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Variation of the cormic index since the onset of summer school camps in Spain (1887) up to present days

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Running title:
Variation of the cormic index in Spain, 1887-2019

Variation of the cormic index since the onset of summer school camps in Spain (1887) up to present days

Objectives: To assess a secular change in proportion between lower limbs and torso, we analised the evolution of cormic index in schoolchildren attending summer camps organised by the Spanish National Pedagogic Museum between 1887 and 1924, also comparing to later studies up to the present.
Subjects and methods: Unpublished primary data for height and sitting height were collected from 805 individuals of both sexes. Data were pooled in cohorts according to age and year of measurement. Additionally, the analysis included comparison with published data from both national and international populations.
Results: Among males, a noteworthy decrease of the cormic index is perceived from the first to the last camps, while in females this is only seen for the group under 11 years old. With data from published Spanish references (1900 to 2019) a decrease is observed for the male series but is not evident for females. Cormic index values from the camps overlap among the international references, despite the former being from much earlier years.
Conclusion: The cormic index decreased among Spanish male children along the decades.

Keywords: historical anthropometric data; children; summer camp; cormic index; sitting height

Introduction

Body proportion is the name used for referring to the relationship among different parts of human body (Esparza Ros 1993). The cormic index, proposed by Giuffrida-Ruggeri (1916, 1917), is calculated as the ratio between sitting height and total body height, which may also be seen as reflecting the relation between leg length and stature, or the correspondence between length of legs and the sum of head, neck and trunk. Two individuals with the same stature may have different cormic indexes, depending on whether they have short or long legs. This parameter is among the ones most used for clinically detecting growth anomalies, as proved in some publications of reference

curves from schoolchildren, e.g. in China (Zhang and Li 2015) or Turkey (Bundak et al. 2014). However, other research studies have indicated that cormic index is not so adequate to determine linear proportion since, while depending on the sitting height, it is influenced by muscle thickness and gluteal-femoral fat (Ramos Rodríguez 1991; Bogin et al. 2008).

Two elements influence the growth and development of the human beings: genetics and life conditions. Many authors defend the strong influence of environment on the cormic index (Leitch, 1951; Eveleth and Tanner 1991; Frisancho, Guilding and Tanner 2001) while others, like Padez, Varela-Silva and Bogin (2009) in their study on Mozambican adolescents, pose a doubt on such a large environmental influence on leg length. Leg shortening is also associated to some propensity to suffer certain coronary diseases (Davey Smith et al. 2001), hypertension (Langenberg et al. 2003; Marcato et al. 2014), overweight or obesity (Zhang, Chu and Zhao 2016), and other conditions.

The aim of the current study is to analyse the secular evolution of cormic index in Spain since the final years of the 19th century up to the present days. The oldest series, between 1887 and 1924, correspond to summer school camps organised by *Museo Pedagógico Nacional* (MPN, the National Pedagogic Museum), which was founded on 1882 by *La Institución Libre de Enseñanza* (ILE, The Free Educational Institution). This private educational organisation, itself created on 1876 by a group of professors who had been expelled from university on political and ideological motivation, established educational principles like coeducation of both sexes and collaboration between school and family, and in addition actively promoted physical exercise and outdoor activities for children (Felipe Maso 2014).

MPN set up the first Spanish summer school camp in resemblance to others in Europe, under supervision of Manuel B. Cossío, in the summer of 1887. For this camp,

each teacher in public schools in the city of Madrid designated three or four of their pupils who were anaemic but had no infectious disease. The final selection of 18 participants was in charge of doctors Luis Simarro and Rafael Salillas, anthropological study specialists (López Núñez 1908). These Spanish educational initiatives were, year after year, perfectly planned by the MPN. Once participants had been selected, the camp director requested the signature of parents or tutors in order to waive responsibility in the case of any accident or illness. Parents were additionally informed of the address for correspondence, the equipment needed for the stay and even some printed instructions about the way to properly tie up the luggage (booklet by Pintado Arroyo [date unknown]).

In these summer outings, which were cost-free for the large majority of children, anthropological forms were filled in, both at entry and exit from the camp, with immediate physical results of each camper, including height, weight, chest circumference across thelion, and right and left handgrip strength, as indicated in the model in page 15 of the above-mentioned booklet. Other generic anthropological forms were also filled in for each participant (pages 16 and 17 in the same booklet), which thoroughly recorded ancestry, metric data (several measurements of head, thorax, trunk, etc.), physiological data and any abnormalities. Following the trend of MPN, very diverse institutions across the whole Spanish geography organised their own school camps in Madrid, Granada, Barcelona, Balearic Islands, Santiago, Oviedo, León, etc. (Salcedo y Ginestal 1900; Rodríguez Pérez 2004).

Data of trunk measurements used in the present work are unpublished, in other words they originate in primary sources and have been retrieved from the original anthropological forms of schoolchildren attending the MPN camps. Data for the stature, on the other hand, needed to calculate the cormic index, have the same origin but have

already been analysed and reported in published form by our research group (González Montero de Espinosa, López-Ejeda, and Marrodán 2018; Herráez et al. 2019)

Material and Methods

Data source

Data for the current work were retrieved from the archives at *Residencia de Estudiantes* in Madrid, corresponding to the general anthropological forms collected by *Museo Pedagógico Nacional* (MPN) between 1887 and 1924, where information was recorded about ancestry, anatomical and physiological data, any abnormalities, etc. of every participant in the camps. The records include, in addition to age and name, measurements of their standing height and sitting height, as well as many other parameters not relevant here. For the current analysis we have used both heights taken at the moment of entry in the camp.

These data are primary, from the records of the MPN, and they have never been published in a processed form. They include the whole set of summer camps organised by MPN (from 1887 to 1924).

Description of the sample population

The whole sample consists of 805 individuals: 480 males and 325 females, all originating from public schools in Madrid. When summer school camps were started the aim was to deal with 9 to 13 year old schoolchildren, but later on they were extended in practice to a wider age range, including from 6 to 16 year olds.

Although we could access full information pertaining to all MPN camps, which always included body height, only some of them included the measurement of sitting height (as reflected in table 1). Additionally, as can be appreciated in the table, participation of girls in the camps was delayed, starting in 1891.

Table 2 describes in detail composition of the sample, with respect to year, camp, age and gender. Again, it may be perceived how girls joined the camps later than boys, until by 1900 the number of both sexes started to be similar. Data from 6-year old children have been omitted from this table and from subsequent analyses due to their very low number.

Given the limited number, or even absence, of data for some ages or camp years, we decided to pool them in periods of 6 or 7 consecutive years, here called the cohorts (see table 2). Even in this way, it was impossible to achieve an equivalent number of data in all cohorts, but it was judged unreasonable to expand some cohort to 12 years.

For similar motives, for some analyses data were pooled into two age groups, below and above 11 years of age, separate for each sex. Specifically, this approach was used for calculating bivariate correlations using Kendall's and Spearman's statistical tests. We decided on a cutoff at 11 years since it matches the median of data and corresponds to the onset of prepuberal differentiation.

Other studies in the literature with comparable data

To complement the results obtained from the camps, we aimed to compare with any other studies available, both from Spain as well as from other countries. We decided to omit some sources reporting data from rural populations, since they could be biased and less comparable with the children from the camps, who all came from schools in Madrid capital city. We could only find 3 coetaneous studies in Spain and one in other countries which included sitting height measurements. Therefore we extended the analysis to the whole time span between the camps and the current time. This will additionally provide some conclusions about the cormic index in different historical moments and across diverse populations. It must be noted that there is heterogeneity in the completeness of data provided in some studies and particularly in records from the MPN summer camps,

with scarce information on the instruments and procedure for measurements, way to express the age, or socio-economical status of the individuals. Additionally, in most published references only simple average values are reported, with no record of individual data; on the contrary, the MPN records we dealt with include separate data from each schoolchild, and the means were calculated for this article.

We will first describe the essential features of the reference studies (in chronological order) based on Spanish populations. These are also summarized in Table 3.

Martín (Martín Barrales 1902) collected data in 1898 from boys 5 to 15 years old in Granada city. He split this population in two sets: the "A" set were 161 boys from working-class families, while the "B" set were 125 boys from middle class families; no girls were included. Only data from 7 years old and above have been retained here for comparison, comprising 144 boys in the A set and 93 in the B set.

Blanco "A" (Blanco Sánchez 1912) took his measures between 1904 and 1908, with 600 boys from Madrid (nearby the Daoiz neighbourhood), 6 to 13 years old. Only data from 7 years up have been retained here for comparison.

Blanco "B" (Blanco Sánchez 1920) collected data on March and September 1919 from primary schools all over Spain: 453 boys-only schools, 83 girls-only schools and 37 mixed schools. Ages were from 4 to 14 years old. Only data above 7 years old have been retained here for comparison, totalling 9065 males and 2209 females.

Prevosti (Prevosti Pelegrín 1949) reported data measured on 1944-45 in schools at Barcelona, originating from several Spanish regions. Children were split into two groups: group A belonged to low income families and public schools (726 boys and 728 girls), while group B came from private schools and middle class families (751 boys only).

Fernández Cabeza (1952) studied 1040 boys, 11 to 16 years old, from middle class families in Málaga (specifically, belonging to *Frente de Juventudes*), measured between 1943 and 1946, with outliers discarded.

Moreno (Moreno Suárez 1974) collected data from 836 middle class boys between 9 and 16 years old, measured in 1969 in schools in Barcelona.

Fernández Rico (1978) analysed 692 boys in Oviedo with all four grandparents from the area. Measures were taken in 1974-75 at different schools.

Sandín (Sandín Domínguez 1985) studied 1837 boys and 1993 girls, 6 to 15 years old, from schools in Madrid.

Hernández (Hernández et al. 1988) reports growth curves from 1800 children in the greater Bilbao area, from birth to 18 years old, with medium-low social status. They were digitised from the original graphs for treatment in the current article.

Latre (Latre Barluenga 1990) measured 919 male children between 4 and 14 in the province of Huesca, between November 1984 and October 1985.

Rebato (Rebato Ochoa, and González Apraiz 1998) assessed 342 male and 395 female middle-class students from 14 to 16 years old in Bilbao.

Mesa (Mesa, Marrodán Serrano and Fuster Siebert 2002) reports a sample of 730 boys and 748 girls, 6 to 14 years old, collected in 1993 from public schools in the town of Ávila. Their data from rural areas have not been considered in the present paper.

González (González Montero de Espinosa, and Marrodán Serrano 2007) measured 275 boys and 240 girls in both public and private schools in the Madrid province, in 2003-2004.

Arriba (Arriba Muñoz et al. 2013) conducted a study between 1980 and 2002 on schoolchildren from Zaragoza city and province. In this longitudinal study, subjects

were measured yearly on their birthday, since birth up to 18 years old. The sample population started with 165 boys and 167 girls and ended at the age of eighteen with 74 and 93, respectively. Since our study covered only from 6 to 16 years old, the number of individuals was 93 males and 101 females.

EPINUT (EPINUT Research Group, n/d): data from an undergoing project supported by Banco Santander, covering 207 males and 170 females at the moment of writing this manuscript, aged between 6 and 16.

Following are the essential descriptions of subject populations in the international articles used as reference. They are also briefly included in table 3.

Godin (1903) collected a sample population of 100 male individuals, between 13 and 17 years of age, sons of military officers and born within the French territory and colonies, particularly in Algeria.

Malina (1991) recollected data from several previous studies. On the one hand, from mild-to-moderately undernourished Mexican schoolchildren and well-nourished white children from United States, in Malina's unpublished data plus data reported by Hamill, Johnston and Lemeshow (1973) and Malina, Hamill and Lemeshow (1974). On the other hand, data taken in 1957 and 1977 from the Japanese population as reported by Tanner *et al.* (1982). These data were digitised from the original graphs for their treatment in the current article.

Frisancho (1990) combines reports from the U.S. National Health and Nutrition Examination Surveys (NHANES) I and II, with 2606 boys and 2683 girls between 6 and 16 years old. These NHANES surveys covered 1971-74 and 1976-80, respectively.

Lomaglio (1999) measured schoolchildren in suburbs of the capital city of Catamarca (Argentina). Data were taken in 1993 on 483 boys and 385 girls, aged 6 to 12. They were mainly offspring of low social extraction.

Zivicnjak et al. (2003) surveyed on 1997 data from 2038 males and 2045 females, 6 to 16 years old, from different parts of the town of Zagreb (Croatia) representing various socio-economic conditions.

Tanaka et al. (2004) worked with data from the Statistical Report on School Health and Hygiene covering the whole Japanese population of schoolchildren in 2000. The sample size for each gender and age group was more than 20 thousand. The original graphs were digitised for their use in the current article.

Fredriks et al. (2005) collected data on 1996 and 1997 from children of Dutch origin, under 21 years old, with a total population of 7482 boys and 7018 girls (number in the 6 to 16 age range is unspecified). Data were here digitised from the original graphs.

Bundak et al. (2014) studied Turkish children in different districts of Istanbul, totalling 1100 boys and 1020 girls aged between 6 and 18. Some children were measured just once while there was a follow-up for others, during diverse periods of time.

Ramoshaba et al. (2017) measured 846 boys and 819 girls, aged 6 to 13 years, among private schools in Polokwane (South Africa). They were mostly black, while only 0.2% were white.

Data treatment

Data for total height and sitting height were manually transcribed from the records of the summer camps to spreadsheets (using both Microsoft Excel and IBM SPSS Statistics), where they were sorted by sex, age and year. The cormic index was calculated for each individual and then the mean values were calculated for each group.

From published references, data were extracted either from tables or digitised from the graphs (using UN-SCAN-IT gel 7.1, Silk Scientific Corp.). When the articles

included values of average cormic index, these were used. In their absence, the quoted mean values of standing height and sitting height were used to calculate an "average" cormic index for each group.

When the trends displayed by the mean values for each group did not provide a clearly observable tendency, linear regression was calculated to provide an overall measure of the behaviour.

For assessing the significance of secular changes, two non-parametric tests were used: Spearman's rho and Kendall's tau rank correlation coefficients, with two-tailed cut-offs at $p<0.05$ (*) and $p<0.01$ (**), using IBM SPSS Statistics.

Results

Secular evolution of cormic index in the summer camps and coetaneous national references

For the male populations some secular reduction of the cormic index is observed (figure 1), meaning that, along history, growth of the legs is more pronounced than body growth, along the cohorts. This situation is not repeated for females, where a descending trend can only be observed in the subpopulations of 8, 9 and maybe 14 years of age.

For a quantitative approach, the correlation between cormic index and cohorts of camp years was examined, for the two pooled age groups in each sex. Since the variables are not normally distributed, Spearman's (1904) and Kendall's (1938) rank correlation coefficients were calculated (table 4). Among males a significant secular decrease in cormic index is appreciated along the last decade of the 19th century and the first quarter of the 20th century in Spain. The same analysis for females displays a significant decrease in cormic index only for girls under 11 years old.

To ascertain the situation of the camp populations with respect to others of similar age, sex and epoch, we sought published references that had studied other Spanish groups (see table 3 as well as the Material and Methods section).

For boys we found only three records (Martín Barrales 1902, with two subpopulations of different socioeconomical status; Blanco Sánchez in 1912 and in 1920). Both groups studied by Martín display higher cormic index than the campists (figure 1); it is of note that they came from a different geographic area (Granada in Southern Spain versus Madrid for the camps). On the other hand, most boys measured by Blanco in two different studies also show higher cormic indexes than boys from the camps, with the exception of 8 year old children in the 1912 group.

Only one published report was available for Spanish female populations (Blanco Sánchez 1920). No overall difference may be established with respect to campists, what may be attributed at least in part to the reduced number of data available for girls (see table 2).

Secular evolution of cormic index in a century-long range of Spanish references

We additionally approached the comparison of all studies on Spanish populations we could locate, even if they do not match the period of the camps, in order to extract any possible conclusions about secular trends in the Spanish population. Figure 2 presents the results extracted from all those references.

For the male populations there is a clear overall decrement in the cormic index for all ages along the years (an exception for 16 y.o. may be due to less data for that age and the lack of data before 1950, which affects the regression line). This is so across the whole period covered by the published references (1900 to 1919). Once again, it reflects a stronger secular growth in the legs than in the trunk. Such a reduction is, in contrast,

not evident for girls where, depending on the age group, either a slight increment or a decrement is observed. Additionally, the analysis of results is somewhat compromised by the irregular data distribution along the years, with a total absence for some decades, e.g. from 1921 to 1948 and 1953 to 1973 for boys and a range even wider for girls.

In order to confirm this interpretation, a further analysis of such secular evolution was done by calculating the rate of increase of the total body height versus that of the sitting height; this is measured by calculating the rate of variation in the cormic index along the years, for all national references. When the slope of each regression line in figure 2 is plotted for each age group and sex (figure 3), results for males display a nearly constant and negative rate (around −0.018 per year), meaning the cormic index decreases for boys along the decades. The rate of decrease rate is somewhat higher for 6 year old boys and less pronounced above the age of 13.

In contrast, the female population does not display the same effect, but rather the rate of variation in cormic index fluctuates around zero (±0.01 per year, at the most), i.e. there has been no increment or decrease along the epochs, and this is approximately so for all age groups.

Correlation between cormic index and socio-economical status

The selection of children attending the camps was planned to pick those of lower socio-economical extraction, since the expectation was that the camps would improve their physical and nutritional condition. We hence tried to compare the values of cormic index in the camp cohorts to those of published references that specified the conditions of the subjects. Only two such reports could be found. Martín Barrales (1902) segregated his subjects (only males) in two subpopulations: the "A" set from working-class families, the "B" set from middle class families. Prevosti Pelegrín (1949) selected his group "A" among low income families and public schools, and group "B" from

private schools and middle class families. Only group "A" included girls, so we cannot make any comparisons for females.

Data from the camp, grouped in cohorts, display an overall decrease in cormic index with children age (figure 4). Most of the values overlap without significant difference with both in the study by Prevosti, even though this latter was done 30 years later.

Data from the study by Martín do show a difference, both between their two subpopulations and with respect to the camps. The cormic index is noticeable higher for all ages, and even higher in the lowest economy group (figure 4, Martín "A").

Comparative analysis of cormic index among the camps and reference data from different countries

Growth and development of an individual are the final outcome of the interaction between genetic and environmental factors. Body proportions, aside from individual variations that are observed in any population, present additional differences which are presumably of a genetic origin.

The comparative analysis was extended to data from children populations from other countries. Among the reports we could locate, only one was coetaneous with the Spanish summer camps; therefore, we are including all other studies even though they cover more recent years (see table 3 as well as a more detailed description in the Material and Methods section). Since data belong to the various populations from diverse countries, the secular study looses its meaning; hence in this case we decided to compare them in parallel along the children age (figure 5).

There is no evident secular trend manifested by these references. Data from children in the Spanish camps are merged in between the international references, despite being from much previous years when higher values would be expected.

Interestingly, this might be, at least partially, a compensation of not having yet reached the increment in gluteal-femoral mass typically found since the 1970s (a theory discussed below in more detail which biases the cormic index upwards) and hence affecting the international references but not the camps. They are somewhat more disperse, particularly for girls (note that the main outliers for girls are those in the 1887-1892 cohort, with only two 8 y.o. individuals and one each of 12 and 13 y.o.).

Discussion

Previous studies have analysed the differential growth of the body segments with age, i.e. legs vs. trunk (see e.g. Susanne and Bodzsaŕ 1988, Marrodán et al. 2000). It is generally accepted that the major increment in body height is due to leg growth. This is properly ascertained by calculating the cormic index, or ratio between sitting height and total body height. Additionally, among other factors, it is assumed that since the lower limbs display the most accelerated rate of growth in the infancy they are most sensible to improvements in the social and environmental conditions (Tanner 1966). According to these ideas and the availability of the historical data from summer camps organised by MPN, we approached the analysis of the anthropometric data from these camps, namely the sitting height and total height or stature, measured at entry to the camp. As it has been presented, these boys and girls were chosen in the schools as the less favoured in socioeconomical status and who would most benefit from the care and activity during the summer camps. Therefore, we anticipated some interesting outcomes regarding growth in children populations when examined along the 40-year period of the camps, possibly reflecting the evolution of the population according to known social and economical conditions. It was also our interest to compare with other published studies in the country and, in some extent, to the situation in other countries, despite the limitation imposed by different genetic makeup among geographically distant

populations.

We start by exploring the secular evolution of cormic index in the summer camps. We aimed also to compare to other available studies with children in Spain in a similar epoch; however, we could only locate three such coetaneous national references, and only one of them included girls. Some secular decrement in the cormic index of boys is appreciated (figure 1) for most age groups, and the correlation is significant for the pooled age groups below and above 11 y.o. (table 4). This means that across the years the leg length has increased faster in the population than the trunk. This trend is however not displayed (figure 1) by data from girls, with only the 8, 9 and 14-year old subpopulations displaying some decrease. Accordingly, the correlation is significant only for the pool under 11 years old (table 4). Any interpretation of these trends is conditioned by the uneven distribution of data in each subpopulation, particularly for females (table 2). The number of older girls in the latest cohorts is scarce and higher in the central cohorts. On the other hand, the initial cohorts have very few girls of any age and in the latest cohorts the girls of central ages predominate. This limitation in the number of data may be related to the higher incidence of feminine illiteracy in the end of the 19th and beginning of 20th centuries (Cobo 2015 reports a difference, in percent points, between men and women of 18 in 1887 coming down to 11 in 1930).

Other concerns that may condition any strict interpretation are mentioned next. First, the camps were coincident with the onset of anthropometric techniques applied to an educational scope, so called Pedagogical Anthropometry (Leal 1906) which was one of the leitmotivs for MPN when setting up the Spanish summer camps (Herráez et al. 2019). Second, the anthropological forms were filled with body measurements taken by different persons (the teachers) in each camp and may therefore not be very consistent

across groups. Third, measuring instruments were of course not validated –as they are nowadays– and indeed are rarely described in the reports.

The coetaneous study by Martín Barrales (1902) displayed substantially higher cormic indexes than the camps. This was so for both populations, from working class and middle class families. Since his study was done on children living in Granada, the difference may be related to such geographical origin, in the sense that the southern Spanish region of Andalusia was economically more depressed than Madrid, as evidenced by the higher rate of illiteracy (Liébana Collado 2009), and this could be reflected in a lower leg to trunk ratio.

The other report on Spanish population in years close to the camps is the one by Blanco Sánchez (1912), who measured boys attending a school near the Normal School (teacher training) in Madrid. In all ages with the exception of 8, boys had a somewhat higher cormic index than boys in the camps. We can find no explanation for this difference. Eight years later, the same author performed another study sampling several regions in the country, showing again higher cormic indexes for boys as compared to the MPN camps. For the girls (with 4 times less individuals sampled) the comparison with the camps is not conclusive, since some are above and some below; a similar situation for both populations can hence be concluded.

Given the scarcity of published data in the 1887-1924 period matching the MPN camps object of our study, we extended the comparative analysis to include any national studies from later years. The aim was to extract any possible conclusions about secular trends in the Spanish population. The combined set of data follows a discreet secular decrease of cormic index in the male series, which is absent in the females.

One possible source of this difference might be a higher “female eco-stability” according to which girls would be less sensitive to external factors that modulate the

ontogenic development, or a stronger masculine "environmental sensitivity", meaning that males are more negatively affected by environmental challenges. This was manifested in the work by Díez Navarro et al. (2017) where several evidences are collected from diverse pieces of research, pointing out that males respond much more readily to improvements in nutrition and quality of life in general. Along the same line is the outcome of research conducted by Cámara (2015), who states that male physical growth in unfavourable settings is negatively affected to a greater extent than females' growth.

Another hypothesis that may be posed is that, even though the model of cormic index variation is similar for both sexes, descending progressively during infancy and then rallying since the pubertal spurt that strongly affects the stature, it is shifted between both sexes as the result of the difference age when the height growth spurt takes place (around 12 in girls but 14 in boys, Hauspie 1980). It may be expected that in past populations the pubertal spurt took place later than nowadays, as it happens with the age at menarche, which has been reduced by about two years. In this respect, girls in the camps, with the same chronological age than those from the end of 20th and beginning of 21st centuries, would be at a different biological age and this difference may be biasing the interpretation.

We could find no thorough analysis of the secular evolution of the cormic index in children populations. Few publications report data from comparable populations in two different moments in history (like Japan in 1957 and 1977, reported by Tanner *et al.* 1982) and none, to the best of our knowledge, covers a period in history. That was one reason to extend our analysis from populations in the summer camps organised by MPN to other references in Spanish populations, and even in international populations, in years posterior to those where the camps were set.

Our analysis with data from the camps, the only population that may be comparable along the years, returns a decrease of cormic index of boys, at −0.018 per year over the 1887-1924 period, of similar magnitude for any age below 14 years old (figure 3). This reflects that the sitting height was increasing at a lower rate than the total body height or the torso height. Above the age of 13, the decrease rate became less pronounced for boys, which would mean that the differential growth of the legs was secularly not so marked. However, one should bear in mind that the number of data for these higher ages is reduced. For the 6 year old population the decrease rate in cormic index was more intense, which could reflect a stronger secular change in the differential growth of the legs for this age than for older boys.

The situation for girls was rather different, displaying no significant decrease or increase in cormic index in the same period for the whole range of ages studied, from 6 to 16.

Socio-economical status of the families is one of the factors known to affect body growth of their offspring and, particularly, body proportions. We tried to analyse such a foreseeable correlation with cormic index, focusing on children from the camps, who were selected as unfavoured members of society, in comparison to those studies on Spanish populations where the status was definite and specified.

Data from the camps display the expected overall decrease in cormic index with children age (figure 4) as the legs grow faster than the trunk, and were all well below the respective values found in the coetaneous study by Martín Barrales (1902). This was unexpected, given that Martín had split his subjects into two subpopulations: group “A” from a lower social extraction than group “B”. There is a definitive difference between them, with the higher cormic indexes matching the poorer economy, but both are well above data from the MPN camps. It is worth of consideration that boys reported by

Martín were from Granada in Southern Spain, while the camps received children from Madrid (central Spain and capital city); this might introduce some bias.

On the other hand, when the years under study are sufficiently apart, it was expected that the nutritional status of the population would be improving along the years. The other reference that had lower and higher economy subgroups (Prevosti Pelegrín 1949) showed no evidence of a difference related to status, and both subgroups mostly overlap with data from the MPN camps, with a marginal difference, if any; this is surprising given that Prevosti's study was done 30 years later, when one could anticipate some secular change in body proportions. A possible factor influencing this lack of a difference could be the effects of the Spanish Civil War (1936-39) which could have hampered an improvement in development between the camps and Prevosti.

Aiming to expand the perspective of secular evolution of body proportions, and in view of the limitations, already discussed, offered by data from the MPN camps as well as other Spanish studies, we also included in our analysis public reports of sitting height from other countries at any epoch, calculating from their data the cormic index for each subgroup of children. Even though no strict comparison can be made due to diverse genetic makeup in the different ethnicities and countries, we expected maybe some indirect insight of the possible assimilation or divergence of the children in the camps object of our study with respect to other countries and epochs.

When the whole set of populations is compared (figure 5), there is no evident secular trend and the camps, despite being from much previous years, overlap among the international references. As it has been mentioned, there is little reason for doing a secular analysis among the international populations; instead, what may be observed is the presence of four groups of countries regarding the values of their cormic index: A top group, with high cormic index, i.e. shorter legs, formed by Japanese and Mexican

populations. Then, a middle group from Turkey and Catamarca (Argentina), and a middle-low group with USA (1973), Netherlands and Croatia. Finally, the lowest group from USA (1990) and South Africa, with low value of cormic index and longer legs. The Spanish camps object of the present study are positioned in the middle zone but more disperse.

It is known that there are population variations with respect to body shape which, leaving aside environmental conditions, are linked to purely genetic issues, or of genetic adaptation. This is manifested and discussed in a recent publication by Vispute (2020), where body proportionality is compared among several ethnic groups in India, based on sitting height and leg length, as well as in Bundak et al.'s report (2014), which supports the view that body proportions are influenced by genetic makeup. In contrast, Bogin and Varela-Silva (2010) defend that environment is the stronger force influencing leg length and body proportions. In their former publication nine years before (Bogin et al. 2001) they even quantify to at least 80% the influence of the social and nutritional conditions on the variation of sitting height. However, in a co-authored work on Mozambican adolescents (Padez, Varela-Silva, and Bogin 2009) they assert that the genetic factors may be dominant for regulation of body proportions in that sample, over environmental factors.

Tanner et al. (1982) indicate that the height of Japanese children did not display any significant increase between 1957 and 1977, but nearly the whole secular trend was attributable to changes in leg length. Research by Ashizawa (2002), aiming to determine whether leg length in the Japanese population kept increasing, held that, up to the 1970s, Japanese increased their leg length, but that increment has since lessened relative to increment in height. That decrease in the cormic index is biased, according to Ashizawa, by the accumulation of gluteal-femoral fat which increases the measurement

of sitting height. As a consequence, Japanese body proportions would remain unchanged as long as their genetic makeup does not change.

Many articles strongly emphasise that sitting height is not a very reliable indicator of changes in linear proportion of the body, since it is affected by muscle thickness and gluteal fat (Ramos Rodríguez 1991, Tanaka et al. 2004, Varela-Silva and Bogin 2012). Following this assumption or hypothesis, estimations of the change in leg length may be biased downwards since it is rarely measured directly as subischial length, but it is instead calculated from the sitting height and total body height, or from the cormic index which also derives from those. This is particularly relevant over the last 50 years, since the worldwide onset of the obesity epidemic (as declared by the World Health Organization, 2020)

Following this assumption or hypothesis and given that the cormic index is calculated from the sitting height, its value would be increased as the muscular and fat mass in the gluteal-femoral area are higher. At the same time, it must be taken into account that, according to the World Health Organization (2017), worldwide rates of weight excess (overweight and obesity) have risen five-fold between 1975 and 2016, which would lead to an increment in the cormic index and to the conclusion that children and adolescents have shorter legs than it is real. This has already been highlighted in recent investigations like those of Rodríguez Lopez and Bajo (2019) and Martín Turrero et al. (2019) which indicate higher values of cormic index are linked to higher body mass index (BMI).

Disclosure of interest

The authors report no conflict of interest.

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Availability of data

Research data are not shared.

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Figure legends

Figure 1: Cormic index along cohorts of the summer camps for each age and sex group. The dots represent the mean values from each population, while the lines are the respective linear regressions. Regression is not available for 6 and 16 years old due to lack of enough data. For comparison, data from coetaneous Spanish references are included (those surrounded by vertical boxes): three references were available for males (one of them with two subpopulations, see Materials and Methods section) while only one reference included females. Reference data are positioned according to the year when measurements were taken, rather than to the publication year (quoted in the legend).

Figure 2: Cormic index along the years, for each age and sex group, taken from all published references reporting on Spanish populations. Dots represent the mean values from each population, and lines their linear regression. The area shaded in yellow is that which overlaps with the camps (presented in figure 1), but data from camps are not included here. For those articles that specify the year when measurements were taken, this has been used in preference to the publication year.

Figure 3: Rate of variation in the cormic index along the years (1898 to 2019), for each age and sex group, taken from all published references reporting on Spanish populations. Data are obtained from the slopes of regression lines in figure 2.

Figure 4: Cormic index for each age group in boys from the camps, separated by cohorts, compared to data from those national references which segmented their sample based on socioeconomical status. The symbols represent the mean values from each population, while the lines are their linear regression (solid lines for the camps, dashed lines for the published references). There were no data available for girls that included a segregation by their status. Data in Martín Barrales (1902) were measured in 1898, while those in Prevosti Pelegrín (1949) were taken in 1944-45.

Figure 5: Recollection of international data for cormic index, compared with data from the Spanish camps, as a function of the children age. Dates quoted in the legend are the publication years, but the legends are sorted on the year of data collection. Note that data published by Frisancho (1990) were collected between 1971 and 1980, those in

Lomaglio (1999) are from 1993, data from Fredriks et al. (2005) were measured in 1996-97, those from Zivicnjak et al. (2003) in 1997 and data from Tanaka et al. (2004) are from 2000. FR = France, JP = Japan; US = USA; MX = Mexico; NL = Netherlands; AR = Argentina; HR = Croatia; TK = Turkey; ZA = South Africa.

Variation of the cormic index since the onset of summer school camps in Spain (1887) up to present days

Tables

Table 1. Listing of years with available sitting height data.

1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
+ f		+ f	+ f	+	+ f	+	+	+		+		
1900	**1901**	**1902**	**1903**	**1904**	**1905**	**1906**	**1907**	**1908**	**1909**	**1910**	**1911**	**1912**
+			+			+	+		+	+	+	+
1913	**1914**	**1915**	**1916**	**1917**	**1918**	**1919**	**1920**	**1921**	**1922**	**1923**	**1924**	
+	+	+	+	+	+	+	+	+		+	+	

Abbreviations: +, data available; f: no females in sample

Table 2. Distribution of the sample population, by year, camp, age and sex.

	7		8		9		10		11		12		13		14		15		16		Totals per year			Totals per cohort		
Sex	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f	T	m	f	T
1887			1	0	2	0			6	0	5	0	2	0	1	0	1	0			18	0	18			
1888																					0	0	0			
1889			1	0			5	0	4	0	8	0	3	0	3	0	2	0			26	0	26			
1890					1	0	3	0	6	0	10	0	4	0	1	0	2	0	1	0	28	0	28	128	7	135
1891			0	2	3	1	6	2	4	0	7	1	6	1	2	0					28	7	35			
1892							5	0	4	0	5	0	6	0	6	0	2	0			28	0	28			
1893					1	0	1	3	1	0	1	2	1	2	1	0					6	7	13			
1894	1	0			2	0	2	1	1	1	1	0	4	1	3	4					14	7	21			
1895			1	0			4	0	0	1	1	1			5	1	1	2			12	5	17	45	26	71
1896																					0	0	0			
1897					1	1	2	2	3	2	3	1	3	1	1	0					13	7	20			
1898																					0	0	0			
1899																					0	0	0			
1900	0	2	0	1			3	0	2	2	5	5	2	0	0	1					12	11	23			
1901																					0	0	0	27	21	48
1902																					0	0	0			
1903	2	0	1	2			1	1	3	1	3	3	3	2	2	0	0	1			15	10	25			
1904																					0	0	0			
1905																					0	0	0			
1906			1	1	1	1	2	3	3	2	5	1	1	2	0	1					13	11	24			
1907					1	1			0	1			0	2	0	1	0	1			1	6	7			
1908																					0	0	0	77	73	150
1909	1	0	1	2	2	0	1	1	3	3	3	3	2	0			0	1			13	10	23			
1910	0	1			0	1	2	0	3	3	1	2	1	1	2	0					9	8	17			
1911	3	1	4	3	5	2	8	7	8	10	9	11	4	3	0	1					41	38	79			
1912					3	3	5	1	2	3	1	3	2	3							13	13	26			
1913			0	2			1	1	1	1	0	1									2	5	7			
1914	3	3	4	5	9	8	7	5	6	7	6	6	2	2							37	36	73	100	103	203
1915			1	0	2	1	4	7	3	2	2	0	1	0							13	10	23			
1916	0	1			1	0	0	1	1	3	2	3	0	1							4	9	13			
1917	1	2	10	0	6	7	3	9	5	6	3	5	2	1			1	0			31	30	61			
1918	1	1	2	2	4	0	6	3	4	2	0	3	1	1							18	12	30			
1919					2	0	1	5	1	2	2	2	0	1							6	10	16			
1920			2	1	8	2	5	4	3	5	1	6	2	2	0	1					21	21	42			
1921	1	0	1	3	5	4	2	3	4	1	3	2	1	0							17	13	30	103	95	198
1922																					0	0	0			
1923			0	1	3	1	5	4	1	3	1	2									10	11	21			
1924			1	0	0	6	11	10	9	5	9	7	1	0							31	28	59			
sum	**13**	**11**	**31**	**25**	**62**	**39**	**95**	**73**	**91**	**66**	**97**	**70**	**54**	**26**	**27**	**10**	**9**	**5**	**1**	**0**	**480**	**325**	**805**			

Abbreviations: m: males; f: females; T: total (both sexes)

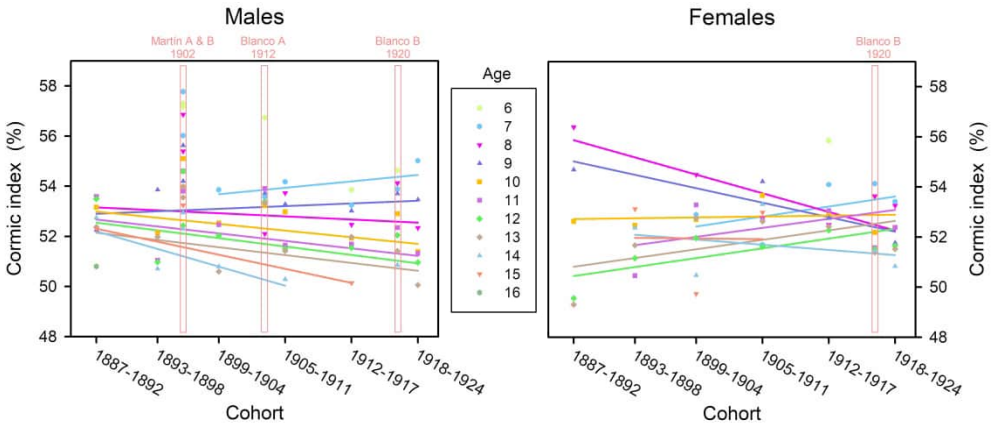
Table 3. Summary of the reference publications used for comparison with data from the Spanish summer camps.

Reference	Date of publication	Designation of sample set	Date of sample collection	Sex	Geographical location	Comments on sample
National						
Martín Barrales	1902	Martín A	1898	males	Granada	working class
		Martín B		males	Granada	middle class
Blanco Sánchez	1912	Blanco A	1904-1908	males	Madrid	
Blanco Sánchez	1920	Blanco B	1919	both	Spain	
Prevosti Pelegrín	1949	Prevosti A	1944-1945	both	Barcelona	working class
		Prevosti B		males	Barcelona	middle class
Fernández Cabeza	1952	F.Cabeza	1943-1946	males	Málaga	middle class
Moreno Suárez	1974	Moreno	1969	males	Barcelona	middle class
Fernández Rico	1978	F.Rico	1974-1975	males	Oviedo	
Sandín Domínguez	1985	Sandín		both	Madrid	
Hernández et al.	1988	Hernández		both	Bilbao area	medium-low class
Latre Barluenga	1990	Latre	1984-1985	males	Huesca province	
Rebato Ochoa & González Apraiz	1998	Rebato		both	Bilbao	middle class
Mesa et al.	2002	Mesa	1993	both	Ávila	
González Montero de E. & Marrodán Serrano	2007	González	2003-2004	both	Madrid province	
Arriba Muñoz et al.	2013	Arriba	1980-2002	both	Zaragoza	
EPINUT	n/d			both		
International						
Godin	1903	Godin FR		males	France, Algeria	
Malina	1991	Malina JP	1957	both	Japan	
		Malina US	1973-1974	both	United States	
		Malina MX	1973-1974	both	Mexico	
		Malina JP	1977	both	Japan	
Frisancho	1990	Frisancho US	1971-1974, 1976-1980	both	United States	
Lomaglio	1999	Lomaglio AR	1993	both	Argentina	working class
Zivicnjak et al.	2003	Zivicnjak HR	1997	both	Croatia	
Tanaka et al.	2004	Tanaka JP	2000	both	Japan	
Fredriks et al.	2005	Fredriks NL	1996-1997	both	Netherlands	
Bundak et al.	2014	Bundak TK		both	Turkey	
Ramoshaba et al.	2017	Ramoshaba ZA		both	South Africa	

Table 4. Correlation between cormic index and camp cohorts.

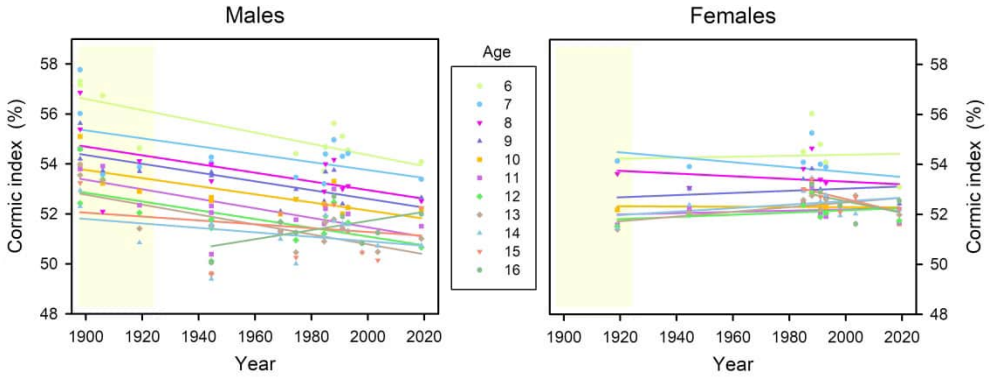
	Males					Females				
Age group	N	Tau_b	p	Rho	p	N	Tau_b	p	Rho	p
< 11	202	−0.128	0.014 (*)	−0.172	0.014 (*)	149	−0.160	0.010 (*)	−0.211	0.010 (**)
≥ 11	279	−0.191	<0.001 (**)	−0.256	<0.001 (**)	176	−0.018	0.748	−0.025	0.744

Cohorts of the summer camps are defined as in figure 1. Bivariate rank correlation was measured with Spearman's rho and Kendall's tau coefficients. The level of significance is tagged as * ($p<0.05$) and ** ($p<0.01$)



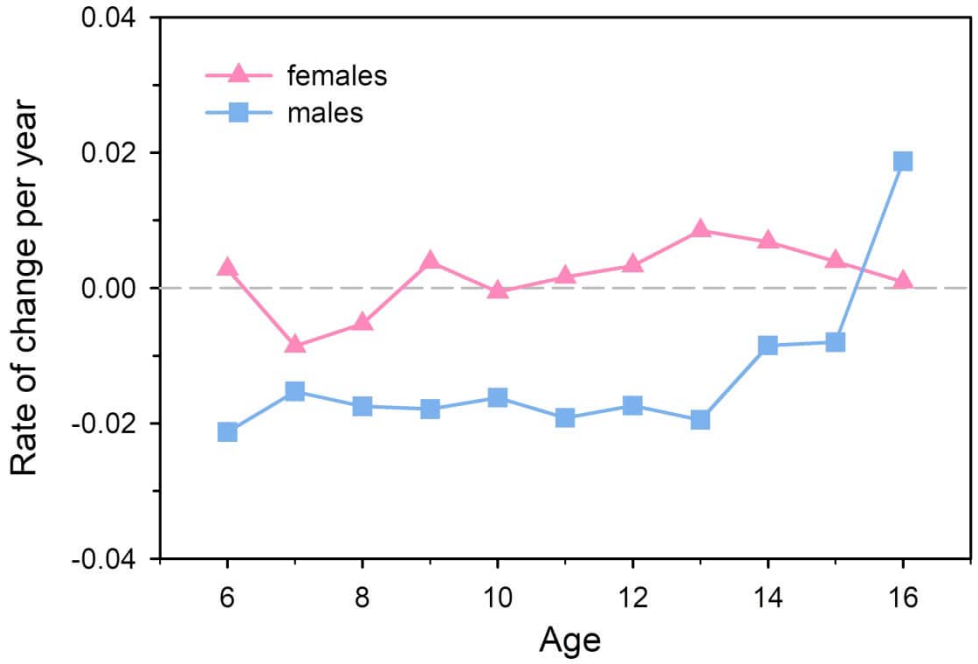
Cormic index along cohorts of the summer camps for each age and sex group. The dots represent the mean values from each population, while the lines are the respective linear regressions. Regression is not available for 6 and 16 years old due to lack of enough data. For comparison, data from coetaneous Spanish references are included (those surrounded by vertical boxes): three references were available for males (one of them with two subpopulations, see Materials and Methods section) while only one reference included females. Reference data are positioned according to the year when measurements were taken, rather than to the publication year (quoted in the legend).

136x57mm (1200 x 1200 DPI)



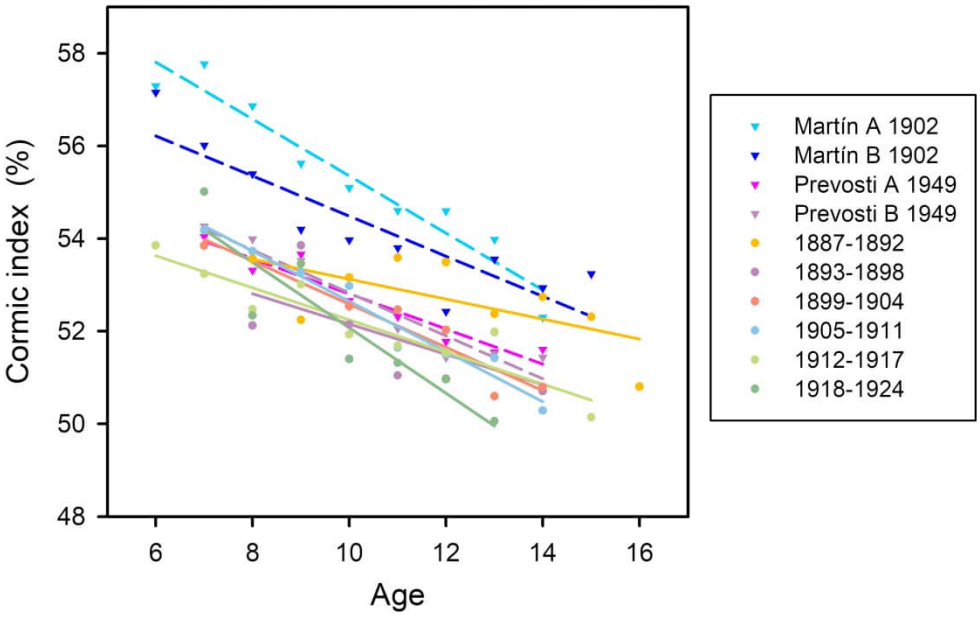
Cormic index along the years, for each age and sex group, taken from all published references reporting on Spanish populations. Dots represent the mean values from each population, and lines their linear regression. The area shaded in yellow is that which overlaps with the camps (presented in figure 1), but data from camps are not included here. For those articles that specify the year when measurements were taken, this has been used in preference to the publication year.

136x51mm (1200 x 1200 DPI)



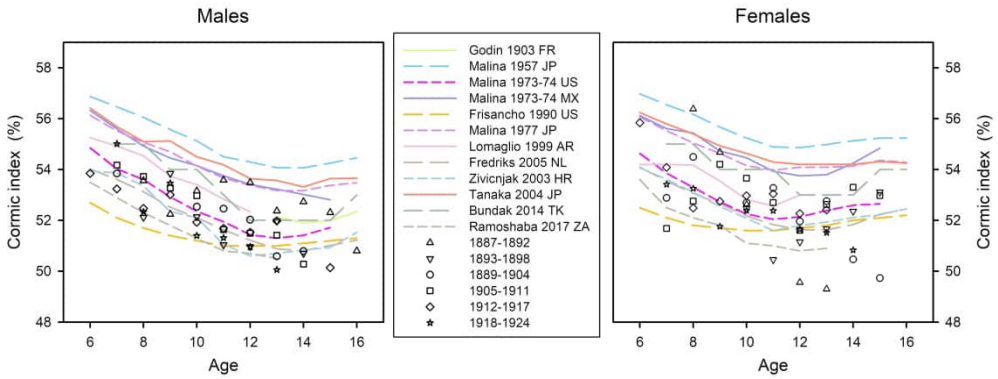
Rate of variation in the cormic index along the years (1898 to 2019), for each age and sex group, taken from all published references reporting on Spanish populations. Data are obtained from the slopes of regression lines in figure 2.

69x48mm (1200 x 1200 DPI)



Cormic index for each age group in boys from the camps, separated by cohorts, compared to data from those national references which segmented their sample based on socioeconomical status. The symbols represent the mean values from each population, while the lines are their linear regression (solid lines for the camps, dashed lines for the published references). There were no data available for girls that included a segregation by their status. Data in Martín Barrales (1902) were measured in 1898, while those in Prevosti Pelegrín (1949) were taken in 1944-45.

86x54mm (1200 x 1200 DPI)



Recollection of international data for cormic index, compared with data from the Spanish camps, as a function of the children age. Dates quoted in the legend are the publication years, but the legends are sorted on the year of data collection. Note that data published by Frisancho (1990) were collected between 1971 and 1980, those in Lomaglio (1999) are from 1993, data from Fredriks et al. (2005) were measured in 1996-97, those from Zivicnjak et al. (2003) in 1997 and data from Tanaka et al. (2004) are from 2000. FR = France, JP = Japan; US = USA; MX = Mexico; NL = Netherlands; AR = Argentina; HR = Croatia; TK = Turkey; ZA = South Africa.

156x58mm (600 x 600 DPI)