight and height. *The American Journal of Clinical Nutrition*, 52(6), 1125–1133. <https://doi.org/10.1093/ajcn/52.6.1125>
- Schönbeck, Y., Talma, H., van Dommelen, P., Bakker, B., Buitendijk, S. E., Hirasings, R. A., & van Buuren, S. (2013). The world's tallest nation has stopped growing taller: The height of Dutch children from 1955 to 2009. *Pediatric Research*, 73(3). <https://doi.org/10.1038/pr.2012.189>
- Silventoinen, K. (2003). Determinants of variation in adult body height. *Journal of Biosocial Science*, 35(2), 263–285. <https://doi.org/10.1017/S0021932003002633>
- Silventoinen, K., Lahelma, E., Lundberg, O., & Rahkonen, O. (2001). Body height, birth cohort and social background in Finland and Sweden. *The European Journal of Public Health*, 11, 124–129.
- Singh-Manoux, A., Goumelen, J., Ferrie, J., Silventoinen, K., Guéguen, A., Stringhini, S., & Kivimaki, M. (2011). Trends in the association between height and socioeconomic indicators in France, 1970–2003. *Economics and Human Biology*, 8(3), 396–404. <https://doi.org/10.1016/j.ehb.2010.03.002>
- Som, S., Ulijaszek, S., Pal, M., Bharati, S., & Bharati, P. (2014). Variation in height and BMI of adult Indians. *Journal of Biosocial Science*, 46(1), 47–65.
- Spake, L., Hoppa, R. D., Blau, S., & Cardoso, H. F. V. (2022). *American Journal Biological Anthropology*, 1–19.
- Spijker, J. J. A., Pérez, J., & Cámara, A. D. (2008). Cambios generacionales de la estatura en la España del siglo XX a partir de la Encuesta Nacional de Salud. *Estadística Española*, 50(169), 571–604. <http://digital.csic.es/bitstream/10261/11346/1/Estatura2008.pdf>.
- Steckel, R. H. (2012). Social and economic effects on growth. *Human Growth and Development*, 225–244. <https://doi.org/10.1016/B978-0-12-383882-7.00009-X>. Elsevier Inc.
- Subramanian, S. V., Özaltin, E., & Finlay, J. E. (2011). Height of nations: A socioeconomic analysis of cohort differences and patterns among women in 54 low- to middle-income countries. *PLoS One*, 6(4), Article e18962.
- Tanner, J. M. (1986). Physical development. *British Medical Bulletin*, 42(2), 131–138. <https://doi.org/10.1093/oxfordjournals.bmb.a072110>
- Thompson, K., Quanjier, B., & Murkens, M. (2020). Grow fast, die young? The causes and consequences of adult height and prolonged growth in nineteenth century Maastricht. *Social Science & Medicine*, 266, 113430.
- Thurstans, S., et al. (2020a). Boys are more likely to be undernourished than girls: A systematic review and meta-analysis of sex differences in undernutrition. *BMJ Global Health*, 5, Article e004030. <https://doi.org/10.1136/bmjgh-2020-004030>
- Thurstans, S., et al. (2020b). Understanding sex differences in childhood undernutrition: A narrative view. *Nutrients*, 14, 948.
- Vinci, L., Florisa, J., Koepkea, N., Matthesa, K. L., Bochud, M., Benders, N., ... Stauba, K. (2019). Have Swiss adult males and females stopped growing taller? Evidence from the population-based nutrition survey menuCH, 2014/2015. *Economics and Human Biology*, 33, 201–210. <https://doi.org/10.1016/j.ehb.2019.03.009>
- Viviani, C., Castellucci, H. I., Arezes, P., Bartsch, A., Bragança, S., Molenbroek, J. F. M., ... Aparici, V. (2020). Educational level and its relationship with body height and popliteal height in Chilean male workers. *Journal of Biosocial Science*. <https://doi.org/10.1017/S0021932019000750>
- Zimina, S. N., Negasheva, N. A., & Godina, E. Z. (2019). Sex-specific phenotypic plasticity as a complex reaction of human organism to different environmental conditions. *Collegium Antropologicum*, 43(3), 175–182.