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Long-Term Trends in Height in Rural Eastern Andalusia (1750-1950)[1]

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1. INTRODUCTION

Over the last decade historical anthropometric studies have shed some light onto the changes in biological well-being experienced between 1850 and 1950, both in a number of Spanish regions and in some areas of Latin America. However, the anthropometric scenario remains uncertain from 1750 to 1850, a period traditionally regarded as the transition from the Ancient Regime to modern society in Spain. This essay, through new and straightforward methodological developments, aims to ascertain biological standards of living in this period by presenting some data on male's height from two rural communities of Eastern Andalusia. Anthropometric data (obtained from military recruitment rounds) are supplemented with some information on population and resources from a variety of documentary sources.

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1. Some materials in this essay come from two previous papers: «La paradoja de la modernización en España: el descenso de la estatura en el medio rural durante la fase expansiva del primer capitalismo agrario (1840-1880)» for the *3rd Congreso Internacional de Historia Económica* (Cuernavaca, México, November 2007) and «Long-Term Trends in Height in Spain. Recent Findings and Implications for the Economic History», for the *Spring Seminars* of the Economic History Department at the University of Michigan (Ann Arbor, April, 2008).

Trend analysis focuses on demographic growth and institutional shifts, as they often conditioned the peasant diet in the context of an agrarian society. The interpretation of results refers mainly to the period 1750-1900 so as to avoid comparisons with later periods in which Spanish rural society had already experienced important changes towards an industrial economy. Likewise, the study focuses on socioeconomic variables, omitting epidemiological context, which has already been analyzed in previous work (Cámara, 2007:286-301). Finally, only major long-term trends in height are discussed, though both short-term trends and annual series are deserving of attention in future studies.

1.1. Rural communities[2]

Santa Fe and Montefrío are located in the Andalusian province of Granada (Southeastern Spain). Santa Fe is on the valley formed by the river Genil (600 meters average altitude), close to the city of Granada and surrounded by major mountain ranges, including the Sierra Nevada. An extraordinarily fertile soil and abundance of water made possible the early development of an advanced agricultural hinterland to meet the needs of Granada. During Muslim rule, a large part of the township may have already been cultivated and irrigated (Garrido Atienza, 1990), and by 1750 it is estimated that 70 percent of the township was devoted to crops and mainly exploited under private properties, whereas public pasture had been reduced to merely four square kilometers (González de Molina and Guzmán Casado, 2006: 76). At that time, local agriculture was already very intensive compared with other Spanish agrarian systems. For instance about half of the crop-land was kept under irrigation and crop rotation systems (e.g., legumes) as was the case in the most agriculturally advanced areas of Northern Europe (Martín Rodríguez, 1982: 39; Grigg, 1992). The short duration of land tenancy and rise of an agrarian bourgeois, together with the active commercialization of agrarian products like linen and hemp were other signs of an early transition to agrarian capitalism during the last third of the 18th century (Martínez-Martín, 1995; Martínez-López, 1996; González de Molina and Guzmán Casado, 2006). In 1752, Ensenada's Cadastre reports a population of about 2,400.

Montefrío belongs to a mid-mountain county (800 meters average altitude) and differed from Santa Fe in several physical and socioeconomic respects. The township is located to the Northwest of the province of Granada on the border of the provinces of Cór-

2. All geographic data are from the SIMA (Sistema de Información Multiterritorial de Andalucía), a public service offered by the Instituto de Estadística de Andalucía (IEA): *http://www.juntadeandalucia.es/institutodeestadistica/sima/* [04/25/08]

doba and Jaén. It stretches over more than 250 km² (Santa Fe was just over 40 km²) of a hilly terrain in which abundant public lands permitted gathering and grazing. By mid 18th century, Ensenada's Cadastre shows how most farms also included some pasture as well as Mediterranean trees such as Holm Oaks, Gall Oaks, Poplars and Elms. The Cadastre reports the importance of traditional extensive non-irrigated farming based on cereals. In contrast with Santa Fe, a good part of the township remained unsettled, commons were abundant and both productive specialization and commercialization are presumed to have been lower at that time. According to Ensenada's Cadastre, the local population amounted to more than 5,000 in 1752.

1.2. Data

Heights in Montefrío come from the Local Military Recruitment Acts (LMRA) extraordinarily preserved since the last third of the 18th century[3]. Heights in Santa Fe come from the LMRAs (available since the beginning of the 20th century)[4] as well as from the Provincial Military Recruitment Register (PMRR)[5], which gathered local data under the same criteria starting at the end of the 1870s (Cámara, 2006). An original database containing nominal information on about 20,000 recruits from both communities was as-

3. Local Historical Archive of Montefrío (LHAM). Section 5.8 *Servicios militares*, Subsection *Quintas.* Document codes match years of recruitment.

4. Local Historical Archive of Santa Fe (LHASF). Section 3, Subsection 12, Series 2, years of recruitment and (document codes): 1919 (1332); 1920 (1333); 1921 (1334); 1925 (1338); 1926 (1339); 1927 (1340); 1928 (1341); 1929 (1342); 1930 (1343); 1931 (1344); 1932 (1345); 1933 (1346); 1934 (1347); 1935 (1348); 1936 (1349); 1937 (1350); 1943 (1356); 1944(1357); 1945 (1358); 1946 (1359); 1948 (1350); 1950 (1362); 1956 (Reemplazo de 1956; actas de clasificación y hojas de filiación); 1963 (Reemplazo de 1963; actas de clasificación y hojas de filiación) ; Section 3, Subsection 12, Series 5, years of recruitment and (document codes): 1942 (1402). (1357); 1945 (1358); 1946 (1359); 1948 (1350); 1950 (1362); 1956 (no code); 1963 (no code).

5.Provincial Historical Archive of Diputación de Granada (PHADG). *Series Expedientes de Reemplazo,* years of recruitment and (document codes):1836 (L02846); 1838 (L03797); 1839 (L03464); 1840 (L03799); 1841 (L03805); 1842 (L02755); 1843 (L02757); 1844 (L02758); 1846 (L02742); 1848 (L02746); 1850 (L02751); 1851 (L02689); 1853 (L02691); 1854 (L02692); 1855 (L02694); 1858 (L02707); 1859 (L02709); 1863 (L02716); 1864 (L02717); 1865 (L02718); 1866 (L02719); 1867 (L02720); 1868 (L02721); 1869 (L02722); 1870 (L02724); 1871 (L02726); 1872 (L02727); 1873 (L02729); 1873 (L02730); 1878 (L02833); 1877 (L02830); 1878 (L02833); 1879 (L03466); 1880 (L03468); 1881 (L03470); 1882 (L03472); 1883 (L03474); 1884 (L03476); 1885 (L03478); 1886 (L03484); 1887 (L03486); 1888 (L03507); 1889 (L03490); 1890 (L03510); 1891 (L03512); 1892 (L03513); 1893 (L03516); 1894 (L03519); 1895 (L03521); 1896 (L03531); 1897 (L03533); 1898 (L03537); 1899 (L03539); 1901 (L03556); 1902 (L03559); 1903 (L03562); 1904 (L03574); 1905 (L03576); 1907 (L03579); 1908 (L03582); 1909 (L03630); 1910 (L03633); 1911 (L03636); 1912 (L03638); 1913 (L03641); 1915 (L03647); 1918 (L03883); 1922 (L03884); Series *Copia de actas de declaración y clasificación de soldados,* year of recruitment and (document code): 1922 (L03884); 1923 (no code) 1924 (0374, 1)

sembled from these archival sources. Recruits were assigned a birth cohort in function of their age and the year of recruitment.

Time-cohort series

Due to changes in the legal framework of conscription, not all anthropometric data available are valid to construct time-cohort series. Reliable annual height averages can only be computed from those LMRA and PMRR where heights were measured to determine draft eligibility (we refer to this as an 'extended' recruitment). In so doing we ensure that mean heights reasonably represent the male community height, preventing prior exclusion of those who did not attain the minimum height to be enrolled[6]. Moreover, in this study only recruitment rounds with a minimum of 20 valid observations have been included in the series (details on the number of observations by birth cohort are provided in the final appendix). No estimates are used to construct the series, since only recruitments specifically recording the height for both *valid* and *excluded* recruits have been used.

Information about the recruits' place of birth is available for those born between 1876 and 1929 in Santa Fe and those born between 1863 and 1927 and 1935 and 1944 in Montefrío. Due to the high percentage of locally born recruits, variations in the mean community height attributable to immigration are very small for single years and even less significant when computing 5-year moving averages[7]. It is thus unlikely that either direction or intensity of trends is affected by this factor.

The main problem in interpreting the series is the age at recruitment, which shifted across time: 16-40 years (18th century), 16-25 years (first decades of the 19th century), 18-19 years (1836-1849), 20 years (1850-1884), 19 years (1885-1900), and finally 21 years (1907-1970). In order to reduce the effect of age on height, all measurements included in the series have been standardized to the age of 21. This standardization is based on a regression model that omitted heights above and below the 90th and 10th percentiles respectively for each birth cohort. Heights of 600 recruits from Montefrío aged 16-40 and born between 1771 and 1837 were used to construct the model. Height displayed a significant relationship with age until age 21. Such a relationship was very marked between

6. Issues related to legislation on military recruitment in Spain (e.g. old measurement units and minimum height and age requirements) can be seen in Martínez-Carrión (2001) and Cámara (2006).

7. In Santa Fe, during the period 1876-1929, 92.3% of recruits whose place of birth was recorded (70% of the total) were born in the township. In Montefrío, where the registration of these data was very exhaustive (95% of recruits) 88% were born in the township for the cohorts 1863-1927 and 91% for the cohorts 1935-44 (percentages rise to 91 and 93 respectively if the neighbor village of Algarinejo is included in the township).

ages 16 and 19, and more moderate from 19 to 21 (Cámara, 2007: 46). Since no other control variables were included, only recruits older than 18 were selected to construct the series, in order to reduce the risk of skewing from earlier ages where physical growth remained intense. It must be noted that this standardization (resulting in adding 1.5 cm and 0.7 cm to recruits aged 19 and 20, respectively) is to some extent arbitrary since the *tempo of growth* during late adolescence depends also on environmental conditions and genetics. The model is not based on the follow-up of recruits' heights across time, but rather on successive cross-sectional observations. Standardization is therefore likely to overestimate the annual mean height because it is applied to all individuals, regardless of their actual height at the time of measurement (Bogin, 1988). For this reason, although the main trends observed should be rarely affected by this potential bias, both crude and standardized heights are included in the study.

Long-term trends (18th-20th centuries)

In the case of Santa Fe, no data from *extended recruitments* are available prior to 1877. As recruits were measured at age 20 at that time, this means that series report on adult height of male cohorts born starting in 1857. Earlier data only refer to the heights of young males enlisted in the military. In that case, as the number of soldiers required of a community was proportional to population, observations in Santa Fe (a relatively small community until the mid 19th century) are scant. Nevertheless, those heights are the result of the same recruitment and draft process. Hence, if the variations of the minimum height required are corrected, some inferences for valid recruits can be made. Two approaches are presented. The first sets the minimum height at 1,625 mm (the minimum during the last third of the 18th century and not surpassed later in Spain) and the second at 1,560 mm (again the highest minimum requirement within Spanish conscription since 1860). In the first case, a trend starting in the final third of the 18th century is obtained, whereas in the second approach the study starts in 1845. Both approaches also used the verification of proper physical status labeled in the sources with terms such as 'soldier', 'able', or 'valid', as well as ages above 18 as additional conditions to include a registered height in the analysis. Results are displayed in Figures 1 and 2.

In Montefrío a slightly different method has been applied since some data from extended recruitments are available earlier (recruitments in 1770, 1773, 1775 and 1794). The problem, however, is the ambiguous registration of height. These recruitments only register whether the recruit attained the minimum height. Since this minimum is always known together with the age of each recruit, some estimation can be attempted. As mentioned above, this may be risky depending on the age range used. If all ages were included, the height estimation would become a more complex two-step process. First, a starting

height should be set up followed by an additional estimation of the potential physical growth until adulthood. For reliability, the second option has been skipped by choosing recruits over 20 years of age. First, using data from 1808 and 1858, the earliest extended recruitments for which we have exact individual height data, we calculate two means 1) for accepted recruits (1,675 mm) and 2) for those rejected (1,573 mm). We assume that these means are valid for accepted and rejected recruits in the last third of the 18th century and are thus weighted based on the proportions of accepted and rejected males. These criteria estimate Montefrío's cohort height prior to 1768 (recruits from LMRA held in 1770, 1773, 1775 and 1794) from the results provided by two single cohorts (1788 and 1838). Though this is not the most solid estimation, we have confirmed that recruits born in 1788 and 1838 did not experience special nutritional disruptions, e.g. severe subsistence crises or epidemics, during infancy. The results of this estimation process can be seen in Figure 6. In contrast, series are based on the recruitments of 1808 and 1858 onwards that recorded the numeric height of all local males ranging from ages 16 to 40. In this case, heights are standardized for those aged 19 and 20. Hence, Figure 7 displays actual heights from cohorts born since 1778 pertaining to recruits over age 18 measured under the extended recruitment system whose exact height was registered regardless of final eligibility (invalid, valid, excluded or enlisted).

2. RESULTS

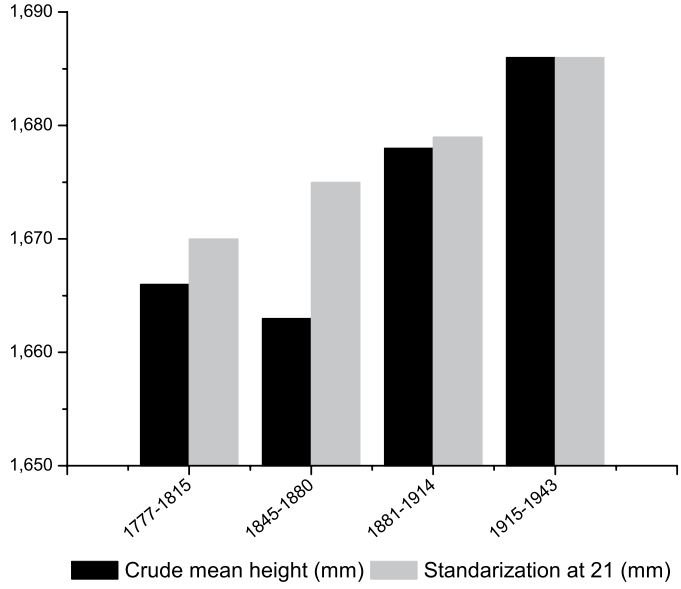
Santa Fe *soldiers* (those males finally enlisted) are likely to have experienced a steady increase in mean heights since the middle of the 19th century. This increasing trend cannot be ensured further back in time due to the scarcity of valid cases and the effect of standardization for the period 1777-1815 (Figure 1). Moreover, most of these young males were within the highest quartile of the height distribution and, thus, the question is whether the trend observed since 1845 is representative of community biological well-being.

Performing the same analysis on a different height criterion (switching to 1,560 mm) reduces the time span but yields more accuracy by including a wider range of statures (Figure 2). In this case, the stable progress of height can only be affirmed since the decade of 1890 whereas, at the very least, a stunting process is detected among soldiers born between 1845 and 1889 (local soldiers' mean height oscillated between 1.64 and 1.65 m during those five decades).

Figure 3 only includes data from the available extended recruitments, and Figure 4 compares the evolution of quartiles upon this kind of recruitments for male cohorts born

since 1857. As shown, the poor results of the indicator by the middle of the 19th century are mainly due to extremely short heights within the lower quartile. Twenty-five per cent of local recruits attained what may be considered modern statures, i.e. between 1.70 and 1.75 m, by the middle of the 19th century. In contrast, the shortest males varied between 1.50 and 1.55 m during the last half of that century. The gap between those quartiles only began to narrow, matching the stable progress of the nutritionally worst-off after the end of the 19th century. This evidence suggests that the observed stunting process since 1845 could in fact have been a downtrend for the overall community.

FIGURE 1
Height of soldiers measuring over 1,624 mm in Santa Fe
Cohorts born between 1777 and 1943



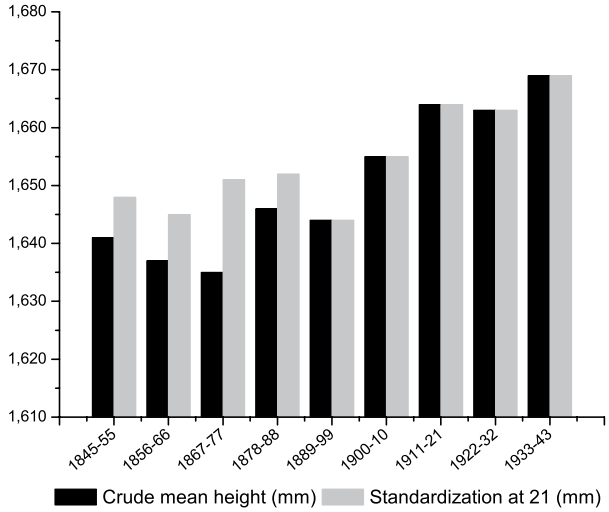
Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5. For details, see Appendix, Table A.1.

To better assess whether this uneven height distribution really reflects nutritional stratification, recruits were located in the local censuses by the time they were infants or adolescents. In so doing, it is possible to relate the socioeconomic environment with the final height attained at adulthood. Four aggregated cohorts were selected regarding the availability of additional information in the recruitment acts (address, parents' names) as well as the availability of local censuses containing the recruits 15-20 years earlier. That eased the location of households in the local censuses. The need to cross these different sources explains that not all cohorts are represented in this analysis.

FIGURE 2

Height of soldiers measuring over 1,559 mm in Santa Fe

Cohorts born between 1845 and 1943[8]



Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5. For details, see Appendix, Table A.2.

FIGURE 3

Male height in Santa Fe. Standardization at age 21 (mm and birth year).

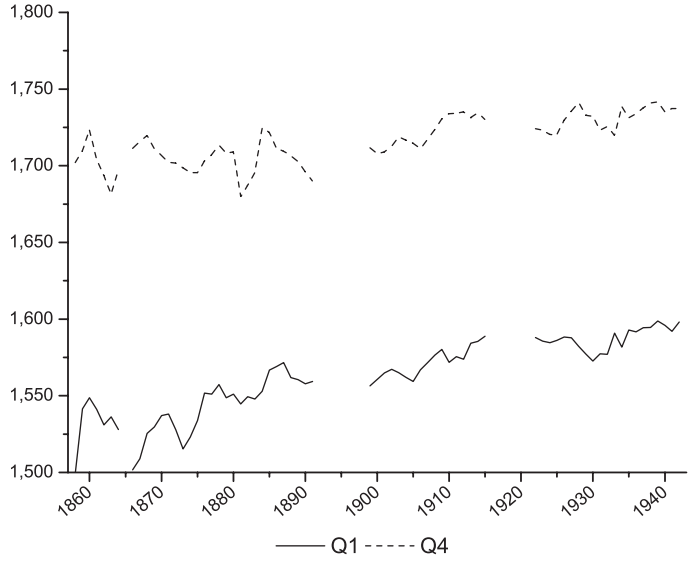
Cohorts born between 1857 and 1943. Five-year moving average



Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5.

8. Ages at measurement in this figure are: for cohorts 1845-55, 20 years (98 valid cases); for cohorts 1856-66, 19 years (47 valid cases) and 20 years (216 valid cases); for cohorts 1867-77, 19 years (290

FIGURE 4
Height distribution in Santa Fe. Standardization at age 21
(first and fourth quartiles, mm)
Male cohorts born between 1857 and 1943. Three-year moving average



Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5.

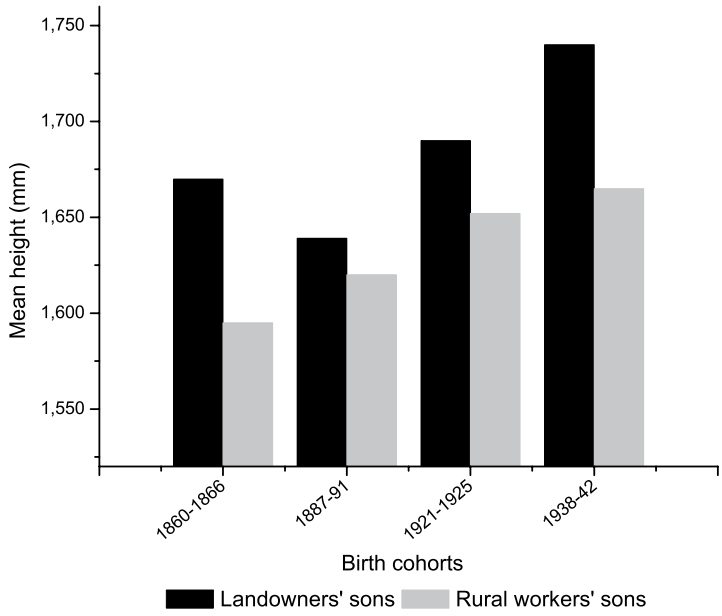
These outcomes strongly support the claim that the social gap in nutritional status matched the period in which community stature stunted or dropped (Figure 5). As shown, even when small peasants and day laborers are aggregated into one category[9], descendents of higher rural classes were invariably taller. Differences became dramatic by the middle of the 19th century, diminished starting in the 1890s and sharply increased again for the

valid cases); for cohorts 1878-88, 19 years (67 valid cases), 20 years (154 valid cases) and 21 years (157 valid cases); for cohorts 1889-99, 21 years (233 valid cases); for cohorts 1900-10, 21 years (620 valid cases); for cohorts 1911-21, 21 years (408 valid cases); for cohorts 1922-32, 21 years (594 valid cases) and for cohorts 1933-43, 21 years (614 valid cases).

9. Occupation is an ambiguous category in the Spanish nineteenth-century local censuses. For instance, the distinction between the landless and the small land holder is sometimes neglected depending upon the season in which the census was taken. Hence Figure 5 has been aggregated in broad categories for rural socioeconomic status. Under the *label rural workers' sons* we have included those potential recruits whose household head appeared in the local census as an agricultural worker, small holder or similar *(campo, jornalero, trabajador agrícola)*. On the contrary, categories such us *labrador* and *propietario,* together with prominent occupations and political positions in the community *(notario, médico, alcalde)* that usually were associated to the large land tenure in this area of Spain have been classified under the label *landowners.*

cohorts who lived their infancy during the Spanish civil war (1936-39) and early post-war period.

FIGURE 5
Male height (standardization at age 21)
and social adscription in Santa Fe (1860-1942)

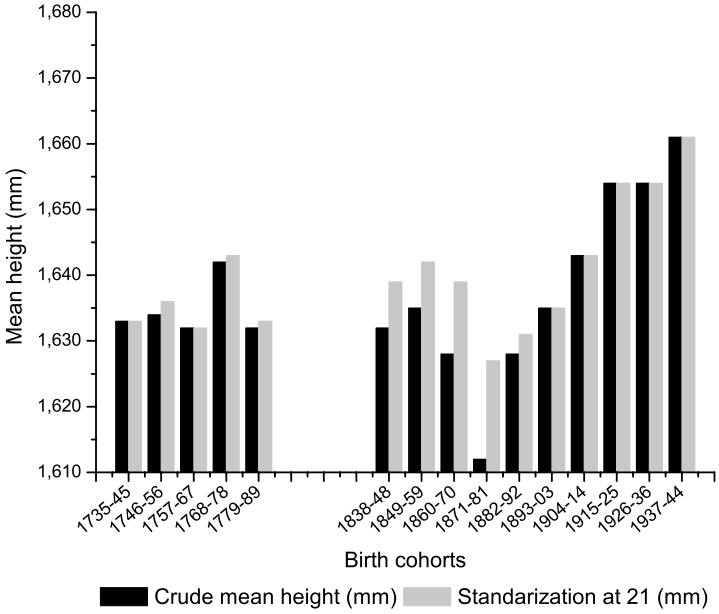


Sources: LMRA, PMRR and Local Censuses from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5.

The military recruitments from Montefrío provide a broader perspective on long-term trends. Local recruits measured between 1.63 and 1.64 m during the second half of the 18th century (Figure 6). These averages are very high among known Spanish 19th century standards, which is also notable considering that the second half of the 18th century was not a particularly favorable period for the Spanish rural population. Conversely, there is evidence of negative economic and epidemic episodes during the late Ancient Regime (Anes Álvarez, 1970; Pérez Moreda, 1980; Fontana, 1985; Sebastián Amarilla, 2004). No steady improvements in height are detected during the 19th century, which would have coincided with the consolidation of the liberal state. Furthermore, the series show a significant down trend at mid-century (1850-1875) followed by a stunting process until 1890 (Figure 7).

FIGURE 6

Height of recruits in Montefrío. Cohorts born between 1735 and 1944



Sources: LMRA from Local Historical Archive of Montefrío. Document codes cited in footnote 3. For details, see Appendix, Table A.3.

FIGURE 7

Male height (mm and birth year) Five-years moving average

Recruits born in Montefrío (1778-1944)



Sources: LMRA from Local Historical Archive of Montefrío. Document codes cited in footnote 3.

Finally, Figure 8 presents a clear period of divergence in the height distribution matching the drop in community height during the second half of the 19th century. Again, it invites one to think that gains and losses in height, and consequently that major cycles in nutritional status, did not occur evenly throughout the community —an aspect further commented in the discussion—.

FIGURE 8
Male height distribution in Montefrío (first and fourth quartiles, mm)
Cohorts born between 1778-1944. Three-year moving average



Sources: LMRA from Local Historical Archive of Montefrío. Document codes cited in footnote 3.

As expected, heights during the late Ancient Regime did not substantially exceed those in later periods. However, this first anthropometric evidence during the period 1750-1850 speaks against any progress derived from the rise of the modern state in these two rural areas. If the estimates made for cohorts born prior to 1770 are correct, the most probable scenario would have been the succession of boom and bust cycles until the middle of the 19th century. If, in turn, the initial reference is the height attained by the last third of the 18th century (based on actual heights), a long-term decreasing trend can be confirmed until the end of the 19th century.

Whichever the approach is adopted (estimates or actual registered heights) the long-term trends point out a structural collapse of the nutritional status in both communities during the second half of the 19th century.

3. DISCUSSION: SOME FACTORS INVOLVED IN MAJOR TRENDS IN HEIGHT

The anthropometric results for the second half of the 18th century are quite surprising regarding the fragility of peasant economies during the Ancient Regime. In turn, they are coherent with some dynamics described by Spanish Economic History and Historical Demography.

In the former kingdom of Granada (current provinces of Granada, Málaga, and Almería), it is estimated that between the end of the War of Succession (1701-1713) and the mid 18th century the percentage of cultivated land reached 50 percent of its potential (Gámez Amián, 1986: 111). This trend held for the population across Spain (Nadal, 1966) once major threats like the plague were eradicated and the total availability of food progressed, partly due to the increasing workforce and the expansion of cultivation to new land. These processes might reflect an improvement in the capacity of population to respond to illness and relative scarcity. To be sure, they encouraged the increasing commercialization of agrarian products and the need to access to land on the part of peasants. As a consequence, in the region of Andalusia, purchasing, letting, sharecropping and even the taking and clearing of public lands were the means through which many former landless gained land during the last third of the 18th century (Bernal, 1979). The Enlightenment measures during the last third of the 18th century together with the liberal agrarian reforms during the first half of the 19th century reinforced this extensive growth pattern as well as the specialization on highly profitable products like cereals. This agrarian development pattern spread over most of the country and might have contributed to sustain biological living standards at relatively stable levels despite periodic episodes of epidemics and acute scarcity. However, it could not progress indefinitely. Once the better lands had been settled by 1850, agrarian growth (either intensive, by improving irrigation and the application of manure fertilizers or extensive, by expanding the area of cultivated land) was extremely difficult to carry out under the existent technological conditions (Naredo, 1971; Garrabou and Naredo, 1996; Pujol et al. 2001). For instance, at the local level, Madoz (1848) provides an interesting testimony of the agricultural scenario in the valley of Genil at that time. His description of the local landscape suggests that the extensive growth possibilities in the township of Santa Fe would have ended even before 1850. By that time, the population had doubled with respect to the mid 18th century increasing after harvest failures during the decade of 1820 and the cholera outbreak in 1834 (from 3,400 to 4,600 between 1836 and 1847) (Figure 9). These factors may have led to an excessive fragmentation of parcels (Martínez-Martín, 1995) and, consequently, to a more vulnerable scenario of social reproduction for the lower classes. In our view, the temporary collapse of demographic growth (related to the increase of mortality; Cámara, 2007)

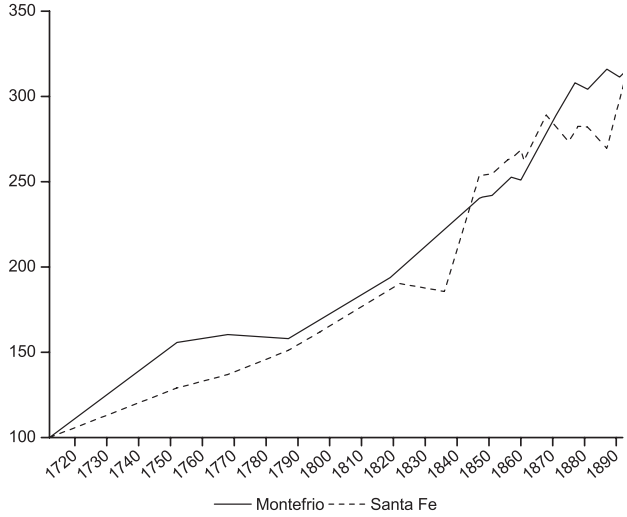
as well as the drop in community male height evidence the negative nutritional consequences that this scenario implied for some sectors of the population. This hypothesis is supported by González de Molina and Guzmán Casado (2006: 229-284) who assessed a growing economic inequality within the community reflected by the concentration of basic resources (land, livestock and income) as the peasant economies integrated the market[10].

A similar process of both demographic and agrarian growth was experienced in Montefrío. During the last third of the 18th century and the first half of the 19th century, intense settlement took place within the township. *Barranco de las Caleras, La Dehesa, Cuesta del Aceite, Lomillas de Gámez* and *Lomas Azules* were the main settlement areas, all of them former public lands registered in Ensenada's Cadastre (1752). These terrains housed a large proportion of the nearly 3,000 people gained by the mid 19th century (Figure 9). In 1848, the population living scattered on the township lands had risen to nearly 35 percent of the total local population. A decade later, in 1857, the first national census reported 400 populated areas within the township. The large size of the township likely allowed extensive agrarian growth to progress somewhat longer than in Santa Fe. Also the closer location of the labor force within the new agricultural operations, rather than a more intensive application of water or fertilizer, probably contributed to improved land productivity. However, by 1850 most public lands had been privatized and plowed, thus dampening a prolonged increase in productivity. As in Santa Fe, it likely provoked a high vulnerability of the lower rural classes as attested by the increase in height differences (Figure 8). To this regard, it must be reminded that the landless, small land proprietors, and the poor in general were often opposed to the liberal program of agrarian reforms. Processes of privatization, crop expansion and specialization encroached on formerly fallow lands and Mediterranean forests that often were part of the commons, and on public lands where the lower rural classes freely practiced gathering and grazed livestock (Cobo *et al.*, 1992). These activities were a complement to monetary income, and a wide

10. The number of landowners in Santa Fe substantially increased between 1750 and 1855 (Martínez-Martín, 1995). However, they only amounted to 25 percent of households (only 5 percent more than a century before). In other words, 75 percent remained landless and completely excluded from alternative resources apart from wages after the process of privatization experienced within the local agrarian system (Gómez Oliver and González de Molina, 1983). Over the same period, agriculture progressed in the agrarian system of Montefrio so that extensive cereal-specialized dry farming became the prevalent activity by the mid 19th century. Note that by 1860, much of the township had already been privatized and many landless had gained access to property since the final decades of the 18th century. This process accelerated during the first half of the 19th century. In this case, it is presumed that the proximity of basic sources providing nutrients remained a major characteristic of the agrarian system. However, the relative abundance of resources, and particularly their accessibility, resulted in an important reduction due to the process of privatization and demographic growth.

range of resources from open lands were either severely restricted or underwent dramatic increases in cost, once they were privatized. The real impact of these changes must be evaluated bearing in mind that they coincide with a significant increase in population. A good example of the reduction in accessibility and changes in allocation of resources is provided by the evolution of livestock in both communities (see the case of Santa Fe in Table 1).

FIGURE 9
Demographic growth in Montefrío and Santa Fe. Index 100 (1712-1900)



Notes: Montefrío: 3,280 inhabitants in 1712 and 10,743 in 1900; Santa Fe: 1,850 inhabitants in 1712 and 6,700 in 1900.
Sources: 1712, Campoflorido's Census (reviewed and corrected in Cámara, 2007); 1752 Ensenada's Cadastre; 1787 Floridablanca's Census; 19th century, local and national censuses.

As is well known, domestic livestock was a major provider of household caloric and protein intake and served to mitigate undernourishment during episodes of severe economic stress. In 1848, Madoz pointed out the scarcity of domestic livestock (namely sheep, goats, pigs, and cows) in the administrative district *(partido judicial)* of Santa Fe because of the few remaining fallow and forested lands. Whereas the best-off residents could obtain meat and animal-derived products daily from the markets, lower rural classes, mainly the landless and small landowners, had lost those valuable spaces where their main sources of protein and calories were raised. The decline in domestic livestock in the community of Santa Fe is likely to have caused a severe reduction in the availability of certain foodstuffs, particularly in those providing animal-derived calories and proteins. Between 1752 and 1856 it is estimated that *per capita* availability of meat dropped from 342 to 54.5 g, while milk dropped from 54.4 to 16.1 cc (González de Molina and Guzmán Casado, 2006).

TABLE 1
Livestock in Santa Fe (1752-1913)

	1752	1856	1860	1876	1904	1913
Mules	51	131	140	97	150	240
Horses and colts	118	141	173	38	83	77
Asses	25	14	23	11	23	6
Cows and oxen	79	44	86	87	101	181
Sheep	1,413	250*	1,000	1,025	1,000	939
Goats	298	47	51	31	51	1035
Pigs	625	-	200	10*	200	-
Index 100 per capita						
Mules	100	126	136	89	98	153
Horses and colts	100	59	73	15	24	21
Asses	100	27	46	21	31	8
Cows and oxen	100	27	54	51	43	75
Sheep	100	9	35	34	24	22
Goats	100	8	8	5	6	113
Pigs	100		16	1	11	

Notes: (*) Likely to be misreported.
Sources: Livestock: 1752 and 1876 (Cámara, 2007); other references (González de Molina and Guzmán Casado, 2006: 260, 107, 133 and 266). Population: Local censuses and inter-census estimates.

In Montefrío, the proximity of large areas of Mediterranean forest allowed locals to gather a wider variety of fruit and raw materials, as well as to raise more livestock. According to Ensenada's Cadastre (1752), local livestock reached 27,000 heads —one of the most numerous stocks in Eastern Andalusia—, including 15,173 goats, 2,213 sheep and 6,733 pigs. Furthermore, this source reports the existence of nearly 600 livestock owners (500 of them owned some of the above-mentioned types of domestic livestock). Though the distribution of livestock was asymmetric, the data from the cadastre confirm many small sharecroppers, tenants and landless owning domestic livestock. Broadly speaking, even humble and poor households were often able to breed a couple of pigs, a goat and some sheep. We have not yet studied the available sources to obtain a detailed follow-up of local livestock. Nevertheless, some testimonies from the end of the 19th century allow us to make provisional inferences. Morell y Terry (1861-1940), a reputed agronomist in Granada, described the sharp decline in livestock within the province in the years prior to 1890. Large extensions of natural pasturelands had disappeared throughout the previous decades, and the author pointed out the lack of proper soil and climate conditions to replace them with fields of cropped pastures oriented to animal feed, such as those of Northern Europe (Morell y Terry, 1888: 133). He also noted that by the middle of the 19th century, the administrative districts of Loja and Montefrío, including 17 townships,

held about 45,000 livestock heads, nearly 39,000 of which were domestic. This is little compared to the quantity documented in 1752 just in the township of Montefrío. Even regarding the likely bias caused by the fiscal nature of sources, evidence of the decline is found in a number of areas. Between 1750 and 1850, the same trend was found across the whole region of Eastern Andalusia (Navarro Pérez, 2002) as well as for the entire kingdom of Castille, particularly during the last half of the 19th century (Garrabou and Sanz, 1985: 116; García Sanz, 1994). Studies made for other Mediterranean areas confirm similar occurrences related to liberal agrarian reforms (Sansa, 2000)[11].

As is shown by the anthropometric series, the first half of the 20th century witnessed some hazardous periods in terms of nutritional status within both townships. However, neither collapses nor annual variations (Cámara, 2007) had the intensity of those experienced throughout the previous century. Furthermore, these and other rural communities in Spain show a stable recovery of height and other indicators of living standards since the end of the 19th century (Martínez-Carrión, 2002). In structural terms, and following the arguments thus presented, we may suppose that the overcoming of height declines and stunting cycles may have been associated with the transition toward an industrial economy. This transition was based according to the physical features of each agrarian system but, in the end, consisted in an exponential increase in energy available to all economic sectors from production to commercialization. In some cases, this dramatic change favored the massive application of chemical fertilizers and, consequently, the breakdown of physical limits constraining the productivity in Mediterranean agriculture (Gallego, 1986; Galassi and Cohen, 1992). In other cases, even without a general industrialization process in terms of mechanization and large-scale irrigation, exportation and market competition became more feasible and were introduced as the preferential alternative to traditional subsistence economies. The two rural communities here considered illustrate these statements.

Santa Fe experienced the transition toward industrial agriculture very early. Firstly, advanced organic fertilization (i.e. the use of guano) had been tested since the middle of the 19th century. Somewhat later, massive irrigation allowed the new imported chemical fertilizers. By 1880 the beetroot was introduced in the local fields, and it took only a decade to develop a powerful agro-industrial sector in the area. The burgeoning economy was participated in, not only by large landowners and tenants, but also by the small peas-

11. The so-called end-of-the-century agrarian crisis *(crisis agraria finisecular)* also contributed to this negative scenario for the rural economies and probably hampered an earlier recovery. A review of this process in Andalusia has pointed out its early appearance with respect to other Spanish regions (López-Estudillo, 2002) so that its impact over traditional peasant economies after 1860 might have worsened the precarious situation of some rural sectors.

antry and rural workers whose incomes rose as a result of the high labor demand created by the new crop. During this period our results show a recovery of the mean height together with a transitory reduction of nutritional stratification which is shown by the convergence in height distribution. Such a trend agrees with previous works pointing out the improvement of lower classes' income in the area (Martín-Rodríguez, 1982).

Montefrío's agrarian system was less conducive to the application of fertilizers thus recovery from the structural crisis had a necessarily different profile. Here, as in many other non-irrigated agricultural areas of Andalusia, the crisis of the liberal growth pattern based on cereals was overcome with the spread of the olive orchard during the first third of the 20th century. Increasing attention to fertilizing, harvesting, and oil extraction procedures contributed to the improvement and development of the agro-industrial sector in terms of productivity and capacity to compete in international markets (Zambrana, 1984). Moreover, the new specialization generated an important income supplement as the harvest did not overlap with that of cereals, thereby reducing labor seasonality for the landless.

Finally, though no less remarkably, the increase in productivity attained across the whole of the country allowed for the devotion of some land to the breeding of livestock, thus leading to its relative recovery during the first third of the 20th century (Garrabou and Sanz, 1985). The benefits from the latter aspect on self-sufficient household production remain to be clarified. To be sure, it contributed to the increase in the total volume of high protein and caloric foodstuffs available in the markets, thereby promoting the so-called *nutritional transition* in Spain (Cussó, 2005).

4. CONCLUSIONS

As Spanish military recruitment archival sources are explored in depth, new methodological approaches become available to expand the periods over which anthropometric historians are able to analyze the biological components of wellbeing in the past. Knowing the minimum height required to be enrolled in the army across time and controlling differences in height by age allow the reconstruction of general trends as well as time-cohort series starting in the Ancient Regime.

The first evidence on height in 18th-century Eastern Andalusia suggests alternating up- and down-swings during the late Ancient Regime and the rise of the liberal state. This is not surprising since it is known that living standards in pre-industrial societies were fragile and unstable. Though oscillating, community heights between 1750 and 1850 were rel-

atively high before the severe collapse of nutritional status during the central decades of the 19th century.

Demographic and institutional changes together with economic scenarios strongly conditioned by the physical features of the agrarian systems have been the main factors analyzed. Whereas the increase of population may have facilitated agrarian growth and food production during the 18th century and the first half of the 19th century, extensive growth patterns promoted by the liberal measures may have exhausted by the mid-19th century. This would have contributed demographic growth (accompanied by a dramatic reduction in the accessibility to basic resources) to become a serious threat to the subsistence and reproduction of lower rural classes. Perhaps this structural crisis would have been unavoidable even if the socioeconomic structures of the Ancient Regime had remained in place. However, in our opinion, some liberal reforms intensified the negative effects of the population-resource imbalance among lower-class residents. In general, socioeconomic and institutional shifts did not lead to any effective improvement in the nutritional status for most of the population within the studied communities until accompanied by effective alternatives of agro-industrialization and competitive specialization. In other words, it is highly unlikely that the rise of a modern *landed society* in Santa Fe and Montefrío contributed to improved biological wellbeing among the majority of households. In fact, this study has shown dramatic differences in mean height associated with socioeconomic status beyond the private land ownership. It is thus less tenable to argue that casual laborers, small tenants, and small proprietors were also benefited by the agrarian liberal reforms. To the contrary, this evidence invites one to think on the costs of liberal reforms and economic growth in biological terms. Furthermore, differences in the timing of height fluctuations between Montefrío and Santa Fe during the 19th century provide a first view into the diverse exposure levels in light of diverse physical conditions as well as socioeconomic and institutional dynamics. In this sense, it is worth positing whether different kinds of socioeconomic organizations mitigated or intensified the impact of those dynamics over some aspects of population's well-being. These lines of study, as well as the prospects of acquiring continuous and more solid longitudinal anthropometric series, are potentially fruitful paths that may contribute to refining the interpretation proposed in this work.

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APPENDIX

TABLE A.1

Height of soldiers measuring over 1,624 mm in Santa Fe

Cohorts born between 1777 and 1943

Cohort	Valid cases	Crude mean height (mm)	Standardization at 21 (mm)	Std. deviation	
1777-1815*	33	1,666	1,670	35.65	35.34
1845-1880	496	1,663	1,675	39.98	39.86
1881-1914	980	1,678	1,679	39.47	39.46
1915-1943	1,039	1,686	1,686	42.89	42.89

Note: (*) Seven recruits were of 19, six of them age 20, one 21, three 22, seven 23, one 24 and eight were over 24. For the rest of the cohorts, see previous comments on the age at recruitment in Spain in section 1.2.

Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5.

TABLE A.2

Height of soldiers measuring over 1,559 mm in Santa Fe

Cohorts born between 1845 and 1943

Cohort	Valid cases	Crude mean height (mm)	Standardization at 21 (mm)	Std. deviation	
1845-55	98	1,641	1,648	53.06	53.06
1856-66	263	1,637	1,645	50.67	50.74
1867-77	290	1,635	1,651	49.59	49.59
1878-88	378	1,646	1,652	49.73	49.69
1889-99	233	1,644	1,644	48.30	48.30
1900-10	620	1,655	1,655	51.73	51.73
1911-21	408	1,664	1,664	51.69	51.69
1922-32	594	1,663	1,663	53.12	53.12
1933-43	614	1,669	1,669	53.15	53.15

Sources: LMRA and PMRR from Local Historical Archive of Santa Fe and Provincial Historical Archive of Diputación de Granada. Document codes cited in footnotes 4 and 5.

TABLE A.3

Height of recruits in Montefrío Cohorts born between 1735 and 1944

Cohort	Valid cases	Crude mean height (mm)	Standardization at 21 (mm)	Std. deviation	
1735-45	88	1,633	1,633	50.47	50.47
1746-56	420	1,634	1,636	48.85	48.74
1757-67	51	1,632	1,632	50.46	50.46
1768-78	206	1,642	1,643	55.10	55.04
1779-89	260	1,632	1,633	60.08	60.14
1838-48	631	1,632	1,639	63.35	63.34
1849-59	798	1,635	1,642	62.52	62.44
1860-70	988	1,628	1,639	74.26	74.36
1871-81	1,156	1,612	1,627	70.46	70.30
1882-92	1,172	1,628	1,631	65.65	65.46
1893-03	1,246	1,635	1,635	59.81	59.81
1904-14	1,166	1,643	1,643	59.00	59.00
1915-25	1,127	1,654	1,654	58.81	58.81
1926-36	1,474	1,654	1,654	60.04	60.04
1937-44	908	1,661	1,661	60.22	60.22

Sources: LMRA from Local Historical Archive of Montefrío. Document codes cited in footnote 3.