Anthropometrics and development in Twentieth-century Spain: cohort trends and spatial patterns of height and robustness

Antonio D. Cámara[1]
Joan García Román[2]

Abstract

This paper seeks new insights concerning the relationship between environmental conditions and the anthropometric measures of a population. We analyze cohort trends and spatial patterns of physical robustness (height, weight and chest circumference) during the process of economic development in twentieth-century Spain. The data were drawn from Spanish Military Statistics that record male cohorts from 1934 to 1973. Dramatic socioeconomic and demographic changes occurred during that period and consequently the life course of those cohorts witnessed very diverse environmental contexts. Time-cohort series and anthropometric cartography are presented and discussed in light of supplementary data on GDP and infant mortality.

Our results show convergence in height and robustness across Spanish regions. This process was especially intense among cohorts born during the 1950s and the 1960s. Spatial patterns—primarily tall-robust North-Eastern regions and short-weak Central-Southern regions—of development persisted at least until the 1990s (cohorts born during the 1970s). These patterns are only partly associated to economic disparities and there are also remarkable discrepancies between height and robustness patterns which moderates conclusions on the evolution of living conditions exclusively approached by height.

[1] Corresponding author. Centre d'Estudis Demogràfics. adcamara@ced.uab.es
[2] Departament de Geografia. Universitat Autónoma de Barcelona. jgarcia@ced.uab.es

Introduction and aims

Spain attained high development levels over the twentieth century as a result of intense economic and demographic changes (Nadal et al., 1987). These changes are reflected through diverse indicators. It is estimated that production multiplied by 8.2 between 1930 and 2000 whereas population increased by a factor of only 1.7. Therefore *per capita* GDP was multiplied by 4.7 which would yield an annual *per capita* growth rate of 2.2 percent (Alcaide, 2003).

Life expectancy at the turn of the century was hardly 35 years[3]; fifty years later, in 1950, it had risen to 62 years and in 2000 it was about 79 ranking among the highest in the world (INE, 1991, 2007).

Adult height, considered an indicator of the net nutritional status as explained in the next section of this paper, also illustrates the intensity of these changes. Spaniards born during the 1970s were about 9 cm taller on average (males) and 6 cm (females) than those born during the first decades of the twentieth century (Spijker et al., 2012)[4].

A composite measure of well-being, the Human Development Index (HDI), that combines three basic dimensions of human development (health, education and income) was estimated to be 0.363 in 1900 (Escudero and Simón, 2003) and 0.839 in 2000 (IHDI, online)[5].

These trends in economic and bio-sanitary indicators imply that the current Spanish population had very diverse life courses: from cohorts who experienced cycles of hardships and severe deprivation to those who grew up in an affluent society.

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[3] In 1900 life expectancy in other European countries was: 32.4 years in Russia, 42.8 years in Italy, 44.4 years in Germany, 47.4 years in France, 48.2 years in the UK, 49.9 years in the Netherlands and 54.0 years in Sweden (Livi-Bacci, 1992).

[4] By contrast the mean height among Spanish males simply increased from 162 cm to 163 cm among cohorts born during the second half of the 19th century (Gómez-Mendoza and Pérez-Moreda, 1985; Cámara and García-Román, 2010; a collection of recent essays in English on Spanish anthropometric history, in Martínez-Carrión, 2009). These figures set Spain among the shortest nations in Europe. Results from works collected by Crafts (1997: 628) show the following male height figures (they have been rounded for simplicity purposes) among cohorts born by the middle of the 19th century: 168 cm (Sweden), 167 cm (Austria), 166 cm (Denmark), 165 cm (United Kingdom and France), 164 cm (Germany) and 162 cm (Italy). Among cohorts born between 1950 and 1959 the mean male height were approximately 172 cm in Spain, 176 cm in Germany, 178 cm in Denmark, 179 in the Netherlands, 176 cm in Britain and 173 cm in France (Spijker et al., 2008; Hatton and Bray, 2010). The gap remained large until the last decades of the 20th-century.

[5] The scale of HDI is 0-1. A value of 0.8 is usually accepted as indicative of a high development whereas values under 0.5 are indicative of low development.

Aside from this generational contrast, Spain was a country of strong socioeconomic and demographic disparities during the 20th century. For instance, within a context of intense economic growth during the central decades of that century both population and non-agrarian economic activities tended to concentrate in the most dynamic regions during the most expansive period of modern development in Spain and other Western European countries (1950-75). This is vividly reflected by the increasing weight of these regions (e.g. Madrid, Catalonia or the Basque Country) on the national per capita GDP (Carreras, 1990).

Few indicators grant insights on both cohort and spatial implications of these development processes given that most of them, including life expectancy, are based on cross-sectional data. In words, spatial disparities reflected by these indicators do not necessarily respond to the disparities in living conditions experienced over the life course in those territories. Height data are usually of the same type (cross sectional) but have properties that allow for both spatial and cohort interpretations.

The final height that one attains in adulthood is the result of two types of determinants: 1) genetics establish a maximum potential for each individual and 2) environmental factor determine to what extend that biological potential will be attained. In consequence, within a genetically uniform population variations in height over time and between subpopulations are mainly the result of environmental factors (e.g. socioeconomic and epidemiological). Accordingly, many studies in the fields of human biology and social sciences have underlined the strengths of height as an indicator of living conditions for its capacity to summarize the balance between body energy inputs and outputs during the physical growth process. There are two post-natal critical periods for growth which are very sensitive to environmental stressors. These periods are infancy (i.e. the two first years of life) and puberty (i.e. when the adolescent spurt occurs, prior to the attainment of the adult final height) (Bogin, 1988; Tanner, 1989). A balanced net result between inputs (quantity and quality of food intake) and outputs (energy expenditure from basal metabolism, physical effort and exposure to illness) contributes to a normal growth pattern (i.e. one attains the stature that is genetically inherited). Oppositely, prolonged environmental stress during the growth cycle (e.g. chronic malnutrition, child labor or a continuous exposure to illness) may alter that biological pattern and may eventually result in loses from the potential height as an adult.

In this work the living conditions of Spanish male cohorts born during the central decades of the twentieth century (1934-1973) are studied.[6] Our main aim is the analysis of the evolution of spatial disparities during the intense process of socioeconomic development experienced by this country over that period. A combination of spatial and cohort analysis is essayed that contributes to better establish the impact of environmental conditions. Anthropometric measures for the study of the interaction between socioeconomic processes and living conditions in a historical perspective are enhanced since we track differences not only in height but also in robustness by including weight and chest circumference (CC) in a robustness index.

Data

Time-cohort series and cartography are based on the charts from the Military Statistics that were included in the Spanish Statistic Yearbooks. These charts summarize the data from the individual records of the compulsory military service in Spain until 1996 (the last mandatory enlistment was in 1995). The charts present relative distributions (i.e. percentages) of three anthropometric measures (stature in centimeters, weight in kilograms and CC in centimeters). This information is provided in 5-unit intervals both nationally and by regions. The yearbooks have been published in Spain since the middle of the 19th Century but relatively few are valid for our purposes (Table 1). For instance some yearbooks only provide the percent of recruits that were excluded due to shortness and also tabulation errors were detected in the data of the 19th century.

Some of aforementioned studies on Spain made partial use of the National Military Statistics but they did not systematically exploit this source and certain anthropometric measures provided were neglected.

[6] In Spain, a number of studies based on military records have displayed a regional gradient of male statures (Gómez-Mendoza and Pérez-Moreda, 1985; Quiroga, 1998; Gónzalez-Portilla, 1998 and 2001; Martínez-Carrión, 2005). Gómez-Mendoza's and Pérez-Moreda's work analyzed male height in Spanish regions in 1858. Martínez-Carrión's work compared regional disparities in height in Italy and Spain in 1955 and 2000. Quiroga's work presented regional series for cohorts born 1873-1934.

The birth year is not provided. We know that the age of enlistment was 21 years in 1955 (first enlistment) and that no single cohort avoided the military service. In consequence, birth years were scrolled from 1934 producing the cohort span 1934-74. In order to obtain homogeneous cohort groups (i.e. 5-yr cohorts) the last cohort analyzed in this work is 1973.

The format of the data remain quite constant but its representativeness decreased since the beginning of the 1990s as the percent of young males that opted for the social service alternative to military service increased. These individuals were not captured by the military statistics and/or a varying percent of those who were enlisted were not measured (the percent of missing cases is provided on Table A5 of the appendix). This compels us to omit the results on CC and RI for the last cohort group that is analyzed in this work (1969-73) as well as to moderate our statements on height and BMI of these cohorts. For the same reason the cohort group 1964-68 was chosen to close the map series.

We believe that these statistics included those recruits who did not scored the minimum height required to enter the army as the lower interval in the distributions is under that minimum height[7]. Also the percent potentially excluded for this reason was very low (Figure 1). Note that the potential effects of rounding caused by the measurements being recorded in half inch increments is smoothed across the intervals since they all use the same convention. All of this leads us to believe that the resulting averages are representative of the whole of the Spanish male population. This conclusion has been tested by comparing these averages with those resulting from series based on the crude height data collected from local archives that included short recruits. Our averages fall solidly within the range of those obtained for different areas in Spain (Martínez Carrión, 2009).

[7] The minimum height required was established at 154 cm. in 1912 (Abella, 1915). Subsequents laws did not establish a minimum height but rather an adequate proportionality between height, weight and CC.

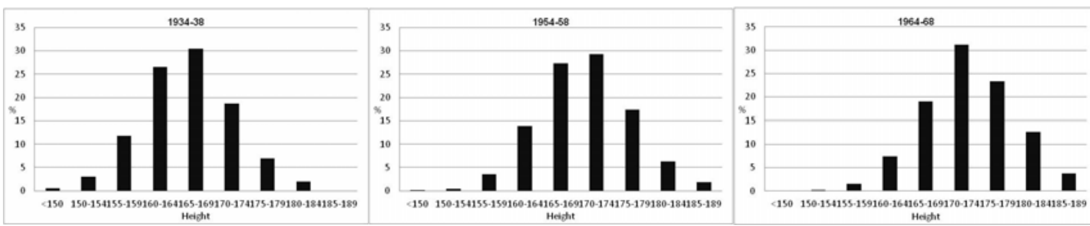
Table 1
Summary of anthropometric information contained in the Spanish Statistic Yearbooks (19th-20th centuries)

	Height			Weight			CC		
Enlistments	1	2	3	1	2	3	1	2	3
1992-95	9 (5)	<155							
1987-91	10 (5)		190+	10 (5)		90+	8 (5)		105+
1964-85	9 (5)		185+	8 (5)		80+			
1955-63	8(5)	<150	180+	7 (5)	<50	75+	7 (5-6)	<75	>100
1925-28	3 (7)	<163							
1917-1924	3 (5-10)		170+						
1915-16	5 (2-5)	154	>171						
1862-67									
1861	13 (3)	<147	>180						
1859	10 (3)	<151							
1858	10 (3)	<150	>175						

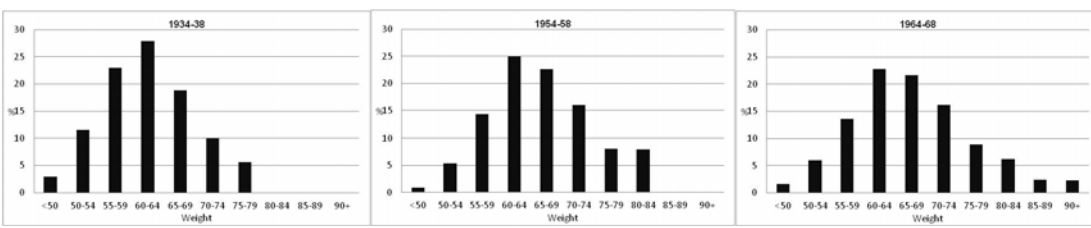
Note: 1, number (and length) of intervals; 2, lower limit of the distribution; 3, upper limit of the distribution

Figure 1
Distributions by birth cohort

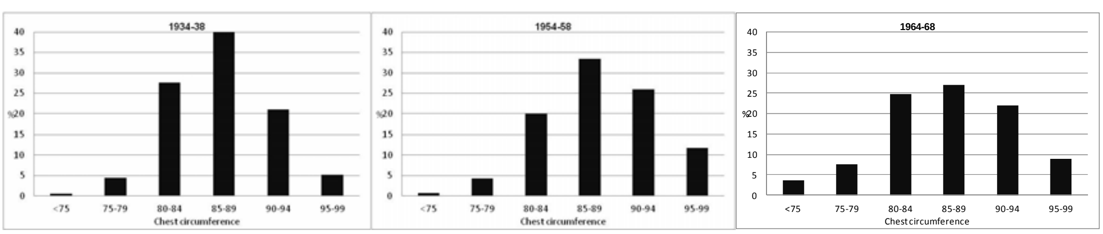
Height (cm)



Weight (kg)



CC (cm)



Source: Own computations based on Military Statistics of Spanish Yearbooks

The data are provided by “anthropo-demographic” zones and regions (Hoyos-Sainz, 1942)[8]. Regions are more convenient for our purposes since they better approach (though not exactly) the current administrative structure of Spain (Figure 2).

Finally, although this is not specified in the source we believe that the data classify recruits to their place of residence at the time of the anthropometric measurement and not to their place of birth. The potential bias caused by this is discussed in the last section of this paper.

Figure 2

Spanish regions
Current division (left) and anthropo-demographic regions (right)

Data on GDP and mortality were drawn from previous works and they were treated to fit the anthropo-demographic regions as it is explained in the next section of the paper. GDP data come from Alcaide’s estimates (2003). They are the most accepted and

[8] The equivalence between the anthropodemographic regions and the current autonomous regions in Spain is as follows (the current regions appear in brakets): *Región Galaica* (Galicia), *región Cántabra* (Asturias and Cantabria), *región Vasca* (País Vasco), *región Aragonesa-Riojana* (Aragón, La Rioja and Navarra), *región Castellano-leonesa* (Castilla-León) *región Catalana* (Catalunya and Illes Balears), *región Levantina* (Comunitat Valenciana and Murcia), *región Extremeño-manchega* (Extremadura and Castilla-La Mancha) and *región Andaluza* (Andalucia). Hoyos’ criterion results in some socioeconomic and cultural discrepancies. For instance, the *región Levantina* includes the current autonomous regions Comunitat Valenciana and Murcia. Per capita GDP was systematically higher in the former during the central decades of the 20th century and Murcia was economically closer to the Southern region of Andalusia. Also most of the region Comunitat Valenciana speaks Catalan, thus being culturally closer to the *region Catalana*. Anthropometric zones were discarded because they were too broad for our purposes. For instance, the Northern zone includes Asturias, Cantabria, País Vasco and Navarra.

one of the few available resources that include data on first half of the twentieth century (Carreras et al. 2005). Some caution must guide the interpretation of the relationship between this economic indicator and anthropometrics although we believe that the figures from Alcaide reflect the patterns and trajectories of economic development in twentieth century Spain in a very reasonable manner. Infant mortality rates were drawn from Gómez-Redondo (1992).

Methods

Series and cartography of anthropometric measures are based on weighted averages that were obtained by using the central value within each five-unit interval across the distribution. Open intervals were assumed to have a length of five units. The limits of open intervals varied (Table 1) but this does not substantially affect our results since 1) their variations paralleled the trend over time and 2) the percents within these open intervals remained very low. The averages that were obtained in that way were compared to those occasionally provided in the Yearbooks. As both figures hardly differed our own calculations were systematically used in order to homogenize the information used to construct series and maps. Height, Body Mass Index (BMI) and Robustness Index (RI) averages were computed on five-year cohort groups in order to make our trends more robust. The average of 1955-1959 enlistments (cohorts 1934-38) is made of three years because regional data are not provided in 1956 and 1957. The average of 1970-1974 enlistments (cohorts 1949-53) is a three-year average (1970, 1973 and 1974). The years 1971 and 1972 were discarded because of the strong drop observed in all three anthropometric measures. This may have to do with tabulation errors or, more likely, with an earlier age at measurement. According to the military laws, from 1907 to 1968 the recruits were enlisted and measured at age 21 with the exception of the Civil War (1936-39) and immediate postwar years. In subsequent years, the age at measurement was 19 years and 18 years (1987).

BMI was computed as the mean weight divided by the square of the mean height. To be noted about the components of this index, stature is a function of prior environmental conditions but weight is partially related to both stature and short-term environmental variations, e.g. illness (this short-term effect, nevertheless, is smoothed when large populations are analyzed).

$$BMI = \frac{W_{kg}}{H_m{}^2}$$

The categories commonly accepted for this index are *underweight* (<18.5 kg/m^2), *normal weight* (18.5–24.9 kg/m^2), *overweight* (25.0–29.9 kg/m^2) and *obesity* (>30.0 kg/m^2). These categories do not apply in this study because the range across regions is not large enough (i.e. we will not find obese regions vs. underweighted regions since the BMI of each region is comprised of many individuals who, obviously, tend to average a normal weight). Therefore this indicator is mapped in intervals of 0.5 units[9].

The Robustness Index (RI, also known as Pignet Index) results from subtracting the weight and the CC to height.

$$RI = H_{cm} - (W_{kg} + CC_{cm})$$

The interpretation of this indicator can be troublesome. RI may indicate different things depending on the context. At present RI is a sort of fitness index (high values indicate a good fitness). In this work the interpretation is the opposite. Lower scores indicate a higher robustness: 0-10 (very strong); 11-15 (strong); 16-20 (good); 21-25 (intermediate); 26-30 (weak); 31-35 (very weak); +35 (pathologic problems)[10]. As with BMI these categories do not apply here and we opted to map the results in 2-unit intervals[11]. Interestingly, it will be found that relatively tall populations present relatively low values of robustness as a result of very low values of weight and CC (i.e. weight does not scale with height in these data as one would expect of healthy populations).

P*er capita* GDP and infant mortality data included are aimed at illustrating development disparities across Spanish regions and potential discrepancies between economic and biological components of well-being (*per capita* GDP comes from Alcaide, 2003, and infant mortality rates come from Gómez-Redondo, 1992). Both indicators required some manipulation to fit the anthropo-demographic regions. Mortality rates were originally provided at the provincial level and had to be aggregated into regions. As the provinces within any region differ in size, population and other

[9] This lenght allows to capturing significant variations in mean BMI between cohort groups as well as regional disparities. For instance, keeping weight constant at 60 kg, a 2 cm change in height (e.g. from 166 cm to 168 cm) makes BMI to decrease from 21.77 to 21.25.

[10] Translation from Spanish is literally (Guillén-Rodríguez, online).

[11] Keeping weight and CC constant at 60 kg and 80 cm respectively, a 2 cm. change in stature (from 1.66 to 1.68) leads to an increase from 26 to 28 in RI.

socioeconomic characteristics, the infant mortality rates had to be weighted. This was done by using the live births recorded in each province. Data on live births were obtained from the historical vital statistics of the Spanish Population (MNP) (INE; online).

GDP from Alcaide (2003) was available by region but occasionally several regions needed to be merged to fit the anthropo-demographic regions. In those cases the sum of GDPs and the sum of populations were utilized to compute *per capita* GDP.

As we work with five-unit birth cohorts, annual mortality rates by province were averaged accordingly. Estimates on GDP were provided every five years by Alcaide so that two GDPs were taken and averaged matching each cohort group and the same was done with the populations that served as denominator of *per capita* GDP. More specifically the values for population used in the computation were those at July 1st of a given year and are also from Alcaide’s work. For instance, for any given region *per capita* GDP associated to cohorts 1934-38 is an average of GDPs 1935 and 1940 divided by the average of mid-year populations in 1935 and 1940.

Our results are a selection of materials. Some more detailed figures are included in the appendix that closes this work and the rest are available from authors on request.

Results

The average stature of Spanish males increased about 9 cm (or 5.4 percent) from 166 cm among those born in 1934 to 175 cm among those born in 1973. This is an increase of more than 2 cm per decade thus steeper than that observed in any other western European country among the same cohorts (over the period 1951-1980 male mean height progressed 2.53 cm per decade in Spain, whereas the mean increase in Europe was estimated to be 1.26; Hatton and Bray, 2010). Among the aforementioned cohorts the average weight increased from 62 kg to 69.4 kg (or 11.9 percent) and the average CC did so from 87 to 89 cm (cohort 1968) (or 2.3 percent).

Both composite indexes, BMI and RI, do not display a consistent (i.e. uniform) trend over time as a result of the changing relationship (i.e. their relative weight in the indexes) among those three anthropometric measures. BMI rose from 22.6 (cohorts 1934-38) to 23.2 (cohorts 1944-48) and decreased among subsequent cohort groups as a result of the strong increase in mean cohort height. RI decreased from 16.6 (cohorts 1934-38) to 13.7 units (cohorts 1944-48) thus indicating an increase in robustness related to a limited progress in stature and proportionally higher increments in weight and CC. This trend was reversed among cohorts born since 1949 as the result of the dramatic increase in height observed during the second half of the 20th century. Such increase was not paralleled by CC that remained stable or slightly decreased (Table 2).

Table 2
Anthropometric measures and composite indexes
Spanish male cohorts born 1934-73

Cohorts	Height	Weight	CC	BMI	RI
1934-38	166.4	62.5	87.2	22.6	16.6
1939-43	167.2	64	87.9	22.9	15.3
1944-48	168	65.5	88.8	23.2	13.7
1949-53	169.4	66.1	88.8	23	14.5
1954-58	170.9	66.6	88.9	22.8	15.3
1959-63	172.2	67	89.1	22.6	16.1
1964-68	173.8	67.3	88	22.3	18.5
1969-73	175	69.1		22.5	

Source: Own computations based on Military Statistics of Spanish Yearbooks

The anthropometric map of Spain became progressively more homogeneous over the life courses of the aforementioned cohorts. For instance, height differences between the tallest (*región Vasca*) and the shortest (*región Andaluza*) among older cohorts were about 4 cm. These differences more than halved among cohorts born at the beginning of the 1970s (less than 2 cm. between the tallest –*región Aragonesa-riojana*— and the shortest at the time –*región Galaica*-) (Figure 3). The variation coefficients of regional heights shifted from 0.009 to 0.004 alongside. Therefore, short regions grew more than tall regions during the central decades of the 20th century. Regional differences in mean weight also lessened. The average weight among cohorts born 1934-38 ranged from 60.5 kg (*región Andaluza*) and 67.0 kg (*región Vasca*) whereas among those born 1969-73 they ranged from 68.8 kg (*región Catalana*) and 70 kg (*región Aragonesa-riojana*). This caused BMI and RI to converge across regions as displayed by their respective variation coefficients (BMI shifted from 0.024 to 0.009 and RI did so from 0.122 to 0.053 among cohorts born 1934-38 and 1964-68 respectively) (Appendix, Table A5).

Figure 3
Spatial patterns
Male cohorts 1934-73

Height

1934-38	1954-58	1964-68
(Spain 166.40 cm)	(Spain 170.89 cm)	(Spain 173.67 cm)

BMI

(Spain 22.6 kg/m^2)	(Spain 22.8 kg/m^2)	(Spain 22.3 kg/m^2)

RI

(Spain 16.6 units)	(Spain 15.3 units)	(Spain 18.5 units)

Source: Own computations based on Military Statistics of Spanish Yearbooks
Note. All regions fall in the height interval 174-176 among the younger cohorts (1969-73). We opted to maintain the same intervals over time as we are interested in showing both the general trend in cohort height and the convergence across regions. In the case of BMI this convergence happened as this index was decreasing as a result of the strong increase in height. Remember that the downturn in RI indicates the rise of robustness (colors on the map were set to point in the same direction: the darker, the taller and the more robust)

The reduction of anthropometric disparities in height was already happening among cohorts born during the 1940s. This is illustrated by the relatively higher growth of Central-Southern regions with respect to North-Eastern regions. This process noticeably intensified among cohorts born during the 1950s and the 1960s which is in accordance with an effective reduction of economic disparities. These disparities, nevertheless, remained significantly higher than anthropometric disparities (Table 3 and Figures 4 and 5).

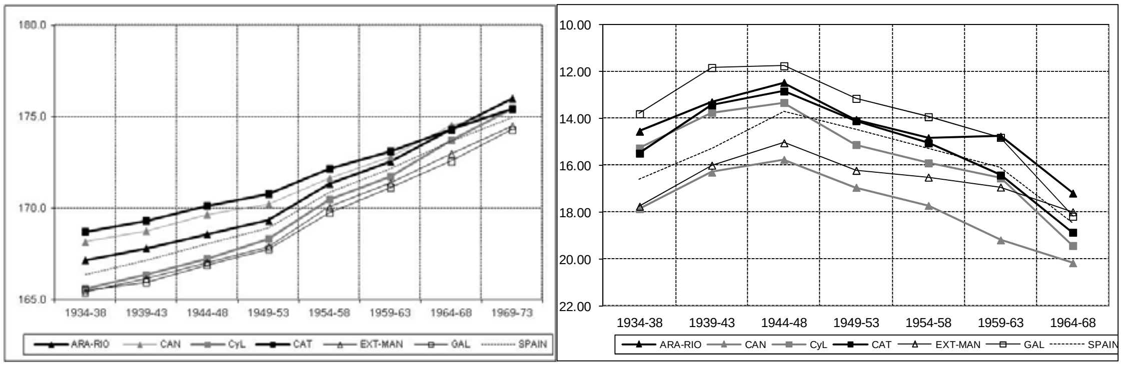
Table 3
Inter-cohort height changes (relative deviations from the national trend)

Region	1939-43		1949-53		1959-63		1969-73	
SPAIN	**0.50%**	Rank	**0.82%**	Rank	**0.76%**	Rank	**0.70%**	Rank
AND	0.12	2	-0.09	7	0.06	1	0.25	4
ARA-RIO	-0.12	6	-0.07	6	-0.06	5	0.27	3
CAN	-0.15	8	-0.26	9	-0.08	7	-0.2	10
CANT	0.05	3	-0.28	10	-0.29	11	-0.02	8
CAT	-0.14	7	-0.13	8	-0.19	9	-0.07	9
CyL	-0.04	4	0.16	2	-0.03	4	0.28	2
EXT-MAN	-0.06	5	0.09	3	0.01	3	0.18	5
GAL	-0.22	11	0.02	5	0.06	2	0.3	1
LEV	-0.17	10	0.08	4	-0.07	6	-0.34	11
MAD	0.24	1	0.17	1	-0.13	8	0.09	6
PV	-0.17	9	-0.38	11	-0.23	10	0.05	7

Source: Own computations based on Military Statistics of Spanish Yearbooks
Note. The first column contains the deviation from the national growth rate in percent points between two successive cohort groups. The national rate is on the first row and it was computed as a rate of change between two cohort groups. For instance, 0.50 percent in the first row is the delta between the cohort groups 1934-38 and 1939-43. The value 0.12 on the second row for Andalusia (AND) means that this region progressed 0.62 percent over the same period.

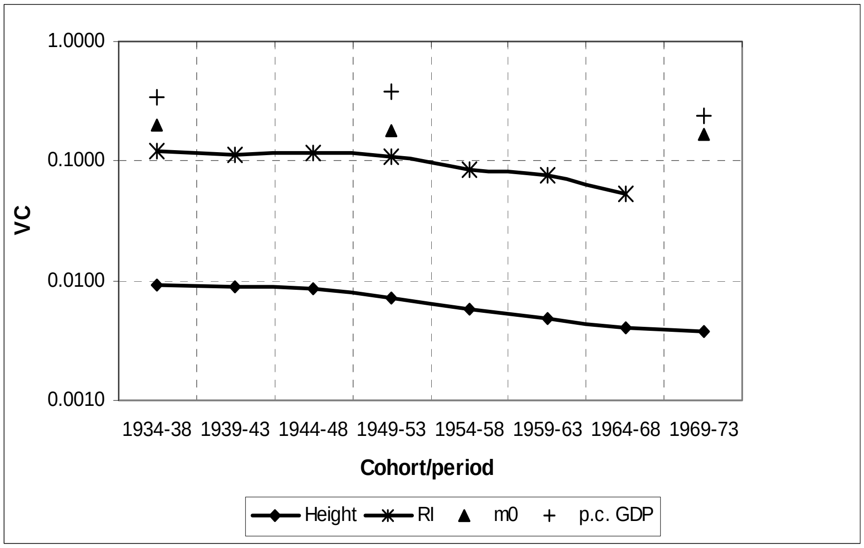
Figure 4
Cohort height (cm) and cohort RI in six Spanish regions

Height **Robustness Index**



Source: Own computations based on Military Statistics of Spanish Yearbooks

Figure 5
Variation coefficients



Source: Own computations based on Military Statistics of Spanish Yearbooks

Despite this convergence across regions, spatial patterns were very persistent. A North-Eastern arch of tall and robust regions compares to a group of short and weedy Central-Southern regions. This pattern disappeared for BMI but it was still observed for stature and RI among cohorts born at the end of the 1960s (this was displayed in Figure 3).

In terms of height, some regions kept their advantage over the whole period analyzed. This is the case of the *region Catalana* (Catalonia and Balearic Islands) the *region Vasca* (Basque Country) the Canary Islands and Madrid. Likewise the South remained as a compact group of regions below the national average. Few regions gained positions in an ordinal ranking of the indicators over the course of the twentieth century. Castille-Leon is an exception. This region began to diverge from the short-averaged regions since the middle of the 1940s and by the 1960s its mean stature was already above the average. On the contrary, the *región Levantina* (on the East coast) lost position and settled below the average in the 1970s along with the short regions. Finally, the progress of the *región Aragonesa-riojana* is outstanding since it rose to the first place in height and also ranked among the top-five regions in RI at the end of the analyzed period.

These anthropometric patterns that basically reflect the nutritional status of the population are only partly related to the economic performance of regions as approximated by GDP and their sanitary context as approximated by infant mortality. Between 1930 and 1970 the regional GDP displayed few variations. Madrid and the North-Eastern regions consistently ranked at the top. With few exceptions (i.e. Madrid and the poorer regions of the North-Eastern arch) infant mortality was also lower in those regions (Table 4). Madrid, an urban region located in the center of the country had high GDP and high infant mortality levels during the central decades of the twentieth century. This region was probably affected by an urban penalty until improved sanitation and hygiene conventions and facilities were spread in subsequent phases of the urbanization process. Illustratively, by the middle of the 1970s Madrid was already among the regions with lower infant mortality rate.

Table 4
***Per capita* GDP (current prices) and m_0**
(Spain=100)

	GDP						m_0					
Region	**1930**		**1950**		**1970**		**1934-38**		**1949-53**		**1969-73**	
AND	76.4	9	72.5	9	72.5	10	105.7	9	98.3	6	111.6	8
ARA-RIO	112	4	110.03	5	108.9	4	92.8	6	101.7	8	94.3	5
CAN	92.1	7	83.2	8	85.2	7	98.2	8	99.3	7	95.2	6
CANT	100.45	5	114.3	4	105.4	5	81.7	3	85.5	4	102.3	7
CAT	148.75	2	138.9	3	133.2	2	64.1	1	72.4	1	77.2	1
CyL	89.7	8	92.6	6	83.5	8	126	11	131.3	11	118.2	9
EXT-MAN	66.55	11	66.9	11	64.8	11	124.6	10	118.7	10	123.3	10
GAL	74.7	10	72.1	10	78.8	9	90.1	5	110.2	9	133.8	11
LEV	92.4	6	89.95	7	91.75	6	82.3	4	80.9	3	91.9	4
MAD	145.7	3	148.3	2	132.9	3	96.1	7	91.1	5	88.1	2
PV	161.2	1	181.6	1	142	1	70.5	2	73.4	2	91.6	3

Source: Own computations based on Military Statistics of Spanish Yearbooks as explained in the section entitled Methods. Absolute numbers are provided on Table A4 in the Appendix.

Short-averaged regions display relatively low GDPs and relatively high infant mortality levels but this association is notoriously ambiguous among tall regions. For instance, the Canary Islands were historically tall-averaged but relatively low-averaged in terms of GDP. Moreover, its mortality levels were close to the national average so they may be considered high relative to the group of tall regions (e.g. the *región Catalana* and the *región Vasca*). It must be noted that tall regions ranged broadly in terms of infant mortality (during the 1930s, m_0 in the Canary Islands and Madrid was over 120 per thousand whereas it was 91 and 82 per thousand in the region Vasca and the región Catalana respectively[12]). Robustness partly resolves those paradoxes in that it sets the Canary Islands with the less-developed regions (i.e. poorly nourished) and Madrid with the high-infant mortality regions during the first stage of the modern process of urbanization.

Yet some discrepancies between economic and anthropometric indicators persist in that the robust North-Eastern arch (presumably well-nourished) includes relatively short and/or relatively poor regions like Galicia and Castille-Leon. This is not the case for less robust Spain made up of Central-Southern regions (presumably poorly nourished and relatively poor with the exception of Madrid).

Discussion

In this work trends and patterns of height and robustness in Spain have been analyzed during the main phase of modern socioeconomic development in this country (i.e. the central decades of the twentieth century).

Trends in cohort height indicate substantial improvements in the nutritional status of the Spanish (male) population during that period. This has been observed even among cohorts that were exposed to war and post-war related hardships.

Trends in robustness as approached by BMI and RI have a double interpretation. In a first stage (cohorts born during the 1930s and the 1940s) these indexes indicate an increase in robustness that technically has to do with a modest progress of height at the time that weight and CC were meaningfully increasing. The opposite occurred among

[12] The latter has mainly to do with the very low infant mortality rates in the Balearic Islands, 72.3 per thousand in 1934-38 (Gómez-Redondo, 1992).

subsequent cohorts whereby less robust bodies are likely to reflect better nourished and healthier individuals.

This anthropometric picture was framed by cross-regional convergence and persistent spatial patterns.

A convergence between tall-robust (well-nourished) and short-weak (poorly nourished) regions is observed. Convergence was particularly strong for cohorts born between 1950 and 1960. This period witnessed the end of autarchic policies and the end of the economic isolation of Spain. Yet the initial disparities observed across regions (i.e. among cohorts born during the 1930s) cannot be explained merely through assumptions of previous hardships. Rather those disparities were the result of a long-term process of height differentiation that might have had its origin during the second half of the nineteenth century. That process would have consolidated during the first decades of the twentieth century since regions appeared in a very similar ordinal ranking among cohorts born 1875-1934 in a nationally representative sample of recruits (Quiroga, 1998 and 2001). The regional ranking of statures until the middle of the twentieth century remained almost invariably headed by the Basque Country, Catalonia and the Canary Islands. Furthermore, the rest of positions in the list also remained very stable with few exceptions (e.g. those born in Andalusia during the last third of the nineteenth Century were on an intermediate position so that cohorts born during the first decades of the twentieth Century relatively shrank and set the region among the shortest)[13].

The range of height differentials deserves some attention. That was estimated to be above 6 cm. among cohorts 1875-1934 which is close to that observed among those enlisted in 1924 (born at the beginning of the twentieth century) which were about 4.5 cm between the Basque (the tallest) and those enlisted in Galicia and La Rioja (the shortest at that time) (Quiroga, 2001). In the main this agrees with our results for male cohorts born during the 1930s. In consequence, after a process of divergence during the second half of the nineteenth century differences would have leveled off during the first decades of the

[13] This agrees with the studies in economic history that have prompted the trajectory followed by Andalusia from its second place among the industrials regions (only behind Catalonia) by the middle of the 19th century to be among the most delayed regions on the eve of the Spanish Civil War (1936-39) (an overview of these studies in Martínez-Carrión, 2005).

twentieth century and they would have decreased thereafter particularly among cohorts born since the 1950s.

This convergence across regions must be interpreted in generational terms by analyzing both the energy inputs (intakes) and outputs (expenditure) that influence the nutritional status of the population. Regarding the inputs, Spanish cohorts born during the second half of the twentieth century grew up in a context of relative food security (stock and access were met although dietary quality was improvable in an initial stage). Spain overcame structural scarcity during the 1950s and this was followed by a diversification of foodstuffs during the 1960s and the 1970s thus going across the patterns of the nutritional transition (Popkin, 1993; Cussó, 2005). Meanwhile potential energy output-related disruptions were dramatically reduced in that hygiene measures and sanitary provisions were substantially improved. These factors endorsed the health transition process at least until the decade of the 1980s (Spijker et al., 2012).

In our view, these shifts in the components of the net nutritional status of a population cannot be dissociated from the Spanish economic take-off during the second half of the twentieth century but anthropometrics are not in total accordance with either the geography of income or the economic trajectories followed by the regions. Poor regions caught up in terms of height and robustness more successfully than in economic terms as income disparities remained relatively large over the analyzed period. The anthropometric convergence seem to us even more relevant given the absence of specific policies aiming at correcting socioeconomic disparities across the country (those policies were not effectively implemented until the arrival of democracy in the late 1970s; García-Ballesteros, 1990). Nevertheless, the convergence hardly modified an ordinal ranking of the spatial pattern. In terms of stature, 3 out of 4 regions initially at the bottom (i.e. cohorts born during the 1930s) remained at those positions during the 1970s (it must be noted that those cohorts grew up during the 1980s and the 1990s).

Finally, some discrepancies found between height patterns and robustness patterns are worth commenting on. That tall but skinny regions are found along with short but robust regions in Spain may be explained by relatively good diet combined with some other high impact environmental stressors or growth disruptors (e.g. sanitary conditions as approximated by infant mortality). In our view this leads to the necessity to interpret trends in height in light of other anthropometric measures when approaching the biological components of living standards.

Southern regions like Andalusia and the *región Extremeño-manchega* were systematically poor, short and less robust during most of the twentieth century. Interestingly, this set of regions coincides with those whose relative *per capita* GDP decreased in the long run (Carreras, 1990).

By contrast, the robust Spain (presumably well-nourished) spread on a North-Eastern arch of regions from Galicia (on the far North-West) to the East coast (current region Comunitat Valenciana) that was to some extent independent from both height scores and economic development. Among Northern Spaniards both relatively tall (e.g. Basque) and relatively short populations (i.e. Galician) are found but all of them were significantly more robust on average than Southern Spaniards. In an examination of their robustness, regions like Galicia and Castille-Leon were not as disadvantaged as would have been concluded in an analysis of height alone. Northern robustness (shared by economically developed and underdeveloped regions) was probably associated with a better provision and/or an easier access to high protein and caloric foodstuffs such as meat and milk. In 1910-12 that arch of robust regions very much coincided with food prices above the national average but also with cheaper meat and dairy products among the Spanish provinces. By contrast, Southern provinces displayed an apparent advantage regarding the prices of cereals and fats (i.e. olive oil; Nicolau and Pujol, 2006). These authors concluded that these differentials were indicative of the actual consumption and that Northern provinces had generally easier access to high protein and caloric foodstuffs than inner and southern provinces had. Along with Simpson we hypothesize that meat and dairy products remained rare in these areas until well into the second half of the century. This supposition has several explanations none of which are mutually exclusive: the historical agricultural specialization by region, the physical constraints to the development of mixed agrarian systems, the limited demand from urban markets and the poor market integration of the country (Simpson, 1995). Simpson argues that ‘from the turn of the nineteenth century onwards, the decline in rural industry and the increasing penetration of cereals from the Interior [i.e. inner regions] encouraged greater livestock specialization in the North […] The North had 7.3 per cent of the agricultural land area, but 36 per cent of livestock output in 1929-33' (1995: 191-192). Furthermore, an estimated food cost index adjusted by wages among twelve Spanish provinces in different regions uncovered systematically higher costs for a set of basic foodstuffs in the Southern and inner provinces (Ballesteros, 1997). This evidence is also in accordance with the variation in the market price of high protein products across regions. For instance milk's prices per liter in 1933 were 0.42 pesetas in the North (regions of Galicia, Asturias, Cantabria and the Basque Country, 0.52 in Castille-Leon, 0.50 in the Ebro valley (region *Aragonesa-Riojana*), 0.53 in the Mediterranean East Coast, 0.60 in the region *Extremeño-Manchega* and 0.73 in Andalusia) (Simpson, 1995: 194). This very much agrees with disparities in robustness that our results have displayed.

The Canary Islands are another interesting case. Any hypothetical environmental advantage attributed to this region in light of its tallness should be questioned in light of our outcomes. Males enlisted in the Canary Islands were tall but not robust which drives us to think about more than just environmental conditions in order to explain their above average height (e.g. ethnic specificities; Hooton, 1925)[14]. Furthermore infant mortality for the Canary Islands was among the highest in Spain at the beginning of the twentieth Century. Thus height cannot easily be related to low morbidity exposure, at least not during that critical period of physical growth.

Some of these findings need to be interpreted with caution. Tall-averaged regions like the Basque Country, Catalonia or Madrid were also the most developed as reflected by industrialization and urbanization levels as well as by *per capita* income. They were also the main destinations of internal migration flows. Within Spain, these flows were intense during the 1950s and the 1960s (García-Barbancho and Delgado-Cabeza, 1988) and they might imply selection effects thus affecting some of the anthropometric trends and patterns. Regarding the anthropometric convergence across regions the most disturbing bias would result from systematically shorter migrants (shorter than non-migrants in their home region and shorter than natives in the destination region). In such a case, migration would partly explain those trends but such a statement contradicts the hypothesis of a selective migration. Contrarily, if migrants were systematically taller than

[14] A series of unpublished papers by Cándido Róman argue in favor of environmental advantages and particular food properties to explain the tallness in these islands. Results, nevertheless, do not seem concluding in that direction.

non-migrants and/or taller than the natives at destination, that might cause anthropometric disparities across regions to increase artificially (i.e. aside from the environmental conditions during infancy and adolescence). The cohort trends that have been displayed in this work do not necessarily point to a systematic bias caused by selective migration but this effect cannot be totally discarded. The anthropometric convergence started very early but it was particularly strong among those cohorts born during the 1950s and 1960s. These cohorts attained their adult height between the 1970s and 1980s once migration flows had moderated. By contrast, cohorts born during the 1930s and the 1940s potentially featured the most intense flows. In consequence, the initial disparities as well as the slow pace of convergence among those cohorts might have partly to do with the aforementioned selective effect. Notwithstanding, regions like Castille-Leon experienced an outstanding progress in height that spanned among cohorts born 1940-70 and essentially ceased their growth between 1970 and 1990. Over this period the intensity and even the net result of migratory flows in that and other regions varied whereas the progress of height and robustness was rather continuous.

With regard to the issue of migration is unfortunate that few and very partial sources are available in Spain. Some military records provide the province of enlistment and the province of birth but this is not enough to disentangle migration and environmental effects since the time of migration is unknown. In consequence, it is ignored to what extent migrants' advantage (if any) would be a result of selection in origin or successful adaptation in the destination place (i.e. favored by an improved environment).

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Appendix

Table A1
Average height in Spain and its regions
Cohorts born 1934-73

Region	1934-38		1939-1943		1944-1948		1949-1953		1954-1958		1959-1963		1964-1968		1969-1973	
AND	165.34	11	166.36	9	167.10	9	168.33	10	169.86	10	171.25	10	172.78	10	174.42	10
ARA-RIO	167.18	6	167.81	6	168.59	6	169.86	6	171.34	6	172.54	5	174.29	5	175.99	1
CAN	168.18	3	168.77	3	169.67	3	170.62	4	171.65	4	172.81	4	174.53	3	175.39	6
CANT	167.43	4	168.35	5	169.16	5	170.07	5	171.39	5	172.18	7	173.93	6	175.12	7
CAT	165.62	8	166.38	8	167.26	8	168.87	8	170.50	8	171.74	8	173.73	8	175.44	4
CyL	168.72	2	169.32	2	170.14	2	171.31	3	172.15	3	173.12	3	174.32	4	175.42	5
EXT-MAN	165.43	10	166.16	10	167.04	10	168.56	9	170.07	9	171.38	9	172.98	9	174.50	8
GAL	165.52	9	165.98	11	166.90	11	168.31	11	169.76	11	171.15	11	172.58	11	174.30	11
LEV	166.97	7	167.51	7	168.25	7	169.77	7	171.12	7	172.31	6	173.86	7	174.49	9
MAD	167.39	5	168.62	4	169.63	4	171.31	2	172.39	2	173.47	1	174.57	2	175.94	2
PV	169.64	1	170.20	1	170.96	1	171.72	1	172.55	1	173.46	2	174.58	1	175.90	3
SPAIN	**166.35**		**167.18**		**168.61**		**169.88**		**170.89**		**172.18**		**173.85**		**175.07**	

Source: Own computations based on Military Statistics on Spanish Yearbooks. The second column for each cohort group indicate the ranking among regions

Table A2
Average weight in Spain and its regions
Cohorts born 1934-73

Region	1934-38		1939-1943		1944-1948		1949-1953		1954-1958		1959-1963		1964-1968		1969-1973	
AND	60.54	11	62.31	10	63.93	10	64.77	10	65.46	10	66.02	9	66.57	10	69.13	5
ARA-RIO	64.36	4	65.50	4	66.79	4	67.27	4	67.55	4	67.75	3	68.11	1	69.96	1
CAN	62.64	8	63.83	8	64.91	9	65.72	9	65.93	9	65.94	10	66.46	11	68.20	11
CANT	65.58	2	67.00	2	68.21	2	68.71	2	68.28	2	68.27	2	67.92	3	69.39	4
CAT	63.12	7	64.20	7	65.42	8	65.84	8	66.09	8	66.44	8	66.84	8	68.91	9
CyL	64.91	3	66.32	3	67.51	3	67.64	3	67.69	3	67.38	7	67.20	7	68.78	10
EXT-MAN	60.77	10	62.18	11	63.80	11	64.67	11	65.33	11	65.91	11	66.58	9	69.11	6
GAL	64.30	5	65.34	5	66.62	5	67.05	5	67.42	5	67.47	6	67.27	6	69.00	8
LEV	63.23	6	64.48	6	65.83	6	66.44	6	67.03	6	67.51	5	67.52	5	69.03	7
MAD	61.79	9	63.66	9	65.62	7	66.41	7	66.76	7	67.71	4	67.52	4	69.44	3
PV	67.05	1	67.98	1	69.68	1	69.93	1	69.24	1	68.44	1	68.03	2	69.68	2
SPAIN	**62.54**		**64.03**		**65.51**		**66.77**		**66.61**		**66.97**		**67.35**		**69.13**	

Source: Own computations based on Military Statistics on Spanish Yearbooks

Table A3
Average chest circumference in Spain and its regions
Cohorts born 1934-73

Region	1934-38		1939-1943		1944-1948		1949-1953		1954-1958		1959-1963		1964-1968	
AND	86.33	11	87.15	11	88.28	10	87.93	10	88.19	11	88.46	10	87.52	10
ARA-RIO	87.98	4	88.51	5	89.19	5	88.81	5	89.17	5	89.97	1	89.34	1
CAN	87.24	8	88.21	6	88.95	7	87.98	9	88.52	9	88.08	11	87.36	11
CANT	88.41	2	88.75	3	89.78	2	89.57	1	89.66	3	89.56	5	88.52	4
CAT	87.14	9	87.71	9	88.58	9	88.05	8	88.80	7	88.87	8	87.85	7
CyL	88.12	3	88.75	4	89.69	4	89.57	2	89.86	2	89.80	2	88.26	5
EXT-MAN	86.64	10	87.21	10	88.10	11	87.59	11	88.40	10	88.56	9	87.98	6
GAL	87.37	6	87.87	8	88.72	8	88.34	7	88.76	8	88.99	7	87.82	8
LEV	87.55	5	88.17	7	88.96	6	88.35	6	89.05	6	89.25	6	87.69	9
MAD	87.36	7	88.85	2	89.76	3	89.08	4	89.59	4	89.64	3	88.58	3
PV	89.33	1	89.63	1	90.38	1	89.56	3	90.06	1	89.59	4	88.64	2
SPAIN	**87.23**		**87.89**		**88.84**		**88.83**		**88.95**		**89.08**		**88.01**	

Source: Own computations based on Military Statistics on Spanish Yearbooks

Table A4

***Per capita* GDP (current prices; million of *pesetas*) and infant mortality rates (per thousand)**

	GDP			m0		
Region	**1935-40**	**1950-55**	**1970-75**	**1934-38**	**1949-53**	**1969-73**
AND	1576	8448	98174	136.81	70.75	31.96
ARA-RIO	2236	12824	143168	120.1	73.18	27.01
CAN	1893	9829	117661	127.16	71.45	27.28
CANT	2224	13431	137402	105.69	61.49	29.3
CAT	3292	18840	177980	82.92	52.06	22.12
CyL	1823	10630	112567	163.09	94.48	33.85
EXT-MAN	1386	8066	91335	161.24	85.43	35.32
GAL	1529	8625	102549	116.63	79.27	38.32
LEV	2102	12016	132944	106.58	58.22	26.34
MAD	3176	18168	183572	124.37	65.53	25.24
PV	3473	21761	184973	91.23	52.81	26.26

Source: Own computations on data from Alcaide (2003) and Gómez-Redondo (1992)

Table A5

Variation coefficients

Period	**Height**	**Weight**	**CC**	**BMI**	**RI**	**m0**	**p.c. GDP**
1934-38	0.0093	0.0342	0.0101	0.0237	0.1222	0.198	0.346
1939-43	0.0088	0.0299	0.0091	0.0212	0.1121		
1944-48	0.0087	0.0282	0.0083	0.0195	0.1187		
1949-53	0.0072	0.0224	0.0082	0.0171	0.107	0.18	0.374
1954-58	0.0058	0.0183	0.0069	0.0142	0.0832		
1959-63	0.0048	0.0136	0.0066	0.0117	0.0747		
1964-68	0.0041	0.0086	0.0065	0.0088	0.0528		
1969-73	0.0037					0.165	0.242
Change (percent)	**-56.3**	**-74.72**	**-35**	**-62.8**	**-56.8**	**-16.3**	**-30**

Source: Own computations based on Military Statistics on Spanish Yearbooks

Table A6

Missing anthropometric data (percent) as reported in the Military Statistics

Cohort 1970				Cohort 1971				Cohort 1973			
Region	**Height**	**Weight**	**CC**	**Region**	**Height**	**Weight**	**CC**	**Region**	**Height**	**Weight**	**CC**
AND	7.9	7.9	99.2	AND	4.9	4.9	14.5	AND	4.4	4.4	14
ARA-RIO	5.7	5.7	98.2	ARA-RIO	4.8	4.8	24.4	ARA-RIO	4.2	4.2	10.5
CAN	20.5	20.2	97.6	CAN	14.1	13.9	43.1	CAN	15.1	15	46.2
CANT	7.5	7.7	99.3	CANT	4.6	4.7	14.3	CANT	1.4	2.4	11.6
CAT	8.9	9	96.2	CAT	4	4	9.4	CAT	3.7	3.7	8.3
CyL	11.4	11.3	82.7	CyL	11.9	11.8	42.6	CyL	13.4	13.2	39.1
EXT-MAN	10.3	10.2	98.9	EXT-MAN	6.6	6.5	19	EXT-MAN	4.7	4.6	14
GAL	12.2	12.2	90.1	GAL	12.5	12.4	21	GAL	10.3	10.3	17.6
LEV	7.5	7.6	97.4	LEV	5.9	5.9	19.3	LEV	3.6	4	15.5
MAD	78.7	78.8	99.7	MAD	13.2	13.2	33.3	MAD	16.7	16.8	31.7
PV	24.6	24.4	99	PV	17.7	17.6	59.7	PV	13.9	13.7	57.3
SPAIN	**20.9**	**20.9**	**95.1**	**SPAIN**	**9.1**	**9.1**	**27.6**	**SPAIN**	**8.9**	**8.9**	**24.9**

Source: Military Statistics on Spanish Yearbooks

Note. No regional data is available for the cohort 1972 that was not included in the analysis. The missing percent for Spain within that cohort were 9.1, 9.1 and 27.6 respectively.