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## POOR BUT TALL. THE HEIGHT PREMIUM IN THE CANARY ISLANDS AT THE BEGINNING OF NUTRITIONAL TRANSITION

José-Miguel Martínez-Carrión\* Begoña Candela-Martínez\*\* Cándido Román-  
Cervantes\*\*\* Ginés Díaz-Carmona\*\*\*\*

S E H A

\* \*\* Universidad de Murcia

\*\*\* Universidad de La Laguna

\*\*\*\* Independent researcher

E-mails: [jcarrion@um.es](mailto:jcarrion@um.es), [bcandela@um.es](mailto:bcandela@um.es), [croman@ull.edu.es](mailto:croman@ull.edu.es)

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Cándido Román-Cervantes y Ginés Díaz-Carmona

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**Abstract:** *This article explores the beginnings of the nutritional transition in relation to height in male populations of the Canary Islands. With military recruitment data for the cohorts of 1860 and 1915, it shows the insular advantage (height premium) compared to the average height of the Spanish populations of the Iberian Peninsula. The secular trend for height was positive. The increase in height of 2.4 cm during the expansive cycle of the island economy was comparable to that of the Spanish average. It also highlights the biological variability of the heights, probably due to the genetic composition of the island populations, and that the average urban height was greater than the average rural height. Finally, we find that height inequality increased in years when average height decreased, especially between 1866-80 and 1900-1905. The Canarian height premium is analyzed based on the insular environment, climate, economic cycles, and diet.*

**Key words:** Biological welfare, nutritional transition, Canary Islands, height premium, rural-urban height gap, inequality.

**JEL Codes** N33, N34, I15, I31

**Resumen:** Este trabajo explora los comienzos de la transición nutricional en relación con la altura en poblaciones masculinas de las Islas Canarias. Con datos del reclutamiento militar para las cohortes de 1860 y 1915, muestra la ventaja insular (height premium) frente a la altura promedio que registraron las poblaciones españolas de la península ibérica. La tendencia secular de la altura fue positiva. El incremento de la altura de 2,4 cm durante el ciclo expansivo de la economía isleña fue parangonable al del promedio español. También destaca la variabilidad biológica de las alturas, probablemente por la composición genética de las poblaciones isleñas, y que la altura promedio urbana fue mayor que la altura promedio rural. Finalmente, encontramos que la desigualdad de la altura aumentó en los años en que disminuyó la estatura promedio, sobre todo entre 1866-80 y 1900-1905. La prima de altura canaria se analiza en función del ambiente insular, el clima, los ciclos económicos y la dieta.

**Palabras clave:** Bienestar biológico, transición nutricional, Canarias, prima de altura, Brecha de talla rural-urbana, desigualdad.

**JEL Codes:** N33, N34, I15, I31

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**Ginés Díaz-Carmona (Independent researcher)**

## **Introduction**

The nutritional changes reflected in human heights have been significant in recent times. A growing body of studies on biological anthropology and economic history reveal the variability in height in the past according to different environments and socioeconomic status (Steckel, 2019; Harris, 2021). Height is a good proxy for income and wealth, health and cognitive development. Although it is conditioned by genetics, growth in height reflects the living conditions of a specific society (Tanner, 1994; Steckel, 1995; Bogin, 2021). Climate and ecological conditions, diet and food consumption habits, the socioeconomic, family and cultural environment and also genetics are determinants of nutritional status and biological well-being. This would explain the differences observed between the average heights in Spain, a country which is highly characterised by inter-regional environmental contrasts. The long-term trends in height during the dietary and nutritional transition in the Spanish peninsula are well known (Martínez-Carrión, 1994; Martínez and María-Dolores, 2017; Cámara et al., 2019). However, we know little about the anthropometric history of the island populations and less still about the Canary Islands at the beginning of this transition. This chapter seeks to cover this gap and contribute to the knowledge on the nutritional status of the populations of the Canary Islands from the mid-nineteenth century until the 1930s. This period was characterised by the insertion of the islands into a production and services economy connected to international trade (Macías, 2011).

The second half of the nineteenth century and first third of the twentieth century constitute a decisive stage for analysing the dimension of the changes in nutrition and health of populations. This period witnessed the first phase of the nutritional, demographic and epidemiological transitions, which led to the eradication of hunger, the control of epidemics and decline of infectious diseases associated with food and water and the fall in infant mortality. This stage represented the beginning of modern economic growth. For the island populations, the period was transcendental due to the implementation of the Free Ports Law of 1852 which inserted the Canary Islands into the international markets and free trade system. This situation of trade exchanges prevailed until the 1930s, unlike the protectionist model that was implemented in peninsular Spain. This commercial stage is known as “the golden age” of economic history of the Canary Islands, which enabled the diversification of the productive structure and incorporated significant technological improvements leading to better levels of well-being among the society of the islands (Macías, 2001). Within this context, we should ask how the socioeconomic changes affected the nutritional status of the Canary population.

The nutritional transition gave rise to extraordinary changes in diet which were reflected in the increase in the consumption of calories, proteins and quality nutrients (Popkin, 2004; Nicolau and Pujol, 2011). The many studies carried out for Spain on the nutritional changes among the different population groups show that the greatest progress was made in the twentieth century due to the intensity of the socioeconomic and demographic transformations. However, in the principal cities, these improvements were not evident until the end of the nineteenth century (Calatayud and Medina, 2017; Cussó et al. 2018; García and Trescastro, 2017; Garrabou and Cusso, 2009; González de Molina et al, 2014; Hernández and Pujol, 2017; Hernández et al., 2019; Nicolau and Pujol, 2005g Pujol and Cussó, 2014; Langreo and Germán, 2018; Medina Albaladejo and Calatayud, 2020, 2021). The environmental and technological changes that led to modern economic growth modified the patterns of production and food consumption, reduced the high mortality and fertility rates and, as a result, altered the family composition and the demand for nutrients from the very beginning of the twentieth century. The technological changes that affected consumption included the improvement of the preservation and processing of foods and their commercial distribution. The reduction in production and transaction costs during the first globalisation gave rise to a decrease in freights and an increase in maritime transport in the final decades of the nineteenth century. From 1860, the international trade of raw materials and food was activated, as was that of labour, which was reflected in the mass migration of Europeans to America. Spanish transoceanic emigration was a phenomenon generated by the crisis of the end of the century, peaking between 1885 and 1913 (Carreras and Tafunell, 2021). This process occurred earlier in the Canary Islands and in the central decades of the nineteenth century, migration to Venezuela and Cuba was particularly noteworthy. Within this context, the study of nutrition is particularly interesting due to the anthropometric evidence of the Canary Islands. Previous research reveals an adult height premium, contrasting with the peninsula at the end of the nineteenth century which recorded one of the lowest heights in Europe (Hatton and Bray, 2010; Martínez-Carrión, 2012). Does this mean that the Canary populations were relatively well fed before the dietary transition?

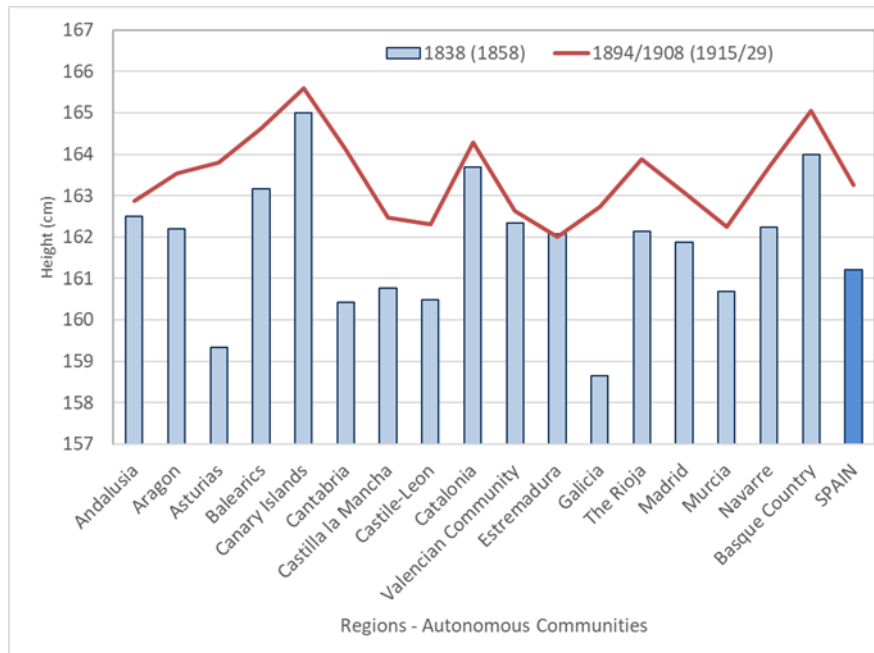
This chapter explores the nutritional status of the Canary population based on a group of male heights (N=16,333). We seek to analyse the adult height premium of the archipelago and the extent to which it differed from the patterns followed in the Iberian peninsula. Furthermore, we wish to determine the extent to which situations of nutritional stress affected the growth in height between 1860 and 1930. The chapter is structured as follows. After the introduction, we will examine the early interest of physical anthropologists in the Canary Island height premium and the debate surrounding genetics and nutrition which focused on the indigenous people prior to the conquest and during the colonisation. The next section presents the results confirming the height premium for the period before the nutritional transition and the positive secular trend in the first third of the twentieth century. This is followed by a discussion on the determining factors of the advantage of the archipelago. Finally, the limitations of the study are identified and the main conclusions are drawn.

### **Exploring the height premium in the Canary Islands. The background**

The greatest enigma in Spanish anthropometric history resides in the height of the Canary populations. The earliest bioanthropological studies on the archipelago documented evidence of relatively tall heights of the historical populations, both the indigenous people

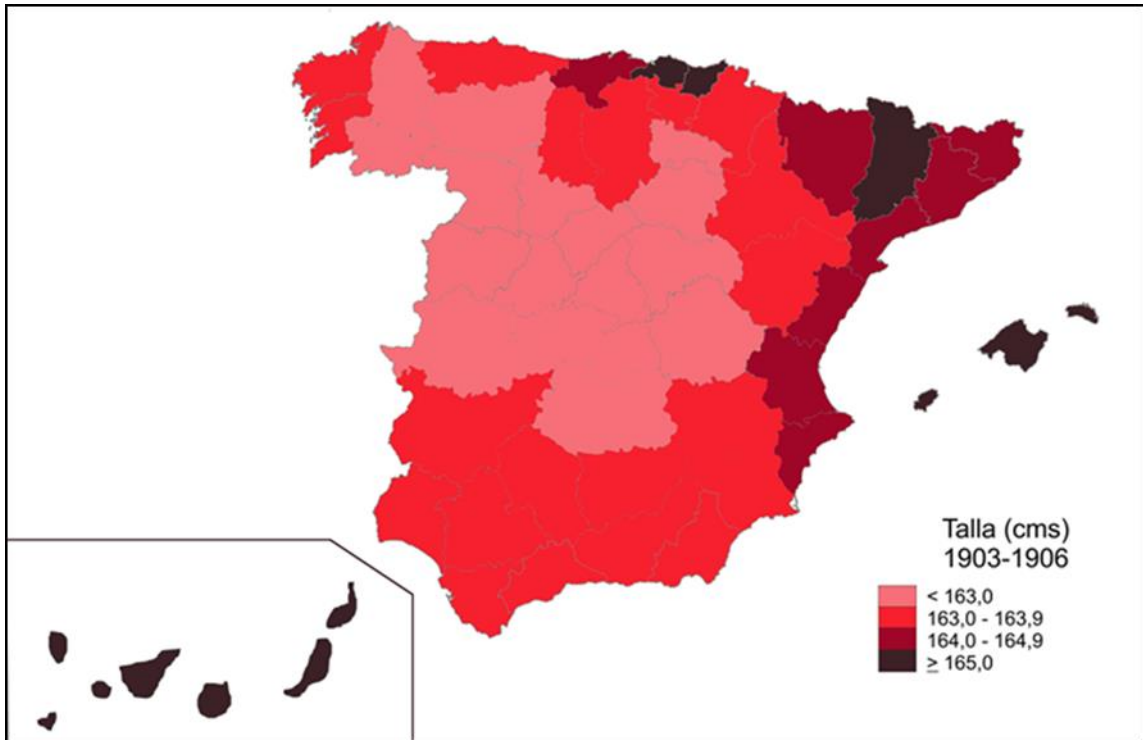
and the populations following the European conquest and Hispanic colonisation. Seminal studies based on skeletons found that the height of the pre-Hispanic population of Gran Canaria, particularly the males, was considerable for the parameters of Iberian populations. Vernau (1887), Hooton (1925) and Schwidetzky (1963) found male heights of 170 cm and 166-164 cm in pre-Hispanic times. Subsequently, other studies estimated male heights of 170.8 cm for the populations of Gran Canaria and 170.5 cm and 168.9 cm for different populations of Tenerife (García-Talavera, 1992; González-Reimers, Arnay et al., 2007; González-Reimers, Velasco et al, 2007). In any event, the heights documented for the indigenous populations and those of the first colonial society following the conquest were relatively taller than those estimated for the Iberian Peninsula. The Canary Island height premium was similar to that of the northern Europeans in dates prior to the industrial revolution (Komlos and Cinnerella, 2007; Floud et al, 2011). This contrasts with the research on the Spanish peninsula which shows average male heights of 163 cm at dates prior to economic modernisation (Cámara et al. 2019; Ayuda et al, 2022).

The evidence of a Canary Island height premium in dates prior to the conquest (fifteenth century) coincides with the debate on the origins of the *guanches*; indigenous people considered as the first settlers in the Canary Islands. Archaeological, genetic and linguistic studies ( Macías, 2000; Atoche, 2013; Velasco et al, 2020, 2021) and research carried out with whole genome sequencing of old DNA of all of the islands (Rodríguez-Varela et al; 2017; Guillen-Guio et al, 2018; Fregel et al, 2019; 2021) confirm that the *guanches* were descendants of the Berbers of north Africa and traces of this population are still conserved in the genome of the Canary Island people today. Different tests also suggest that some of the islands experienced demographic pressure before the European conquest. Control mechanisms, such as infanticide, strong social hierarchisation, an increase in internal conflicts and competitiveness for essential agricultural resources could explain the declining population in the thirteenth and fourteenth centuries suffered by the archipelago before colonisation. The conquest led to the enslavement of a good part of its inhabitants and a high mortality rate which almost eliminated the indigenous people (Macías, 1992). Studies on the molecular genetics of the Y chromosome (only transmitted by males) of the indigenous population have determined that the paternal lineages almost disappeared, to the extent where they were replaced with European lineages from the pre-Hispanic period which still prevail today. The trade of African slaves for working on the sugar cane crops was also influential and the exchanges of individuals from north and sub-Saharan Africa in the seventeenth and eighteenth centuries led to the gradual reduction of indigenous paternal lineages. The impact of European colonisation and the different migrations with Africa, America and Europe was dramatic for the reduction in the indigenous male population and the acculturation of the surviving population (Baucels, 2013). Genetic studies reveal that, due to extensive human mobility after the conquest, the proportion of European lineages in the current population of the Canary Islands represents more than 90%, which was associated with the persistence of maternal lineages (Fregel et al., 2009, 2019, 2020). This sexual asymmetry is common in mestizo populations and is attributed to the higher socioeconomic level of the Europeans (Fregel, Gómez et al., 2009).



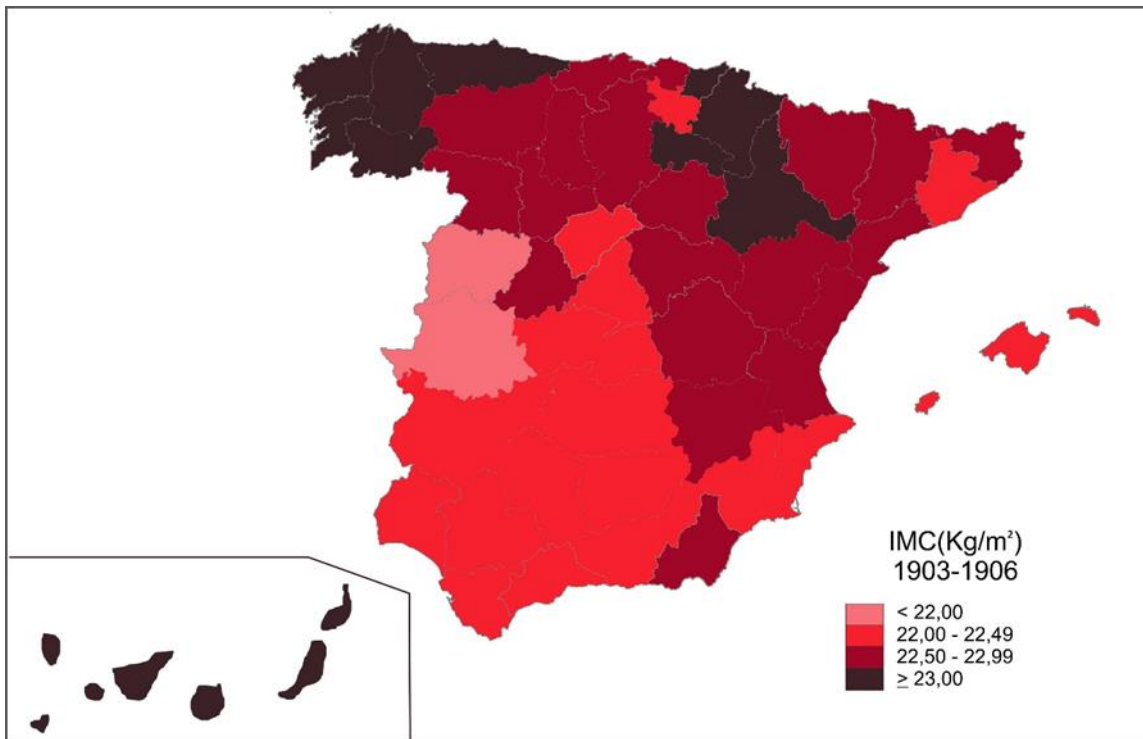
**Figure 1. Average height in the regions and autonomous communities of Spain, Cohorts 1838 and 1894-1908.**  
 (Source: Gómez Mendoza and Pérez Moreda, 1985)

Studies with male height data at the beginning of the twentieth century have shown that the Canary Islands, then one of the poorest Spanish regions, recorded taller heights than the Spanish average. A seminal study on the average height of recruits aged 18-20 years old between 1858 and 1915-29 showed that the height recorded by the recruits of the archipelago was the tallest in Spain, at around 165 centimetres (hereafter, cm) or more, while the Spanish average was between 161 and 163 cm (Gómez-Mendoza and Pérez-Moreda, 1985; ver Figura 1). The first anthropometric study by Spanish province was elaborated between 1903 and 1906 by Luis Sánchez-Fernández, medical sub-inspector of the Military Health Agency, with a broad sample of useful soldiers called to service. As a novelty, as well as including height, the data of Sánchez included the weight and chest circumference of 119,571 Spanish soldiers born between 1883 and 1886 (see Martínez et al., 2016) The results show that the average height of the Canary soldiers (estimated at 165.6 cm) was among the tallest in Spain after Guipúzcoa and Biscay, and two centimetres above the Spanish average (Fig. 2). The average weight was recorded at 63.56 kg, only below that of Guipúzcoa and much higher than the average weight of the Spanish soldier estimated at 60 kg. Body Mass Index (BMI) was in the range of 23.18 as opposed to the Spanish average of 22.42 (Fig. 3.). Similarly to height, the use of average BMI values is related to net nutrition and health (Fogel, 1994; Carson, 2016).



**Figure 2. Average height of young men useful for military service by province in Spain (1903-1906).**

Source: From Sánchez Fernández (1913)



**Figure 3. BMI of young men useful for military service by province in Spain (1903-1906).**

Source: From Sánchez Fernández (1913)

At the end of the period analysed (1926-34), the average height of Canary Island men had increased by several centimetres and reached 167.4 cm, whereas the Spanish average was 164.5 cm (Beltrán, 2015). Recent research based on military recruitment data corroborates the height premium in both the western and eastern Canary Islands. The results indicate that tall heights were the norm at the end of the nineteenth century and the first half of the twentieth century (Román, 2013; Martínez, Candela y Román, 2018; Candela, Martínez and Román, 2021). The findings are consistent with the height premium of the indigenous populations.

The height premium of the Canary people with respect to the Spanish average was maintained throughout the twentieth century, shared by the Basque and Catalan populations. The populations of the Canary Islands were among the tallest population groups of Spain, together with those of the most industrialised, literate and most economically developed regions (González-Portilla, 2000; Quiroga, 2001; Cámara and García, 2014; Martínez and María-Dolores, 2017). However, it is noteworthy that the Canary Island height premium contrasts with the relative poverty of the economic indices of the archipelago during the modern economic growth process. The Canary Islands was the least industrialised region in Spain (Martínez-Galarraga et al, 2021) and was among those with the lowest per capita income (Carreras and Tafunell, 2021). Until 1930, the archipelago had the lowest rate of human capital formation and the lowest literacy rate of all Spanish regions (Beltrán et al, 2019). The economic standard of living contrasted, therefore, with the biological standard of living. Genetics and the environment also formed part of the Canary puzzle.

The studies show the complexity of the determining factors that intervene in human growth. In the case of the Canary Islands, the hypotheses that could explain the height premium are: 1) the climate: a much milder and less irregular climate favoured a lower impact of supply crises; 2) dietary habits, due to the proximity to sources of animal and vegetable proteins: fish, livestock meat and milk, cheese, *gofío* (a product obtained by grinding different toasted cereals, usually wheat and corn or millet), and 3) the relative isolation of the islands could protect the population of the archipelago from certain diseases or epidemic invasions which traditionally affected the peninsula until the end of the nineteenth century or beginning of the twentieth century. Our study is the first to offer robust results on the height premium in the Canary Islands and to explore the determining factors.

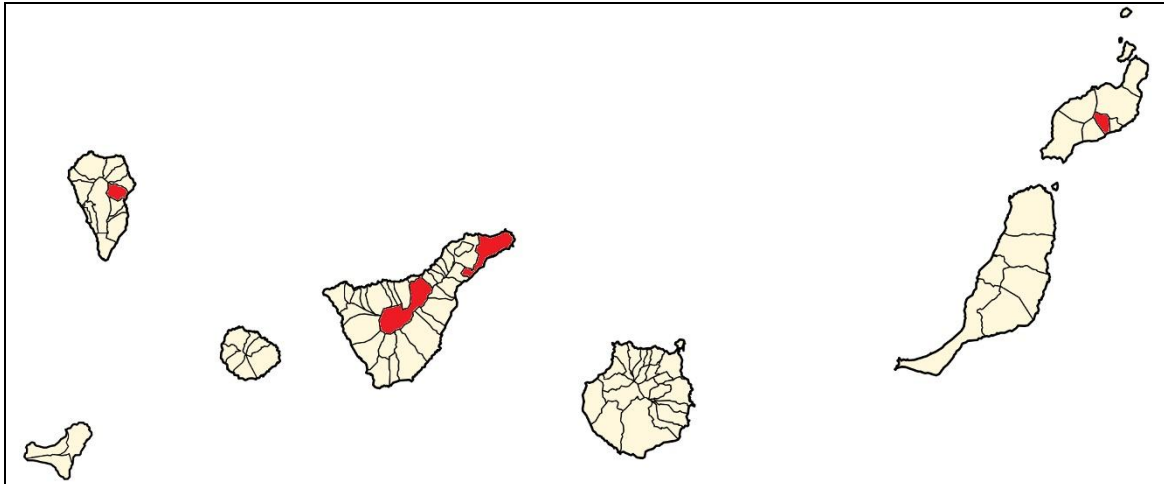
## **Material and method**

### *Recruitment sources*

The Canary Islands are located in the Atlantic Ocean, approximately 100 km from the coast of Morocco. The demography of the Canary Islands is exceptionally complex due to the migration of people from different geographical regions. This makes them an interesting case study for population geneticists, historical demographers and economic historians. The latter use average adult height as an indicator of the biological standard of living and net nutritional status. In this way, we can verify biological variability before and at the start of the nutritional transition.

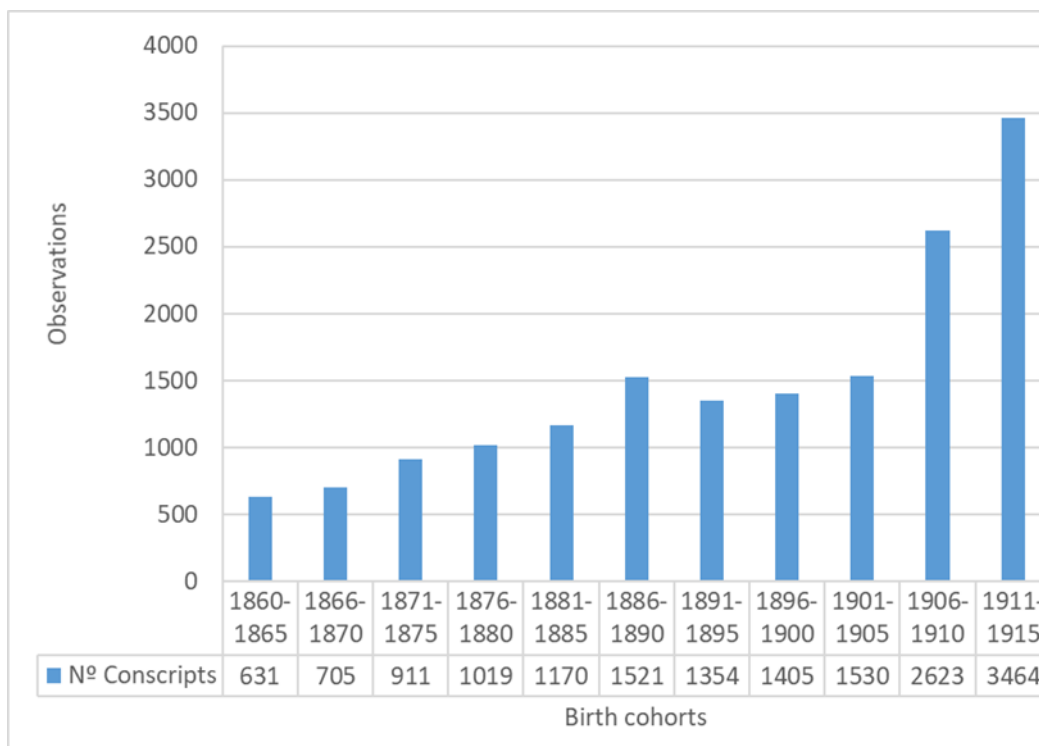


In this study we analyse a set of data of 16,333 male heights measured between 1880 and 1936. The heights have been standardised at the age of 21 years, as they are drawn from different enlistments of recruits called to service at the ages of 18 and 21. The data correspond to different municipalities: the province of Santa Cruz de Tenerife: La Orotava and Santa Cruz de Tenerife (both on the island of Tenerife), Santa Cruz de La Palma (capital of the island of La Palma), and the province of Las Palmas de Gran Canarias: San Bartolomé on the island of Lanzarote (see Figure 4).



**Figure 4. Municipalities analyzed in the Canary Islands in this study**

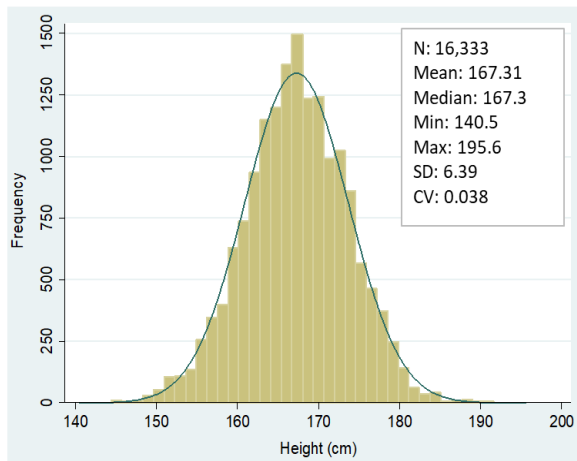
The principal source of local data are the Actas de Clasificación y Declaración de Soldados (Classification and Declaration Records of Soldiers) (hereafter, ACDS), which contain rich information about military recruitment enlistments. As well as height, they inform of whether the recruits know how to read and write, their occupation and place of residence, including where they emigrated to. Together with the Personal Recruitment Files, the ACDS constitute the most important documentation referring to military recruits stored in the municipal archives. In this study we mainly use height. There are inconveniences when using other socioeconomic variables, such as occupation, as the information is scarce and fragmented. We have used the weight data for 1912-13 as these are the only years for which they are available until 1955 when they appear again. With the height and weight data of these years, we analyse the BMI which informs us of the nutritional status of the moment. We use the following classification of the BMI value: low weight ( $BMI < 18$ ), normal weight ( $18.5 \leq BMI < 25$ ), overweight ( $25 \leq IMC < 30$ ) and obese ( $MBI \geq 30$ ).



**Figure 5. Evolution of the number of observations analysed with height data, recruits of 1880 to 1936 (cohorts of 1860 to 1915).**

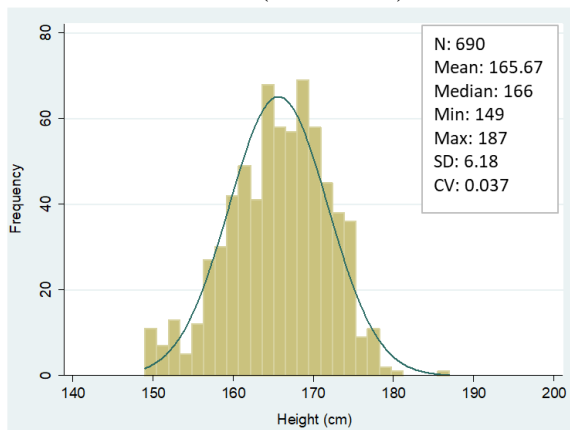
Source: Actas de Clasificación y Declaración de Soldados (hereafter, ACDS)

We have standardised the heights at age 21 years, due to the regulatory changes established in the military legislation between 1857 and 1906. The evolution of the number of observations analyzed can be seen in Figure 5. As of this date, all recruits were measured at ages 21 years. There were previous changes, given the need for soldiers for the armies in times of war. From 1857 to 1885, the recruits were measured at the age of 20 years, from 1885 to 1900 at the age of 19 years, at 20 years again in 1901 and at 21 years in 1906. These changes should be taken into account, as although the adolescents stopped growing at around the age of 18, stunting was frequent in situations of nutritional stress until adult ages. Some testimonies and military medical reports at the beginning of the twentieth century indicate that the recruits and soldiers continued growing until the age of 25 (Sánchez, 1913). In order to compare the heights in these changing periods, we have standardised the height at the age of 21 years. In this respect, several procedures may be used (Martínez-Carrión and Moreno-Lázaro, 2007; Ramon-Muñoz, 2009). In our case, we have added one centimetre to the height of the 19-year-old recruits and half a centimetre to that of the 20-year-olds, in line with the results of previous research. On another note, we have found no significant truncation or rounding in the height data. All of the recruits are represented in the sample analysed, as we can see in the tails of the histograms in Figure 6. The figure shows a normal distribution of heights corresponding to a Gaussian distribution.

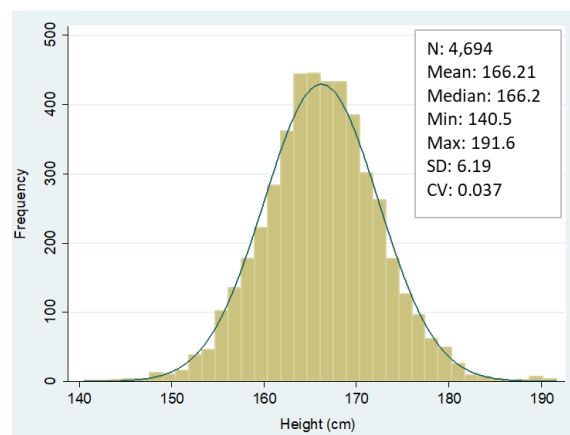
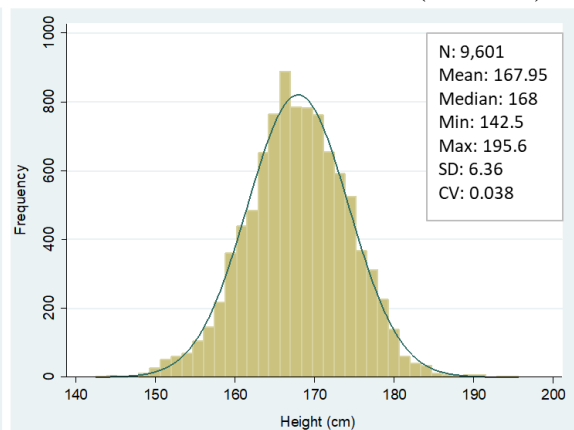


6.1. Sample of the four municipalities

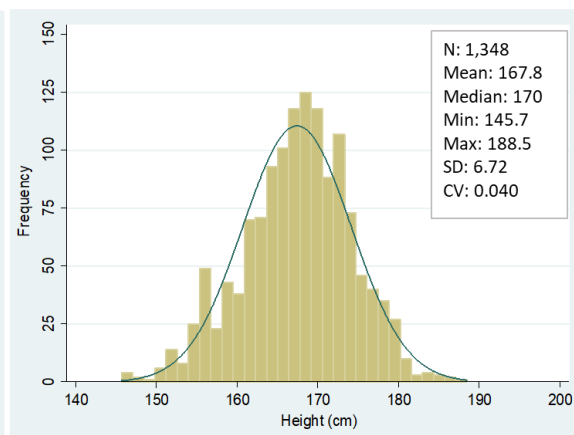
6.2. San Bartolomé (Lanzarote)



6.3. Santa Cruz de Tenerife (Tenerife)



6.4. La Orotava (Tenerife)  
Palma)



6.5. Santa Cruz de La Palma (La Palma)

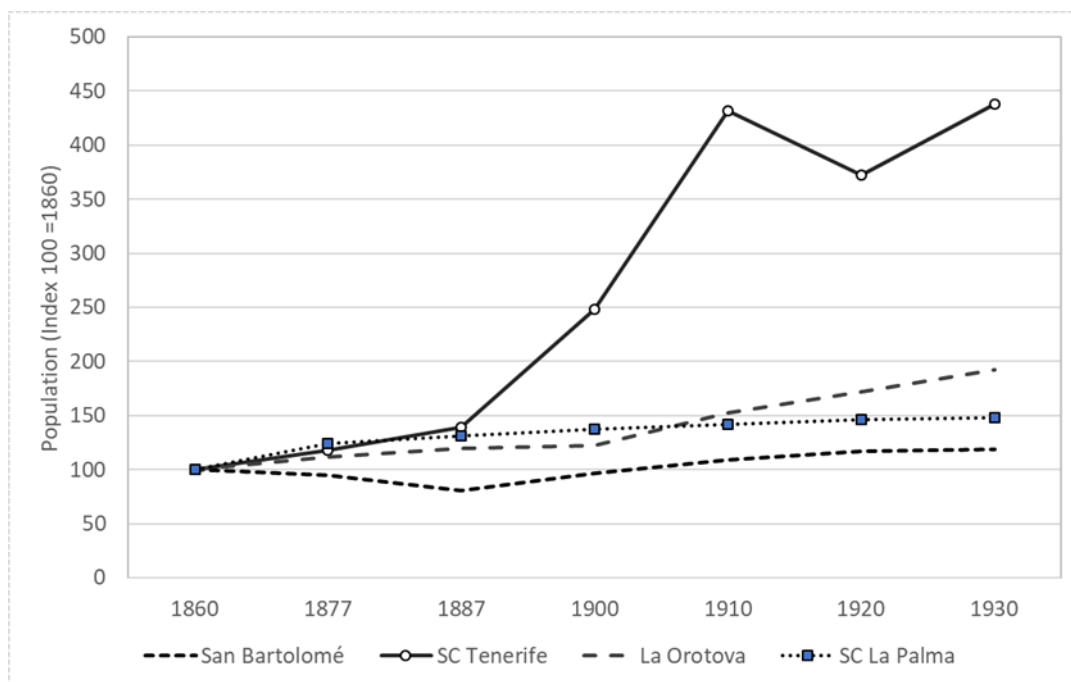
**Figure 6. Histograms. Distribution of heights in the municipalities analysed of the Canary Islands 1880-1936.**

Source: Archivo(s) Municipal(es), sección Quintas, ACDS and personal files, own elaboration.

We have used a descriptive methodology. We present height averages in five-year periods for the trends in net nutritional status and explore the evolution of inequality using the coefficient of variation (CV). This indicator seems to show inequality better than other measurements of dispersion (Baten and Blum, 2012; Blum, 2013).

*Demographic and environmental characteristics*

Finally, the environmental and demographic characteristics of the populations analysed should be examined. In Tenerife, the population of the Valle de La Orotava is noteworthy as it is the largest municipality of the island (20,592 hectares) and in its territory we can find the Teide National Park which is at an altitude of 3,718 m. It is a municipality with a diverse agricultural and climate and an important forestry and agricultural activity. The verticality of the terrain enabled the diversity of agricultural products. Its population reached a size of more than 7,500 inhabitants in 1860 which doubled in 1930 (Figure 7).



**Figure 7. Demographic growth indices in the Canary populations analysed, 1860-1930 (Base 100 = 1860).**

Source: INE: Population censuses.

The most populated municipality of this island and its capital is Santa Cruz de Tenerife. It recorded a population of 14,146 inhabitants in 1860 which quadrupled in 1910. Its demographic vitality is largely due to the Free Ports Law of 1852 which stimulated the growth of the port of Santa Cruz and of the village as a trading centre. An economic model was developed that was sensitive to the international situation. The European colonial expansion across Africa and the opening of the island ports to Atlantic traffic led to an active trade in consignment goods and the development of economies of scale connected to the port infrastructures (Macías, 1992, 2001, 2010). In the final decades of the nineteenth century, the Canary Islands played a prominent role as an axis on the Atlantic routes, attracting capital from the principal European powers to its port towns. The ports of Santa Cruz de Tenerife and Las Palmas became obligatory ports of call for the leading

shipping companies on their trading routes. Thanks to their location and agricultural specialisation in export products (particularly extra-early fruit and vegetable products), as well as constituting provisioning and coaling stations, the Canary ports definitively became part of the Europe-Africa-Oceania and Europe-Africa-America trading networks (Castillo-Hidalgo, 2010). However, the first World War led to the plummeting of exports, causing a crisis for a large part of the island economy and, as a result, there was mass emigration. In the case of Santa Cruz de Tenerife, a demographic stagnation was recorded until the 1930s.

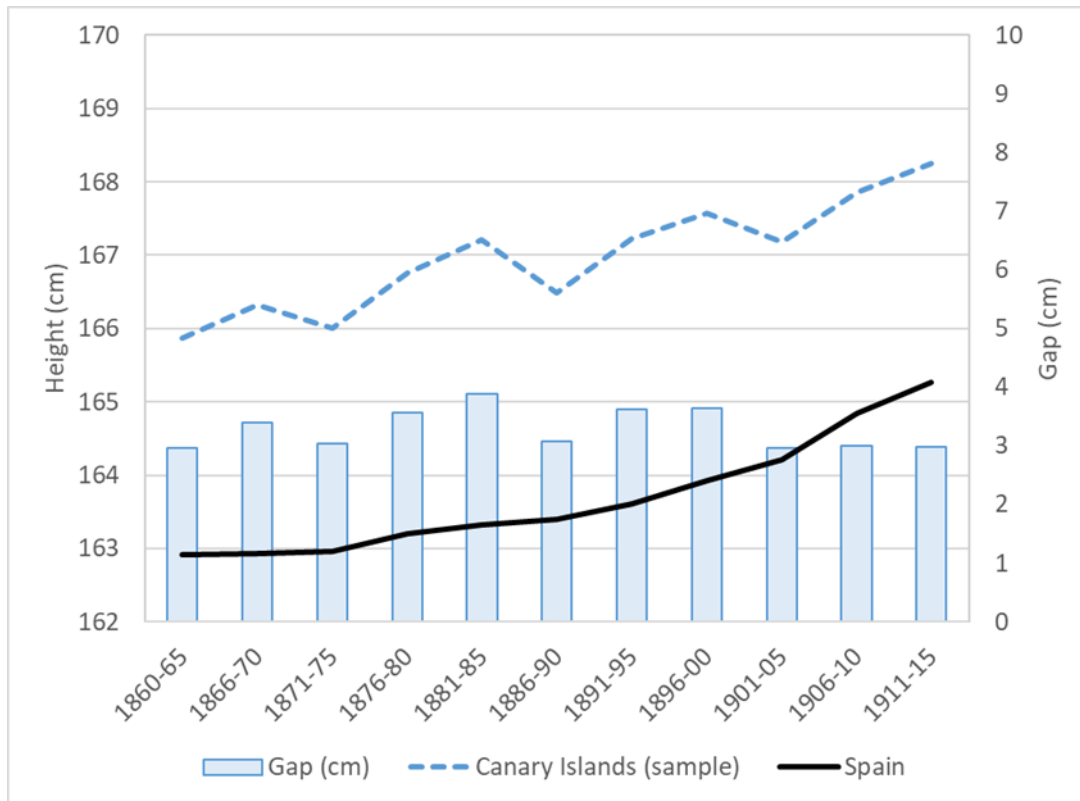
In the far west of the archipelago, we have analysed Santa Cruz de La Palma, the capital of the Island of La Palma. It had a medium-sized population which remained stable due to the high level of emigration throughout the period. It grew from 5,364 inhabitants in 1860 to 7,951 in 1930. Of the easterly islands, we have analysed the rural population of San Bartolomé, a municipality located in the centre of the island of Lanzarote in the province of Las Palmas de Gran Canaria and 77 miles from the African coast. During this period, the municipality was principally composed of a peasant population, which grew from 1,959 inhabitants in 1860 to 2,319 in 1930. Similarly to the rest of the islands, the economy of Lanzarote received a boost from the mid-nineteenth century from free trade, which increased cereal exports and, most of all cochineal (grains) for the European industry, principally in Great Britain. Cochineal, used as a purple dye in the textile industries, was one of the engines of economic growth of Lanzarote from 1850 to the 1880s. After the cochineal and cereal crisis, the diffusion of new substitute crops (mainly potatoes, chickpeas, onion, tomato, pumpkin, corn or *millet* and vine), consolidated in the first half of the twentieth century (Ulises, 1995).

Finally, we should highlight the mild and stable climate as a unique element that characterises the environment of the islands and, specifically, the populations studied. In La Orotava has average temperatures of around 17°C, with maximums of 21°C and minimums of 14°C. In Santa Cruz de Tenerife the average temperatures are around 21°C, with maximum averages of 24°C and minimums of 18°C, very similar to those recorded for Santa Cruz de la Palma, with averages of 20°C, maximum averages of 23°C and average minimums of 18°C. On the other hand, the temperatures fluctuate mostly in San Bartolomé (Lanzarote), where they generally vary from 15°C to 28°C, and very rarely drop below 12°C or increase above 31°C. The altitude and a mild climate without large contrasts are favourable environmental conditioning factors of health status (German et al. 2020).

## **Results and discussion**

Fig. 8 shows the evolution of male heights standardised at age 21 years in the sample of the Canary populations which are compared with the Spanish average). A variability in the heights in the Canary Islands can be observed at the beginning and the end of the period, but the average is above 165 cm and almost three centimetres above the Spanish average. The height data revalidate the Canary Island height premium for the period before the beginning of the nutritional transition, in the mid-nineteenth century. Differences with the Spanish average are observed in the 1860s and remained constant over time. Despite the fluctuations, the progress made in island heights is significant and shows an average increase of 2.4 cm between the cohorts of 1860 and 1915, the same increase as that of the Spanish population. The period with the largest gap between

peninsular Spain and the Canary Islands was in 1876-85 and 1891-1900. In 1881-85, the gap increased by 3.9 cm.



**Figure 8. Comparative evolution of the average male height between the Canary sample and a Spanish sample Cohorts of 1860-1915.**

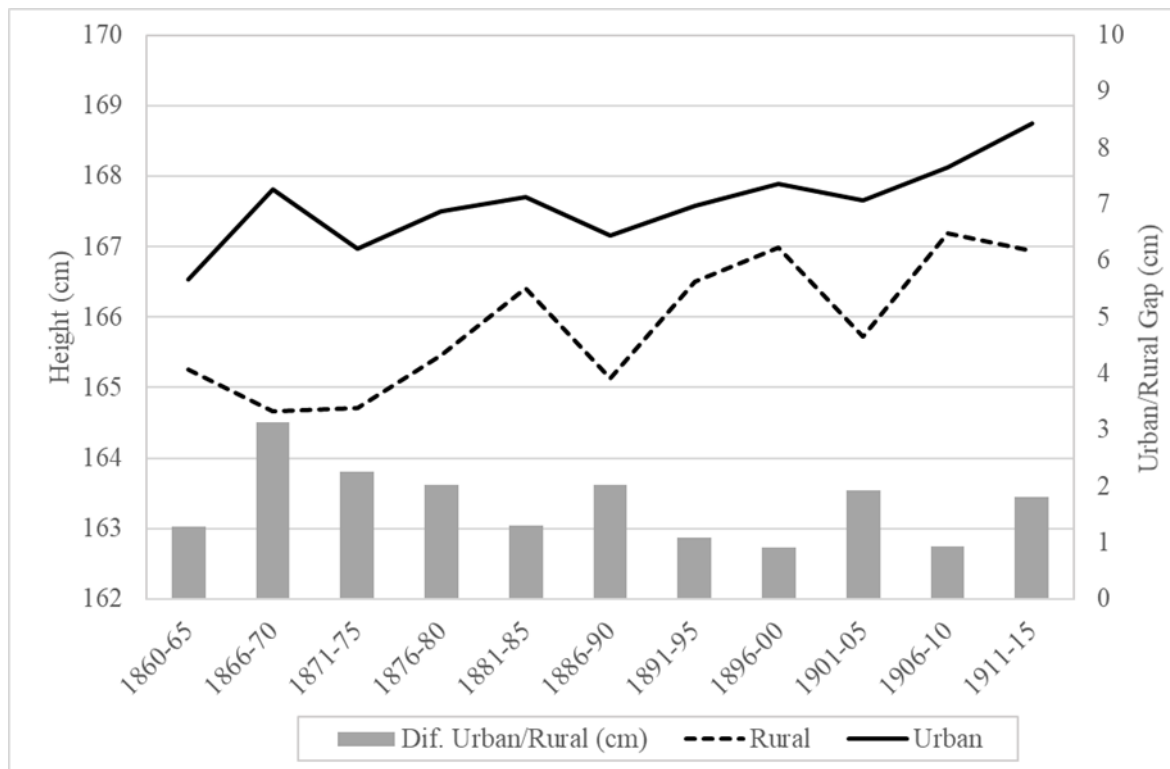
Source: Ibidem F. Data for Spain in Cámara et al. 2019.

Despite the advantage of Canary heights, the data suggest differences in heights between the populations of the islands. Only the population of San Bartolomé in Lanzarote differed to the rest with heights somewhat lower than the others and significantly among the cohorts of 1866-75. At the end of the 1860s, the difference in height between the rural population of Lanzarote and the urban population of Tenerife was 4.3 cm. For the whole period, San Bartolomé in Lanzarote (the most easterly population of the islands) recorded an average height of 165.7 cm. On the other hand, the average heights of the western islands were taller: 166.2 cm in La Orotava (Tenerife), 167.9 cm in the municipality of Santa Cruz de Tenerife and 167.4 cm in Santa Cruz de La Palma.

There was a noteworthy fall in height recorded at the end of the 1860s and beginning of the 1870s which was greater in the rural villages. This deterioration of the nutritional status in 1866-75 has been registered in almost all of the Spanish regions and has been related to the supply crises and epidemics that mostly affected the peninsula. The impact of the cholera-morbo of 1851 is well documented, but we do not know the dimensions of the crises of 1868-69. After an increase in height in the years following these dates, another overall fall was recorded in 1886-90. However, it is tempting to establish a relationship between the variations in height and the economic circumstances. As a starting point, in the mid-nineteenth century, the island economies were boosted by their inclusion among the free and duty free ports from 1852 (Macías, 2001). After the

improvement in port infrastructure, the export capacity increased as did the foreign trade of raw materials and food. Grain was one of the engines of economic growth of the archipelago, particularly from Lanzarote to Tenerife (with a predominance of La Orotava) between 1850 and the 1870s. These were the golden years of cochineal (González-Lemus, 2001).

In the final decades of the nineteenth century, the economies of rural families suffered from the grain crisis which led exports to plummet. The cause was the diffusion of anilines and fuscines, (artificial dyes) that led to a sharp recession in the 1880s. The way out of the crisis came with the development of the agro-industry of sugar and tobacco and fishing in the Saharan Banks. After the cochineal and cereal crisis in the 1880s, a new agricultural cycle gained strength due to the diffusion of new substitute crops (González-Lemus, 2005). A new agro-export supply, led by bananas, tomatoes and potatoes, re-established the traditional connections with England and intensified the use of land and water factors. Wells and galleries were opened, canals and reservoirs were built and higher doses of chemical fertilizers were used. Exports gained weight between 1880 and 1914. The English market absorbed most of the exports (Súarez Boza et al., 1995; Macías, 2011). Within this growing economic context, the average height recovered and increased by 1.8 cm. The average height of the cohorts born between 1886-90 and 1911-15 grew from 166.5 cm to 168.3 cm (Figure 9).



**Figure 9. Average rural-urban height. Cohorts, 1860-1915**

Source: ACDS. Urban height: SC Tenerife and SC de La Palma. Rural height: San Bartolomé (Lanzarote) and La Orotava (Tenerife).

The improvement in the nutritional status was widespread across the island populations, irrespective of the environment in which they lived. In Figure 8, which shows the rural-urban gap, we can see that the rural populations had somewhat lower heights than the urban populations. The tallest heights were found in the two capitals of Tenerife and La Palma, which coincides with the urban height premium found in the majority of the Iberian peninsula and non-industrialised European populations. The results are similar to other Spanish studies which record taller heights in urban environments. The urban height premium was probably due to the weight of the elite classes and the presence of social groups with incomes that were higher in the cities, as seen the majority of Spanish urban environments, than in the main rural, low-income and poorer contexts (Martínez and Moreno, 2007; Martínez et al., 2014; Cañabate and Martínez, 2017).

In any event, the differences between the two environments decreased at the end of the period, with the nutritional transition well under way. Despite the fluctuations in height in these years, which could be affected by the migratory flows at the beginning of the twentieth century and in the First World War, the rural-urban gap reduced from 2 cm between 1860 and 1890 to 1.3 cm in the following decades. This reduction in the environmental gap can be observed in most of Spain. In addition to this finding, a seminal study carried out by Castellano-Gil (1990) with data of recruits of the municipality of La Laguna in Tenerife between 1886 and 1935, showed differences in height between the city and the countryside, which persisted throughout the period. The greatest gap is observed between the cohorts of 1860 and 1880. In 1860-64 it reached 4.2 cm in favour of the urban world. In the following decades, the advances were notorious for the rural world and the differences between the different environments were no more than six millimetres. However, more research is required on the topic.

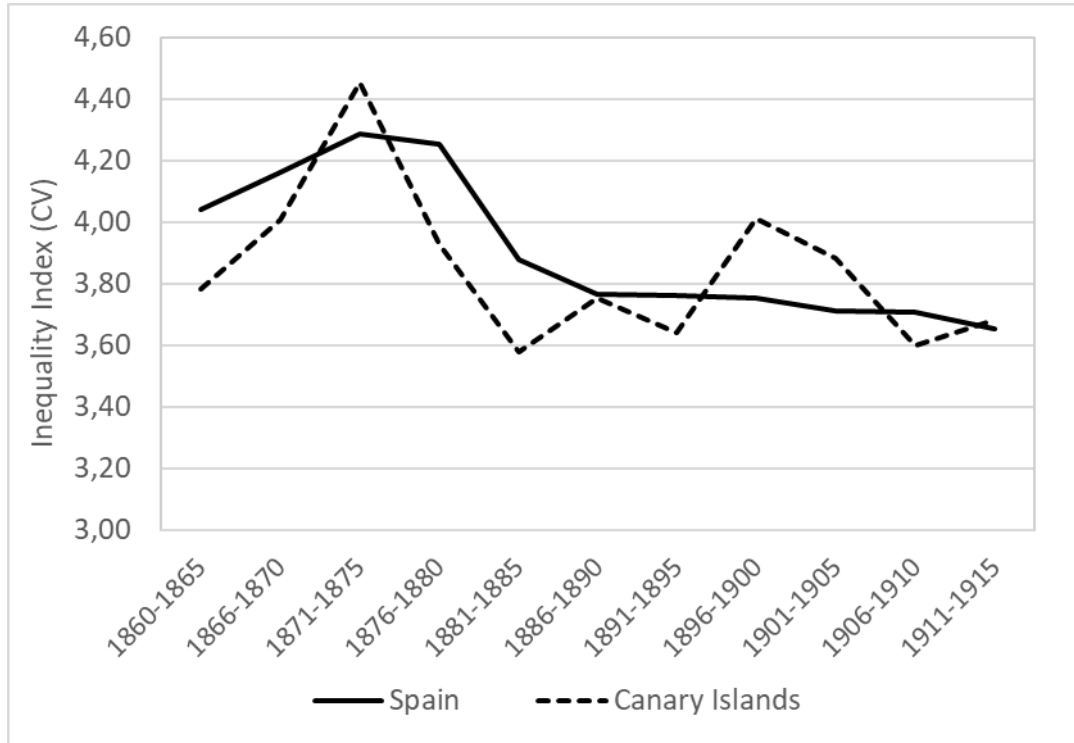
Economic and institutional aspects played a role in the improvements in the standard of living, health and nutrition in the first third of the twentieth century. If we exclude the period of the First World War between 1914 and 1918, the previous decades and then the years after 1922 were favourable times for the production and export of food, due to the increase in demand, principally from abroad. The technical changes in export agriculture were significant, particularly in the 1920s and the beginning of the following decade: the consumption of chemical fertilizers increased, water resource endowment improved and exports increased. Mainly bananas, tomatoes and potatoes increased their share of the agricultural economy. The increase in banana production was vigorous until the mid-1930s (Suarez Bosa et al. 1995).

With respect to institutional changes, the Free Ports Reform of 1900 is noteworthy as it extended its free trade content. The economy of the Canary Islands was strengthened between 1900 and 1936 with respect to the national economy. The competitiveness of the Canary Island industry resided in producing raw materials imported without tariffs at international prices and taking advantage of the freedom of the flag. The Local Administration Law (1907) was also influential, with the creation of the island “Cabildos” in 1912. This new entity was responsible for the competencies of the provincial governments. With the income generated by the island’s wealth (the island taxes), the Cabildos undertook the role of the State in terms of education, health or communication infrastructures (Macías, 2011). One index of the nutritional status, the Body Mass Index, shows a healthy image of the recruits who were weighed and measured in 1912-13. The number of cases observed is few, only 207, with an estimated BMI of 22.25, with the



average weight of 61.4 kg and height of 165.7 cm. The recruits who knew how to read and write were taller (166.7 cm) and had a slightly higher weight (63.1 kg) than the illiterate recruits with an average height of 165.2 cm and weight of 62.2 kg. On the other hand, the differences in BMI are irrelevant. 22.4 for the literate and 22.8 for the illiterate. This image shows us relatively taller and slightly heavier young Canary men than the Spanish average, although with a similar body mass (Martínez, Cámara and Pérez, 2016).

Finally, the inequality between heights is analysed using coefficients of variation (CV). There are many studies with height data for historical populations which have shown the appropriateness of CVs, which express inequality better than other measures of dispersion (Baten and Blum, 2012; Ayuda and Puche, 2014; Baten and Blum, 2014). The seminal studies of Baten found a high correlation between the coefficient of variation and the differences in average height of different social groups. This indicator of statistical heterogeneity has been used as an indirect measure of anthropometric inequality and can tell us about socioeconomic inequality. Figure 10 shows the evolution compared to that of Spain, revealing two moments when inequality increased: 1) between 1866-75 and 2) between 1896-1905. Both coincide with periods of deterioration in height. The greatest increase in around 1870 was also recorded in Spain. The reduction in dispersion occurred in the final decades of the nineteenth century and at the end of the period. The data reveal that there were lower inequality indices in the 1920s among the recruits who were children and adolescents during the first decades of the twentieth century. However, more research is also required in this respect.



**Figure 10. Evolution of the inequality in height (CV) in the Canary Islands and Spain. Cohorts born between 1860 and 1915**

Source: ACDS. Own elaboration

The results as a whole corroborate that the Canary population enjoyed a healthy nutritional status with improvements in the first third of the twentieth century. The increase in height is similar in intensity to that of the whole of peninsula Spain. The determinants of the Canary Island height premium are the object of speculation. Therefore, more anthropometric studies are required on other islands, such as Gran Canaria, Hierro and Fuerteventura and within the islands, including rural-urban analyses. However, among the determinants of nutritional status, the mild climate of the archipelago could have had more influence than previously believed, as it conditioned the crops, which were more regular and extra-early compared to those of the peninsula. A range of beneficial effects have been identified, such as the trade winds of the east, a fresh wind which provides environmental humidity to the islands. The cloud cover acts as a thermal regulator which makes the atmosphere of the Canary Islands unique; tropical at ground level and temperate at a higher level. The temperatures are mild and although the precipitations are irregular due to the variability of the altitude, climate and orography, they foster more regular crop cycles throughout the year than in the peninsula.

As a main hypothesis of the Canary Island height premium we highlight the proximity to the sources of nutrients. During this period, the development of the traditional fishing and livestock farming activities and the boom in the fishing and cheese industries led to an improvement in the consumption of nutrients, particularly fish and meat proteins. Beef and lamb were particularly prominent among the higher social groups and much less so among the popular classes. On the other hand, the consumption of fish was widespread in almost all of the islands, either fresh or in its different forms of preservation (smoked, dry, pickled), with salted fish being the most demanded. Traditional fishing with rods and the development of the fishing industry in the Canary-Sub-Saharan Bank boosted the consumption of sardines, horse mackerel, seabream, dreamfish, red seabream, damselfish, redhead cichlid (usually consumed dried), grouper, mackerel and white seabream, among other local species, while the groups with the highest purchasing power consumed dried cod, herring and smoked salmon, particularly in the principal cities (Quintana, 2003).

With respect to livestock, one of the traditional economic sub-sectors of the archipelago, goat meat, was the most affordable for the popular classes. Goat meat was abundant in Fuerteventura but spread across the other islands, given the excellent ability of the animals to acclimatise and their grazing of poor pastures of the hilly terrain of the islands (Pérez-Vidal, 1963). At the beginning of the twentieth century, the consumption of goat's milk was relatively significant. In 1925, the Canary Islands had dairy consumption patterns similar to those of the Cantabrian coast or the regions of Atlantic Spain (Muñoz-Pradas, 2011). Cheese consumption, derived from the sheep and goat farming activity, was a traditional source of proteins. However, further research is required with data and calculations of consumption, given the importance that the consumption of animal proteins, meat and milk, had on the growth in heights (Baten and Blum, 2014). Currently, the Canary Islands is the region where the most cheese is consumed per inhabitant in Spain, with an annual intake of 13.1 kilos, 4.3 kilos above the national average, according to the reports of the Ministry of Agriculture, Fishing and Food (MAPA, 2021).

Among the nutrients most consumed by the popular classes was *gofio*. This flour, made with different toasted and ground cereals (wheat, corn, millet, rye, barley and oats) was widespread in the modern age (Quintana, 2003). The popular and poorest classes

consumed *gofio* of rye and corn or millet, which was combined with wheat depending on the season or purchasing power. Also noteworthy was the consumption of lentils and chickpeas, as the principal legumes and fruit and vegetables. Due to its high nourishing power, *gofio* became the staple food of the Canary diet until the 1960s. It played a fundamental role in mitigating the famines suffered by the archipelago in successive periods (Mora-Morales, 1986; Bello-Luján and Serra-Majem, 2016). Its nutritional value is outstanding. It is a superfood, rich in fibre and proteins, vitamins A, B, (B1, B2 and B3) C and D, minerals such as phosphorous, calcium, potassium, magnesium or zinc, with a low fat content, the majority unsaturated and, most of all, with a high content of carbohydrates which were necessary to withstand intense labour activities (Rubio et al., 2006; Caballero et al., 2014). Different testimonials of the nineteenth century insist that it was widely consumed by the wealthier classes, but it could have been a common food of the popular classes, both children and adults. Its consumption had positive effects on the physiological development of children and adolescents as it compensated the lack of animal proteins of a high biological value, necessary at critical moments of growth. As well as tomatoes, another product of the local fruit and vegetable activity that was particularly noteworthy from the end of the nineteenth century was the banana. Bananas are rich in the micronutrient potassium, which has favourable for physical performance, muscle function and muscle mass growth. Recent studies indicate that the intake of bananas contributes to improving the nutritional composition of the diet due to their high content of vitamin B6, vitamin C, total dietary fibre and potassium (Fernández-Cruz et al., 2021).

Finally, the influence that climate has on child growth through sun exposure has been indicated (Candela et al. 2022). The sun provides vitamin D for the development and growth of the bones. A vitamin D deficit leads to stunted growth and rickets in children, it precipitates and exacerbates the risk of osteoporosis, diabetes, cardiovascular disease and increases the risk of fractures (Holick et al., 2008; Martín-Gómez et al. 2022). Vitamin D is mostly obtained through solar radiation, and to a lesser extent through food in the form of fish, animal proteins, juices and cereals, among other nutrients. The natural environment of the Canary Islands has been an ally for health due to its exceptional climate conditions. Located on the sub-tropical strip of the northern hemisphere and with its easterly islands close to the African continent, the archipelago enjoys a climate which is beneficial for health due to the number of hours of light per year, which is the highest in Europe. While the average number of hours of light in Spain is 2,500, that of the Canary Islands is almost 3,000 per year, or even more, as in the case of Tenerife. With unique characteristics and features, the Canary Islands have a climate similar to that of the island of Madeira and, to some extent, the rest of the Macaronesian Archipelagos (Azores and Cape Verde). It is an ideal location for treating ailments and diseases, making it an attractive place for developing health tourism.

The literature on the impact of climate on height in the past is becoming more abundant (Galofré-Vilà, Guntapalli et al. 2018), but we still know little about the Spanish case (Galofré-Vilà, Puche and Martínez, 2018). For the Canary Islands, recent studies show that they developed health tourism early on, beginning at the end of the eighteenth century. From the mid-nineteenth century, the Canary Islands found that they had the ideal conditions for becoming a health resort (González-Lemus, 2015; González-Morales and Ramón-Ojeda, 2015). Reports of European travellers in the 1770s talk about the benign climate of the islands for curing those suffering from pulmonary diseases and other ailments. In around 1840, prestigious English doctors referred to the healthy effects of

the climate for the sick in scientific journals. At the end of the nineteenth century, there was a migratory wave of wealthy British citizens in search of the warm climate of the Canary Islands and some places became health resorts, such as the Puerto de la Cruz (then, Puerto de La Orotava) in Tenerife and Las Palmas de Gran Canaria. The development of tourism in the islands was related to the curing of pulmonary diseases, mainly tuberculosis, and was clearly based on a health and therapeutic concept (González-Lemus 2007). This reinforces the suggested hypothesis, also indicted by doctors specialised in the endocrine system: that the climate conditions such as the sun and mild temperatures are a potential sources of nutritional health and physiological growth.

## Conclusions

This paper analyses the nutritional health status of the populations of the Canary Islands before and at the beginning of the nutritional transition. With a sample of male heights drawn from military recruitment records from 1880 to 1936 (cohorts born between 1860 and 1915), it explores the impact of the socioeconomic transformations and environmental changes on adult height. The period analysed between 1860 and 1936 covers the complete phase of child and adolescent growth of the recruits called to service from their birth. It is an important stage in the contemporary history of the Canary Islands. The islands were incorporated into the international circuits of Atlantic trade through the free trade system which came about with the implementation of free ports from the mid-nineteenth century and which lasted the whole period. The free-trade economic model gave rise to a long phase of economic expansion for the islands, which was marked by crises (collapse of grain/cochineal exports in the 1870s and 1880s, the block caused by the First World War (1914-18) and the crisis of the 1930s) and growth cycles fostered by the new export crops (bananas, tomatoes and potatoes), the development of fishing and traditional livestock farming, a source of protein for the internal market. Emigration acted as an escape valve during famines and mitigated the impact of the crises on household economies, mainly in the rural world. The migrants headed for America or the principal urban economies of the islands. Santa Cruz de Tenerife stood out as one of the most attractive urban centres for the surplus rural areas. Despite emigration, the social and economic changes in the long term improved the biological standards of living of those who remained. The diet was more diverse and rich with the diffusion of the new crops, the intake of animal proteins and, most of all, carbohydrates provided by *gofio* which improved the quality of the nutrients.

The results show that the nutritional transition had effects on health and physical well-being. Although we do not know the dimension of the nutritional changes in the consumption of energy and calories and of nutrients, the height data suggest that there was a healthy nutritional status for growth. First, we can verify that the height of Canary Island men was taller than the average height of the Spanish peninsula. It was closer to the average height of the populations of Western Europe. The differences found of between 3 cm and 3.9 cm confirm the Canary Island height premium. This finding is consistent with those carried out with skeletons of indigenous populations. Second, the evolution of height followed dynamics similar to those of the Spanish average. In the long term, the secular trend of height was positive, although not intense as it only increased by 2.4 cm among the conscripts measured between 1880 and 1936. Assuming that adult height reflects the environment of the early years of life, the cohorts of 1871-75, 1886-90 and 1901-05 exhibit slight reductions in height probably related to the nutritional

deprivation caused by the successive crises. The evidence shows a movement with ups and downs, with a recovery of height and a growing trend. The results may have an upward or downward bias due to the dynamics of migration. This aspect should be studied further. Third, in the analysis of the rural-urban gaps, a rural height penalty can be observed. Finally, we have found that the inequality in height was greater at the beginning of the period and increased in the years when which height decreased. This was probably due to the deterioration in nutrition in the poorest population segments and those with the lowest standards of living.

One limitation of the study resides in the peculiarity of the sources used. As in the case of other studies based on military recruitment data, the results have a gender bias. Even though many studies suggest the feasibility of using male heights to assess the environmental impact on health and nutrition as they are more eco-sensitive than female heights, alternative sources are needed to mitigate possible biases. Another limitation is the size and location of the sample, basically the western islands. More spatial data of the archipelago are needed, together with a longer time period which would allow us to explore the evolution of the nutritional status during the dietary change and epidemiological transition. This study covers a gap existing in the anthropometric history studies between peninsula Spain and its islands. The results provide more knowledge about the differences in the nutritional status between the populations consuming Atlantic diets and those consuming Mediterranean diets. Naturally, the genetic composition of the native people should be taken into account in order to better understand how the indigenous colonisation process and the evolution of the population of each island had their own anthropometric and nutritional peculiarities.

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