Height, robustness and living conditions: spatial patterns and cohort dynamics in 20th-century Spain

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Abstract

Anthropometrics, stature in particular, have been profusely utilized during the last decades in the analysis of long-term trends in biological living standards. In this work we analyze regional patterns and differentials in height and robustness across Spanish regions among male cohorts born during the central decades of the 20th century. These cohorts grew-up during a key phase of the contemporary history of that country because of the dramatic socioeconomic and demographic changes experienced alongside. Interestingly, those cohorts lived very different life experiences that included contexts of hardship and severe deprivation and context of generalized welfare provisions. The study covers 40 birth cohorts born between 1934 and 1973 whose living conditions are approached by means of the aforementioned anthropometric measures.

Data come from the Military Statistics that were included in the Statistic Yearbooks of Spain and therefore they are exclusively referred to males. From these data, time-cohort series and anthropometric cartography are constructed (i.e. cohort trends and regional patterns of height, BMI and robustness index) which are supplemented with data on regional *per capita* GDP and infant mortality rates. Deviations from the national means as well as variations in the ranking within the country serve for the purposes of the paper.

Results show a process of convergence both across regions and between cohorts that was particularly intense among cohorts born during the 1950s and the 1960s. Nevertheless, the regional anthropometric pattern was very persistent at least until the 1990s (cohorts born during the 1970s). This pattern was characterized by a higher robustness of North-Eastern regions which has only part to do with wealth. In general, wealthy regions were traditionally taller and more robust but there are interesting discrepancies on this correlation that are conveniently analyzed and commented. Also discrepancies between height and robustness are observed that will deserve in-depth comments.

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1. Living conditions in 20th-century Spain: cohorts and territories

Spain attained high development levels over the 20th Century as a result of a rapid and intense process of socioeconomic and demographic changes. This process is vividly reflected by diverse health-related indicators. Life expectancy at the beginning of that century was hardly 35 years[2]; fifty years later it had risen to 62 years and in 2000 it was about 79, among the highest in the world (Instituto Nacional de Estatística, INE, 1991 and 2007). This dramatic change took about two centuries in some early transitional countries like Sweden or France.

Adult height, which is considered a good proxy of living conditions until it is completed in adulthood, also illustrates the velocity and intensity of these changes. It is estimated that 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 20th century (Spijker et al., 2011)[3]. Yet Spanish cohorts born 1950-59 displayed a remarkable disadvantage with respect to other high developed Western countries (for instance German males were about 180 cm tall on average, Americans were about 179 cm whereas their Spanish counterparts were about 172 cm (165 cm, 164 cm and 160 cm on average among females respectively). Only two decades later (i.e. less than one actual generation) differences had been largely reduced. Spanish males had progressed to about 176 cm whereas Germans and Americans had stagnated or even slightly decreased in height which also happened among females (Spanish females attained 163 cm, equaling Americans who had decreased and the difference with respect to Germans passed from 5 to 2 cm (Komlos and Baur, 2004; Spijker et al., 2010).

As a result of the rapidness and intensity of these changes the current Spanish population is made of cohorts who lived very different lives: from those who experienced

[2] In 1900 life-expectancy elsewhere in Europe ranged from 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, and 49.9 years in the Netherlands to 54.0 years in Sweden (Livi-Bacci, 1992).

[3] Oppositely, a number of studies show that the progress was very discrete during the 19th century when even drop cycles occurred (Martínez-Carrión and Pérez-Castejón, 2002; Cámara, 2009; García-Montero, 2009; Ramón-Muñoz, 2009; Hernández and Moreno, 2009). These studies point that the mean height among Spanish males merely progressed, from 1,62 m. to 1,63 m. among cohorts born during the second half of the 19th century (Gómez-Mendoza and Pérez-Moreda, 1985; Cámara and García-Román, 2010). These figures set Spain among the shortest countries of Europe at the beginning of the 20th century (Komlos and Baur, 2004).

dictatorship, hardships and scarcity to those who grew up in a democratic, affluent and well-provided welfare State.

Aside of this generational contrast, Spain was a country of strong socioeconomic and demographic disparities in the 20th century. Illustratively, during its central decades, in a context of intense economic growth, both population and key economic activities tended to concentrate in the most dynamic regions like Madrid, Catalonia or the Basque Country.

The cross-sectional dimension of classical indicators such us GDP and life expectancy implies some shortcomings to merge both perspectives (generational and spatial) in the study of living conditions. In words, the regional disparities reflected by these indicators respond to a given context at a given moment and not strictly to the living conditions experienced over the life course. The latter can be indirectly approach by some alternative indicators like adult height.

2. The cohort approach to living conditions through adult height

The final height that an individual attains in adulthood is the result of two types of determinants: 1) genetic determinants that establish a maximum biological potential for each individual and 2) environmental that determine to what extend that biological potential will be fulfilled. In consequence, within a genetically stable population or between ethnically uniform populations, variations and differentials in mean height are mainly the result of *environmental* processes (e.g. socioeconomic, epidemiological, etc.)

A number of works in the fields of human biology and axiology (the discipline that studies the physical growth) have underlined the strengths of height as an indicator of living conditions. Adult height is net result of body energy inputs and outputs during the physical growth process which, *grosso modo* encompasses the two first decades of life (Tanner, 1986; Bogin, 1998)[4]. A positive balance between inputs (mainly coming from the quantity and quality of food intake) and outputs (energy expenditure derived from diverse factors such us the basal metabolism, prolonged physical effort and exposure to illness) favors a normal development of growth (i.e. one attains the stature that is genetically inherited). Oppositely, environmental stress (e.g. a deficient nutrition or structural exposure to illness) may alter the normal cycle of growth as well as some definitive loses of height (i.e. with respect to that inherited) when adulthood is reached.

In Spain, a number of studies have displayed a regional gradient of height among recruits at different moments in the 19th and the 20th centuries (Gómez-Mendoza and Pérez-Moreda, 1987; Martínez-Carrión, 2005; Gónzalez-Portilla, 2001; Quiroga, 1998). However, no previous study to our knowledge has coped with regional differences in height by systematically joining cohort and spatial perspectives. This will be done in this paper for those cohorts born during the central decades of the 20th century, a period that witnessed the most intense process of economic and demographic changes in the contemporary history of Spain. Also, in this work it is presented an unprecedented anthropometric analysis that includes not only height but also weight and chest circumference in order to go in depth with the regional anthropometric patterns and

[4] There are to post-natal critical periods for growth which are very sensible to environmental stressors (either episodes or contexts). 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).

trends of robustness among Spaniards born between 1934 and 1973. The relationship between those anthropometric patterns and trends with two traditional wellbeing indicators (*per capita* GDP and infant mortality rate) will be also analyzed.

3. Data

Anthropometric time-cohort series and anthropometric cartography are presented that are based on aggregated military statistics so that they are restricted to males. These statistics are summaries from the individual records of the recruits enlisted (whether they finally were enrolled or rejected in the army) by the compulsory military service in Spain[5]. This information is included in diverse sections of the Spanish Statistic Yearbooks and consists on relative distributions of three anthropometric measures (stature in centimeters, weight in kilograms and chest circumference in centimeters[6]). This information is provided in 5-unit intervals both for the country and for regional areas[7] (Table 1).

The yearbooks are published in Spain since the middle of the 19th Century but relatively few are valid for our purposes and the military statistics were dropped at the middle of the 1990s when the military service became no longer compulsory in Spain (the last Yearbook containing this type of information is that of 1996, enlistment of 1995; i.e. males born in 1974). In function of the cut off enlistment and the age at enlistment, the Yearbooks provide anthropometric information of male cohorts born between 1934 and 1974 which is the time span covered in this work[8].

The format of the data remain quite constant but its representativeness decreased since the beginning of the 1990s as the percentage of young males that opted for alternative social services instead of the military service increased. These people were not

[5] More on the Spanish military anthropometric sources in Martínez Carrión (2001) and Cámara (2006).
[6] Chest circumsference have been assumed to be at rest but this is not specified in the source.
[7] The anthropometric data are not always available in a valid format to construct series. Some yearbooks only provide the percentage of recruits that were excluded due to shortness. The yearbooks that contain the required information for our purposes are 1859 (enlistments 1858 and 1859), 1915-1929 (only height) and from 1958 onwards (1958 contains the enlistments 1955-58) until the military service was cancelled in Spain. We have opted to not expand our analysis back into the 19th century because serious caveats have been detected at the regional level that might even invalidate some results from previous studies (González Portilla, 2001).
[8] In order to make homogeneous cohort groups the last cohort analized in this work is 1973.

registered by the military statistics but we tend to think that the statistics did record all recruits (also those who were excluded from the army due to shortness)[9]. In addition, the minimum anthropometric measures required in the 20th century were really low and consequently the percentage of males excluded for this reason was also very low similarly to the proportions within the lower intervals of stature, weight and chest circumference (Figure 1)[10]. This invites to believe that the resulting averages are representative of the whole of the Spanish male population.

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

Enlistments	Age	Coverage	Descriptive	**Height**			**Weight**			**Chest circumference**		
				1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
1992-95		Region	Own estimates	9 (5)	<155	190+	10 (5)	<50	90+	8 (5)	<75	105+
1987-91			Mean and mode	10 (5)	<150							
1964-85				9 (5)		185+	8 (5)		80+	7 (5-6)		>100
1955-63	21			8 (5)		180+	7 (5)		75+			
1925-28		Province (*valid* recruits)*	Own estimates	3 (7)	<163	170+	No information					
1917-1924				3 (5-10)	154							
1915-16				5 (2-5)		>171						
1862-67	20	Country		13 (3)	<147	>180						
1861		Province										
1859				10 (3)	<151	>175						
1858	20			10 (3)	<150							

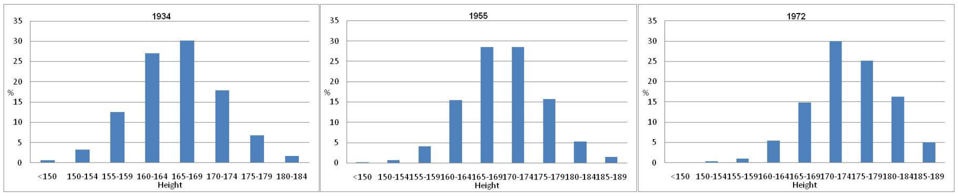
*Only in 1955 the mean and the mode by region are also provided. For the rest of years they have been calculated using the relative distributions originally provided in the source.
1 Number (and length) of intervals; 2 lower limit of the distribution; 3 upper limit of the distribution

[9] The minimum height required was established at 154 cm. in 1912 (Abella, 1915) and subsequents laws did not refered to height in exclusive as a reason of rejection but also to weight and chest circumference and their adequate proportionality.

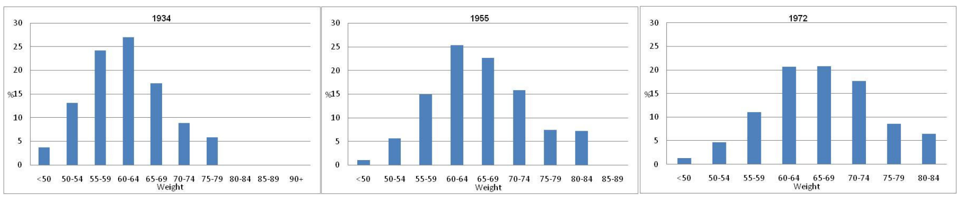
[10] In the case of height the lower interval did not amount to more than 1% for any of the cohorts included in the analysis. In the case of weight, that percentage was 3.7 among those born in 1934 and it decreases among succesive cohorts. Finally, also chest circumference presents very low percentages in the lower interval (around 1%) until the middle of the 1980s (from then on, the percentage is about 3).

Figure 1
Relative frequency distributions
Cohorts 1934, 1955 and 1972

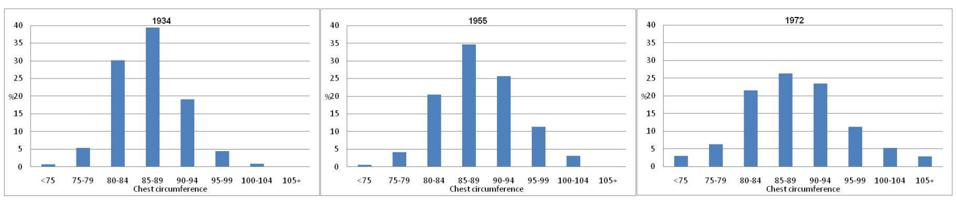
Height



Weight



Chest circumference



Now regarding the geographic criteria, the data are organized by anthropo-demographic zones and regions. Regions are the most disaggregated unit so that they were more convenient for our purposes since they roughly coincide with the current autonomous regions system that bases the administrative structure of Spain (Figure 2). Interestingly, those anthropo-demogrpahic regions were established following anthropological criteria (Hoyos-Sainz, 1942)[11].

[11] Correspondence between the anthropodemographic regions and the current authonomous regions in Spain is as follows: Region *Galaica* (Galicia), Region *Cantabra* (Asturias and Cantabria), Region *Vasca* (Basque Country), Region *Aragonesa-Riojana* (Aragón, La Rioja and Navarra), Region *Castellano-leonesa* (Castilla-León) Region *Catalana* (Catalonia and Balearic Islands), Region *Levantina* (Comunidad Valenciana and Región de Murcia), Region *Extremeño-manchega* (Extremadura and Castilla-La Mancha) and Region *Andaluza* (Andalusia). Hoyos' anthropological criterion results in relatively homogeneuous territories in socioeconomic terms but some exceptions should be mentioned. For instance, the region named *Levantina* includes the current autonomous regions of Valencia and Murcia. Between these two regions, remarkable differences in GDP existed during the analyzed period. Probably, Murcia shared more characteristics with the Southern regions until relatively recent times whereas Valencia, according to both cultural and economic criteria, might have been closer to the Region *Catalan*. The anthropometric zones were too broad and diverse for our purposes and they were discarded as a unit of analysis. For instance, the Northern zone included Asturias, Cantabria, the Basque Country and Navarra.

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

Figure 2
Regional administrative structure of Spain

4. Methods

Both series and cartography are based on weighted averages that are computed from the relative frequencies of height, weight and chest circumference (the central value within each interval was utilized to compute these means). Open intervals have been assumed to be of the same length (i.e. five units). To be noted, the limits of the open intervals varied (Table 1) but this does not substantially affect our results since 1) the changes paralleled the increasing trend of the anthropometric measures and 2) the relative frequencies of these open intervals are always very low as it has already been mentioned. The estimated averages were compared with the averages that are occasionally provided in the Yearbooks both for Spain and its regions. Results hardly differed so that estimates were finally used in order to homogenize the type of information of series and maps. Five-year cohort averages were computed to smooth annual variations as well as the bias caused by the changes of age at enlistment (this is commented later on)[12].

Three indicators are presented: height, Body Mass Index and Robustness Index.

BMI was computed as the mean weight divided by the Square of the mean height[13].

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

The categories commonly accepted for this index are *underweight* (<18.5 kg/m2), *normal weight* (18.5–24.9 kg/m2), *overweight* (25.0–29.9 kg/m2) and *obesity* (>30.0 kg/m2). These categories does not apply in this study since regional BMI does not range enough as it would have been the case among individuals (i.e. we will not find obese

[12] The average of 1970-1974 enlistments (cohorts 1949-53) is a 3yr average (1970, 1973 y 1974). Data from 1971 and 1972 are not used because of the observed abnormal decrease of the anthropometric averages. This may have to do with an incorrect data tabulation or, more likely, with a temporary change of the age at measurement (i.e. at an ealier age). According to the military laws, from 1907 to 1968 the recruits were enlisted and measured at age 21 (this was not the case during the civil war years and the first postwar years (Quiroga, 2001; Cámara, 2007). In subseqüent years, the age at measurement was established at 19 years and it was 18 years in 1987. Likewise, the average of 1955-1959 enlistments (cohorts 1934-1939) is based on three years because regional data are not available in 1956 and 1957.

[13] In this indicator we find two components. One is stature that refers to living conditions in a retrospective manner. The other is weight that is partly related to stature but also related to variations that may occur relatively recently from the time at measurement (this effect, nevertheless, is smoothed when large populations are analyzed).

regions vs. underweighted regions since the BMI of each region is the result of the aggregation of many individuals). Therefore, this indicator is mapped in intervals of 0.5 units[14].

The robustness index (RI, also known as Pignet Index) results from subtracting the weight and the chest circumference to height.

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

The interpretation of this indicator is not as straightforward as it would be desirable. This interpretation may be opposite in function of the context and purpose of the study. Currently, RI is sort of fitness index (high values are indicative of a good fitness). In this work, the interpretation is the opposite whereby relatively low values are indicative of a high robustness as it is established in the original classification by military authorities: 0-10 (very strong); 11-15 (strong); 16-20 (good); 21-25 (intermediate); 26-30 (weak); 31-35 (very weak); +35 (pathologic problems)[15]. Similarly to BMI these categories do not apply here so that we opted to map the results in 2-unit intervals[16]. Interestingly, it will be found that relatively tall populations present relatively low values of robustness as a result of very low proportional values of weight and chest circumference.

Data on *per capita* GDP and infant mortality that supplement our results come from previous works (the relative *per capita* GDP comes from Carreras et al., 2005 and infant mortality rates come from Gómez-Redondo, 1991). The latter required some adaptation to our anthropodemographic regions. We did this on the basis of the rates of the provinces computed by Gómez-Redondo. We weighted those rates to obtain a regional infant mortality rate. The weighting factor that was utilized was based on the live births recorded in each province belonging to a given anthropo-demographic region.

[14] This lenght is enough to capture significant mean variations in BMI between cohort groups as well as to capture regional differences since, for instance, keeping weight constant at 60 kg., a 2 cm. change in height (e.g. from 1.66 to 1.68) makes BMI to decrease from 21.77 to 21.25.

[15] Translation from Spanish into English is literal. The source refers to *strength* in some categories and to *robustness* in some others.

[16] Keeping weight and chest circumference constant at 60 kg. and 80 cm. respectively, a 2 cm. change in stature (from 1.66 to 1.68) implies RI to increase from 26 to 28.

Data on births was obtained from the historical series of the natural movement of the population (MNP) provided by the National Institute of Statistics (INE; available online).

Finally, birth cohorts were computed in function of the year and age at enlistment which results in a covering of 40 cohorts (born 1934-1973). These cohorts are representative of diverse life-cycle experiences: from those who grew up in conditions of scarcity and deprivation to those that entirely grew up during the consolidation of the welfare state (i.e. from the transition to democracy during the last third of the 20th century).

5. Results

In about for decades, from cohorts born in the 1930s to those born in the 1970s (less than two real generations) the average stature of Spanish males increased 9 cm. (from 166 cm among those born in 1934 to 175 cm among those born in 1973) (Table 2). This means an increase of about 2 cm per decade thus higher than the increased observed in any other Western European country among the same cohorts[17].

The average weight increased from 62 kg to 69.4 kg and the average chest circumference progressed from 87 to 89 cm. The average BMI remained quite stable about 22.5 kg/m2 whereas robustness decreased (i.e. RI increased from 16.6 to 18 units) as a result of a strong and proportionally higher height increase.

Altogether, these trends indicate a noticeable improvement in the net nutritional status of the Spanish (male) population. Two aspects deserve special attention: 1) the convergence observed between regions and 2) the persistent spatial pattern.

Regarding the former aspect, a progressive homogenization of the anthropometric map of Spain is observed among cohorts 1934-73. For instance, height differences between the tallest (Basque) and the shortest (Andalusian) among older cohorts were of 4 cm. These differences more than halved among cohorts born at the beginning of the 1970s (less than 2 cm. between the tallest –region *Aragonesa-riojana*—and the shortest at that time –Galicia--) (Table 3 and Figure 2). Therefore, short regions grew more than tall regions during the central decades of the 20th century.

A similar process is observed for BMI and RI. These converged across regions although this process was paralleled by a decreasing trend within the overall country (inter-cohort variations in weight were generally upwards but they were proportionally lower than those observed in height). Illustratively, the average weight among cohorts born 1934-38 ranged from 60.5 kg (Andalusian) and 67.0 kg (Basque) whereas among those born 1969-73 it ranged from 68.8 kg (Catalan) and 70 kg (region *Aragonesa-riojana*).

[17] This rapid increase in height over the second half of the 20th century was also observed in other Southern European countries but the increment in Spain was the highest by far. For instance, during 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).

Table 3
Average height in Spain and its regions
Cohorts born 1934-73

	1934-38		1939-43		1944-48		1949-53		1954-58		1959-63		1964-68		1969-73	
AND	165.34	11	166.36	9	167.1	9	168.33	10	169.86	10	171.25	10	172.78	10	174.42	10
ARA-RIO	167.18	6	167.81	6	168.594	6	169.86	6	171.34	6	172.54	5	174.29	5	175.99	1
CAN	168.18	3	168.77	3	169.668	3	170.62	4	171.65	4	172.81	4	174.53	3	175.39	6
CANT	167.43	4	168.35	5	169.162	5	170.07	5	171.39	5	172.18	7	173.93	6	175.12	7
CAT	168.72	2	169.32	2	170.138	2	168.87	3	172.15	3	173.12	3	174.32	4	175.42	5
CyL	165.62	8	166.38	8	167.264	8	171.31	8	170.50	8	171.74	8	173.73	8	175.44	4
EXT-MAN	165.43	10	166.16	10	167.035	10	168.56	9	170.07	9	171.38	9	172.98	9	174.50	8
GAL	165.52	9	165.98	11	166.904	11	168.31	11	169.76	11	171.15	11	172.58	11	174.30	11
LEV	166.97	7	167.51	7	168.254	7	169.77	7	171.12	7	172.31	6	173.86	7	174.49	9
MAD	167.39	5	168.62	4	169.629	4	171.31	2	172.39	2	173.47	1	174.57	2	175.94	2
PV	169.64	1	170.20	1	170.961	1	171.72	1	172.55	1	173.46	2	174.58	1	175.90	3
SPAIN	**166.35**		**167.18**		**168.05**		**169.43**		**170.89**		**172.18**		**173.85**		**174.96**	

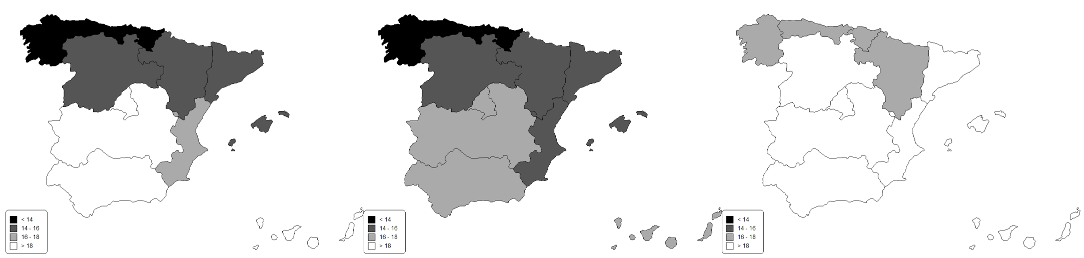
Figure 2
Anthropometric cartography of Spain
Male cohorts 1934-73[18]

Height

1934-38 (Spain 166.40) | 1954-58 (Spain 170.89) | 1964-68[19] (Spain 173.67)

BMI

RI



[18] We made the full cartography and tracking of 5yr cohort groups (not shown; available at request).
[19] The map corresponding to cohorts born 1969-73 shows all regions in the category 174-176. We have opted to fix the same categories for all the maps on height to display properly both the general increase in height and the homogenization among regions.

The regional trajectories are diverse and they would deserve specific attention but here we will focus on the most significant trends and patterns. In first place, the reduction of anthropometric disparities across regions is already observed among cohorts born during the 1940s. However, this process meaningfully intensified among cohorts born during the 1950s and the 1960s. Among these cohorts it is observed a relative higher growth of Center-Southern regions with respect to North-Eastern regions (Table 4 and Figure 3).

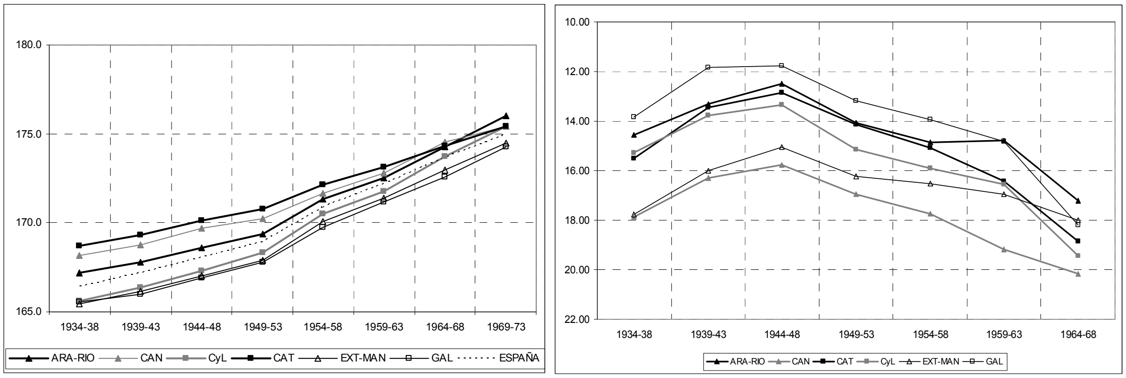
Table 4
Height increases between successive cohort groups
Differences with respect to the national increment and regional rank

	1939-43		**1944-48**		**1949-53**		**1954-58**		**1959-63**		**1964-68**		**1969-73**	
SPAIN	**0.50%**	Rank	**0.52%**	Rank	**0.82%**	Rank	**0.86%**	Rank	**0.76%**	Rank	**0.97%**	Rank	**0.70%**	Rank
AND	0.12	2	-0.08	11	-0.09	7	0.05	2	0.06	1	-0.08	7	0.25	4
ARA-RIO	-0.12	6	-0.05	8	-0.07	6	0.01	4	-0.06	5	0.05	2	0.27	3
CAN	-0.15	8	0.01	4	-0.26	9	-0.26	9	-0.08	7	0.02	4	-0.20	10
CANT	0.05	3	-0.04	6	-0.28	10	-0.09	7	-0.29	11	0.05	3	-0.02	8
CAT	-0.14	7	-0.04	7	-0.13	8	-0.37	10	-0.19	9	-0.28	9	-0.07	9
CyL	-0.04	4	0.02	3	0.16	2	0.09	1	-0.03	4	0.19	1	0.28	2
EXT-MAN	-0.06	5	0.01	5	0.09	3	0.04	3	0.01	3	-0.04	5	0.18	5
GAL	-0.22	11	0.04	2	0.02	5	0.00	5	0.06	2	-0.13	8	0.30	1
LEV	-0.17	10	-0.08	10	0.08	4	-0.06	6	-0.07	6	-0.07	6	-0.34	11
MAD	0.24	1	0.08	1	0.17	1	-0.23	8	-0.13	8	-0.34	11	0.09	6
PV	-0.17	9	-0.07	9	-0.38	11	-0.37	11	-0.23	10	-0.32	10	0.05	7

Note. The first value in columns is the difference in percent points from the national growth rate. This national rate is enlightened in the first row of the table. The second column for each cohort group is the rank within the country

Figure 3
Cohort height (cm) and cohort RI in six Spanish regions

Height **Robustness Index**



The second aspect to be commented is the persistence of a regional pattern despite the above described convergence process. Among cohorts born during the 1930s it is found a North-Eastern arch of tall and robust regions that compares to a group of short and weak Center-Southern regions. Disparities decreased over time, particularly in terms of BMI, but the pattern was still observed in the case of stature and RI among cohorts born at the end of the 1960s.

Some regions such as the Catalan, the Basque, the Canary Islands and Madrid kept their height advantage over the whole analyzed period whereas the South remained a compact and well defined group of regions below the Spanish average. In terms of height only two regions changed significantly their position in the ranking over the course of the 20th century. Castille-Leon began to diverge from the short-averaged regions since the middle of the 1940s and as early as the 1960s this region ranked above the average together with the traditionally tall regions. Oppositely, the region *Levantina* (to the East coast) including the current autonomous regions of Valencia and Murcia lost some positions to rank below the average in the 1970s along with the short regions (Andalusia, Galicia and the region *Extremeño-manchega*). Finally, the progress of the region Aragonesa-riojana is outstanding since it rose to the first position in height and it also ranked among the top five regions in RI among cohorts born during the 1970s.

Next we proceed to analyze these anthropometric patterns and differentials in light of other well-being indicators such us *per capita* GDP and infant mortality. Also these indicators indicate a persistent regional hierarchy. For instance, between 1930 and 1970 the regional GDP ranking displayed few variations whereby Madrid and the North-Eastern regions were at the top and the Southern regions were at the bottom. This economic division is close related to health dimension of well-being as it is illustrated by the data on infant mortality (Table 5). Nevertheless, disparities in infant mortality decreased much more than economic disparities over time. In the 1930s, the difference between the highest and the lowest mortality rate among infants was as high as 80 points whereas this gap was of 16 points at the beginning of the 1970s.

Table 5
Relative per capita GDP (Spain = 100) and infant mortality rate (per thousand)
Values and ranking

	GDP						**m0**					
	1930		**1950**		**1970**		**1930s**		**1950s**		**1970s**	
AND	76.4	9	72.5	9	72.5	10	136.81	9	70.75	6	31.96	8
ARA-RIO	112	4	110.03	5	108.9	4	120.10	6	73.18	8	27.01	5
CAN	92.1	7	83.2	8	85.2	7	127.16	8	71.45	7	27.28	6
CANT	100.45	5	114.3	4	105.4	5	105.69	3	61.49	4	29.30	7
CAT	148.75	2	138.9	3	133.2	2	82.92	1	52.06	1	22.12	1
CyL	89.7	8	92.6	6	83.5	8	163.09	11	94.48	11	33.85	9
EXT-MAN	66.55	11	66.9	11	64.8	11	161.24	10	85.43	10	35.32	10
GAL	74.7	10	72.1	10	78.8	9	116.63	5	79.27	9	38.32	11
LEV	92.4	6	89.95	7	91.75	6	106.58	4	58.22	3	26.34	4
MAD	145.7	3	148.3	2	132.9	3	124.37	7	65.53	5	25.24	2
PV	161.2	1	181.6	1	142	1	91.23	2	52.81	2	26.26	3

GDP comes from Carreras et al. (2005: 1372-73); infant mortality data are own calculations base don the corrected rates by province in Gómez Redondo (1992).

Short-averaged regions also display relatively low wealth levels and relatively high infant mortality rates. In turn tall regions are not all among the better-off. The Basque Country and the Catalan region are among the wealthiest but the Canary Island was among the poorest. Tall regions also range broadly in infant mortality (during the 1930s, m0 in the Canary Islands and Madrid was above 120 per thousand whereas it was of 91 and 82 in the Basque Country and the Catalan region respectively). The Canary region is the paradigm of these discrepancies between economic, health-related and anthropometric indicators. This is a poor region with high rates of infant mortality and high mean statures together with low robustness reflected by high values of the RI.

In terms of robustness, we find a more uniform map although some discrepancies with GDP per capita are again observed. The geographical pattern of robustness in Spain can be summarized in a robust North-Eastern arch (presumably well-nourished which also includes relatively short regions such us Galicia and Castille-Leon during a good part of the analyzed period) and a less robust Spain made of Center-Southern regions (presumably poorly nourished) that includes Madrid. Madrid, an urban region located in the center of the country, displayed relatively high statures and GDP but very low values of RI and high infant mortality levels during the central decades of the 20th Century.

6. Discussion and conclusions

The improvement of anthropometric indicators among the Spanish cohorts born during the central decades of the 20th century was extraordinary and contributed to the convergence with the most developed Western European countries. This improvement was paralleled by a convergence between tall-robust (well-nourished) and short-weak (poorly nourished) regions which was mainly observed among the cohorts born between 1950 and 1960. This convergence was of a similar magnitude for other bio-sanitary indicators such us infant mortality and, in any case, more outstanding that that observed in economic terms as indicated by the relative *per capita* GDP. For instance, the difference between the wealthiest and the poorest region as measured by the relative *per capita* GDP shifted from 94 points in 1930 to 77 points in 1970 (an 18 percent reduction). Still in 1990 that difference was of 67 points. This compares with a 50 percent reduction in height differences between those born in 1934 and those born in 1973.

To be noted, regional disparities in height must not be associated to any conjuncture (e.g. the civil war and immediate postwar decade) but they probably originated in precedent decades. Previous works point that the aforementioned regional ranking in male height originated during the second half of the 19th Century and consolidated during the first decades of the 20th century. From a national sample of individual military records a similar regional pattern was observed among cohorts born 1875-1934 (Quiroga, 1998 and 2001). Over that cohort-span, the ranking in height was almost invariably headed by the Basque Country, Catalonia and the Canary Islands.

Furthermore, the rest of positions remained very stable over the period with few exceptions (e.g. Andalusian born during the last third of the 19th Century were on an intermediate position so that cohorts born during the first decades of the 20th Century relatively shrank and set the region among the shortest).

The range of the differences in height is another point that deserves attention. That range was estimated to be above 6 cm. by Quiroga which is quite higher than that resulting from the comparison of local series from diverse regions among male cohorts born during the second half of the 19th century (Cámara and García-Román, 2010[20]). In turn, Quiroga's estimates are close to the differences observed among the youth of the 1924 enlistment (born at the beginning of the 20th century) which were about 4.5 cm between the Basque (the tallest) and Galician and those from La Rioja (the shortest at that time). These figures are also close to what has been observed in this work among male cohorts born during the 1930s. This evidence invites one to think that, after a process of divergence in height occurred during the second half of the 19th century, differences leveled off during the first decades of the 20th century. In subsequent decades, a convergence process would have taken place that was particularly intense among cohorts born since the 1950s. All this happened in the framework of a persistent regional pattern that was characterized by several aspects. In terms of stature, 3 out of the 4 regions at the bottom during the 1930s were still in those positions among cohorts born during the 1970s (it must be noted that those cohorts grew during the 1980s and the 1990s).

Our results display that, with the exception of the central region of Madrid, wealth was negatively correlated with infant mortality in 20th century Spain. Madrid, a markedly urban region was probably affected by an urban-penalty effect in this sense until improved sanitary and hygiene implementations 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 a lower infant mortality rate.

Broadly speaking, a high correlation among economic disparities and anthropometric disparities has also been found. Nevertheless, some remarkable exceptions must be pointed out that question the universal validity of height as a proxy of

[20] Local series do not totally cover the national territory (for instance we lack of long-term series for the Basque Country where the military service was not compulsory until the 20th century).

some dimensions of well-being. Tall but skinny regions together with short but robust regions are found in Spain. The latter may be indicative of a relatively good feeding but also indicative of some other disruptors of the net nutritional status.

In our view, composed indexes such us RI and BMI are a more reliable approximation to the nutritional status of the population. The results provided by these indexes partly modify the anthropometric geography resulting exclusively from statures. According to this revised cartography the anthropometric pattern in Spain was defined in a dichotomous manner until the decade (i.e. cohorts) of the 1960s.

On one hand, we find the robust Spain (presumably well-nourished and composed by the North-Eastern regions, from the current Asturias to Valencia). This geography of the robustness in Spain was to some extend independent from the economic and height geography. Among Northern Spaniards both relatively tall (e.g. Basque) and relatively short populations (i.e. Galician and Castille-Leon initially) are found but all of them were more robust than Southern Spaniards and people from Canary Islands on average. From this perspective, some regions like Galicia and Castille-Leon were not as disadvantaged as it was assessed by the anthropometric indicator of stature. In turn, such disadvantage is always confirmed in the case of Southern regions. The higher robustness in the North is probably associated to a better provision of high protein and caloric foodstuffs such as meat and milk the access to which was not straightforward in the South until relatively recent times.

On the other (and all the anthropometric indicators coincide): Andalusia and the region *Extremeño-manchega* were the most pauperized regions of Spain in nutritional terms during a good part of the 20th Century. The Canary Islands are a special case. The presumably environmental advantage that was attributed to this region from the height approach must be revised in light of the outcomes that we present in this study. Canary Islands' males born 1934-73 were pretty tall but little robust which invites one to think in ethnic components rather than environmental specificities regarding height. Actually infant mortality, contrary to the Balearic Islands, was among the highest of Spain at the beginning of the 20th Century. This means that tallness might hardly be related to a lower morbidity exposure during the critical periods of physical growth.

The homogenization of the anthropometric map in Spain must be analyzed in terms of both, inputs and outputs of the net nutritional status. Spanish cohorts born during the second half of the 20th century entirely grew up in a context of food security. Spain overcame structural scarcity during the 1950s and this was followed by a diversification of foodstuffs during the 1960s and the 1970s to complete the so called nutritional transition (Cussó, 2005). In terms of outputs, hygiene measures and sanitary provisions were substantially improved and this accelerated the central stage of the health transition process that was completed in the decade of the 1980s (Spijker et al., 2011). These improvements are linked to the Spanish economic take-off since the decade of 1960s but, remarkably, the poorest and worse nourished regions took more advantage if the progress is measured by the biological indicators (i.e. anthropometrics and infant mortality which displayed a very important relative disadvantage with respect to the wealthy regions). This is particularly worth mentioning taking into account the absence of specific policies aiming to correct territorial disparities within the country (those policies were not effectively implemented until the arrival of democracy in the late 1970s (García-Ballesteros, 1990).

In other words, the convergent in biological living standards between the Spanish regions took place in a context of strong economic growth but also in a context of important regional disparities in terms of wealth as well as of a noticeable unbalance in terms of demographic flows. This is a last aspect that deserves some comments due to the potential bias that it may cause in our results (on height in particular).

Our results show that anthropometric indicators are good approximations to the impact of economic processes on some dimensions of human well-being. For instance, it has been shown that the tallest regions were commonly associated with high *per capita* GPD levels. The point is that some of these regions (the Basque Country, Catalonia or Madrid) were also the main destinations of the internal migration and this was very intense in Spain during the 1950s and 1960s (thus presumably featured by people born between the 1920s and the 1940s). Thus the anthropometric disparities across regions could be explained not only by environmental (broadly understood) disparities but also by these flows (i.e. anthropometric differentials might have been amplified if it is admitted that migration is selective and, therefore, people who move tend to be taller and/or stronger than those who stayed). In that case, the effect would be one of height lose in the region of origin although the effect in the region of destination is to some extend uncertain since such effect would depend on the native population's mean height. We believe that both the magnitude of the flow and its potential selective strength might modify some of the observed trends as well as the intensity of the spatial differentials but they should not alter any main conclusion of this study. In fact, we have shown that there is not a perfect correlation between tall/robust/immigrant regions and short/weak/emigrant regions. The relationship is not solid between anthropometric cohort trends and the intensity of the flows either. For instance, Castille-Leon started an outstanding progress in mean height that spanned among cohorts born 1940-70 which means that it occurred between the 1960s and the 1990s. Over this period, migratory flows in that region registered very diverse intensity.

References **(this will be properly fixed in the final version of the paper)**

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