

## ORIGINAL RESEARCH ARTICLE



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# Hand grip strength in boys and girls from summer school camps in Spain, 1900–1925. A comparison with 21st century data

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## Abstract

**Objectives:** The Spanish National Pedagogic Museum (*Museo Pedagógico Nacional*, MPN), founded by *La Institución Libre de Enseñanza*, organized the first summer school camps in Spain and their initiative was followed by other institutions in this country. MPN prepared anthropological forms for those sojourns, which included information about both metric and physiological measurements of the schoolchildren. The aim of the current work is to analyze hand grip strength data and to compare them with recent values.

**Methods:** The initial sample included 2418 schoolchildren from 6 to 16 years old (1467 males, 951 females) attending the camps, but after preliminary analyses, the study was restricted to 1073 boys and 818 girls in the 1900–1925 interval. Three time periods were established and 13 categories of height at camp entry, every 5 cm. Normality tests were run as well as contrasts of means, and both average values and percentiles were calculated for hand grip strength in both hands, as a function of age and height categories.

**Results:** The 1900–1925 interval was chosen since there were no significant differences among hand grip data within that period. Results show that children attending the camps had dynamometry values in both hands well below the current ones, both with reference to their height and to their age.

**Conclusions:** Camp attendees displayed very low values of height and hand grip strength in both hands. Both are significantly lower than contemporary values, manifesting a secular effect.

## 1 | INTRODUCTION

Anthropometry, a discipline currently under active development, has its origins in the 19th century. In the last quarter of that century, the earliest initiatives appeared in Spain aiming to apply to infancy and the school

environment the new techniques of study and classification proposed by this science (Ortiz García, 2003). *La Institución Libre de Enseñanza* (ILE, The Free Educational Institution) was the first to implement in our country the so-called school anthropometry, or Paidometry, which united pedagogical and anthropological objectives.

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This institution founded in 1882 the *Museo de Instrucción Pública*, later renamed to *Museo Pedagógico Nacional* (MPN, Public Instruction Museum and National Pedagogic Museum, respectively). This museum was created in the image and likeness of others already existing in Europe.

This institution planned the first school holiday camps, for which schoolchildren were selected among the poorest and most anemic, though suffering no infectious disease (see Herráez et al., 2019 for further details). These camp stays were started in 1887 with just males and became mixed-sex from 1891 onwards. MPN arranged an anthropometric office where an anthropometric form was devised, to be used as part of the mentioned school activities. The form collected information on the child ancestry and anatomical data both descriptive and metric (nutrition, skeleton, muscular development, dentition, skin color, etc., plus stature, trunk length, arms opening, diverse lengths, diameters and perimeters of skull, face, chest, abdomen, hands, and feet). Further data included physiological variables like weight, right and left hand grip, beats per minute, etc., and, finally, any kind of anomalies perceived in the schoolchildren attending the camp (Antropometría escolar, 1906). Some of those measurements were taken, for later comparison, both at the moment of entry to the camp and on leaving it at the end of the stay.

The excellent results achieved by these MPN camps encouraged multiple associations and institutions all over Spain to follow trend. Therefore, summer holiday activities were also organized for schoolchildren by town councils, municipal corporations, provincial governments, child-protecting societies, universities, friends of the country societies, and art-promoting societies. This happened, for example, in Madrid, Barcelona, Granada, Sevilla, León, Oviedo, the Balearic islands, Santiago, and so long and so forth (Rodríguez Pérez, 2004). Following this pathway, in 1894 the corporation of ILE alumni (*Corporación de Antiguos Alumnos de la ILE*, AAILE) decided too to organize their own camps, which were run uninterrupted up to 1936 in their first stage.

As it has been indicated, in the majority of ILE camps, in some among those by AAILE and in others from the rest of Spain the dynamometry of left and right hands were measured, both at entry to and exit from the camp. Measurement of the hand grip strength is an easy and quick test, determines muscular strength in children, and is deemed reliable from 6 years of age onwards (Becker et al., 2015). It is though influenced by several factors, like sex and body mass index (Fernández-García et al., 2019), and there is even some research pointing that the grip strength helps identify malnutrition (De Souza et al., 2014). Furthermore, hand grip strength

also varies with age (Marrodán Serrano et al., 2009) and with body size along growth; this is the basis for the aims of the current work. We pretend to analyze the secular evolution of hand grip strength as a function of both age and body height. To this purpose, dynamometry values in schoolchildren attending the camps (first quarter of the 20th century) were compared to references from contemporary Spanish populations, published by our research group (García López et al., 2017; Marrodán Serrano et al., 2009).

## 2 | MATERIAL AND METHODS

Hand grip strength data used in this research came for the original camp records, most of them located at the library of *Residencia de Estudiantes* in Madrid. To the best of our knowledge, these data have never been disseminated and, particularly, have not been processed and analyzed in any scientific publications before. The raw data are part of the anthropological forms related to the health and anthropometric exploratory examination of school camp attendees. Unfortunately, those anthropometric records did not always include dynamometric data, and hence, despite having access to a much larger number of individual forms, we could only use for the present work 2418 forms, which included this parameter and correspond to 1467 boys and 951 girls, between 6 and 16 years of age. As Table 1 shows, most of the studied camps were promoted by ILE or AAILE and departed from Madrid, but a few are included that left from different parts of the country, like León, Granada, Segovia, Santiago de Compostela and Valencia (specifically from Cabañal).

Dynamometry was ascertained twice, when the children entered the camp and when they left, and this variable was measured by the teachers participating in each camp. It must be noted that they might have lacked rigorous training and, of course, different dynamometers were used in each of the locations. No documents state the procedure for taking these measurements, nor the kind of instrument(s) used, nor which was the dominant hand of each individual measured. In the current study, we chose to take into account only data from camp entry, since it obviously reflects the original status or condition of the schoolchildren.

In order to establish comparisons explained in the previous section, data were pooled into 13 categories for body height, defined at 5 cm intervals, and into three cohorts of camp date, with a span of 13 years each. The first cohort extends from 1887 to 1899, the second from 1900 to 1912 and the third from 1913 to 1925. An initial analysis was performed with individual data (each one with its camp year) which statistically showed that in the

TABLE 1 Sample distribution

Town of origin	Camp ID	Year	N males	N females	Source
Madrid	ILE 1	1887	18		a
Madrid	ILE 3	1889	26		a
Granada	1	1890	9	9	b
Madrid	ILE 4		28		a
Granada	2	1891	9	8	c
Madrid	ILE 5		23	8	a
Granada	3	1892	8	11	d
Madrid	ILE 6		28		a
Granada	4	1893	9	13	e
Madrid	ILE 7		19	10	a
Santiago de Compostela	1		32		f
Granada	5	1894	13	12	e
Madrid	ILE 8		17	7	a
Granada	6	1895	12	12	e
Madrid	ILE 9		19	5	a
Granada	7	1896	13	12	e
León	2		23		g
Madrid	ILE 11	1897	13	7	a
Madrid	AAILE 3	1898	20		h
Madrid	ILE 12		10	8	a
Madrid	AAILE 4	1899	28		i
Madrid	ILE 13		10	8	a
Madrid	AAILE 5	1900	28		j
Madrid	ILE 14		11	11	a
Madrid	ILE 15	1901	12	11	a
Segovia	2		21		k, l
Madrid	ILE 16	1902	16	9	a
Madrid	AAILE 8		25		m
Madrid	ILE 17	1903	15	10	a
Madrid	AAILE 9		24		n
Madrid	ILE 18	1904	11	9	a
Madrid	AAILE 10		29		o
Madrid	ILE 19	1905	15	11	a
Madrid	AAILE 12	1906	32		p
Madrid	ILE 20		14	15	a
Madrid	ILE 21	1907	15	18	a
Valencia (Cabañal)	1		10	10	q
Madrid	ILE 22	1908	14	19	a
Madrid	ILE 23	1909	15	15	r
Madrid	ILE 24	1910	24	17	r
Madrid	AAILE 17	1911	29	14	s
Madrid	AAILE 18		32	14	s
Madrid	AAILE 21	1913	29	21	t

(Continues)



TABLE 1 (Continued)

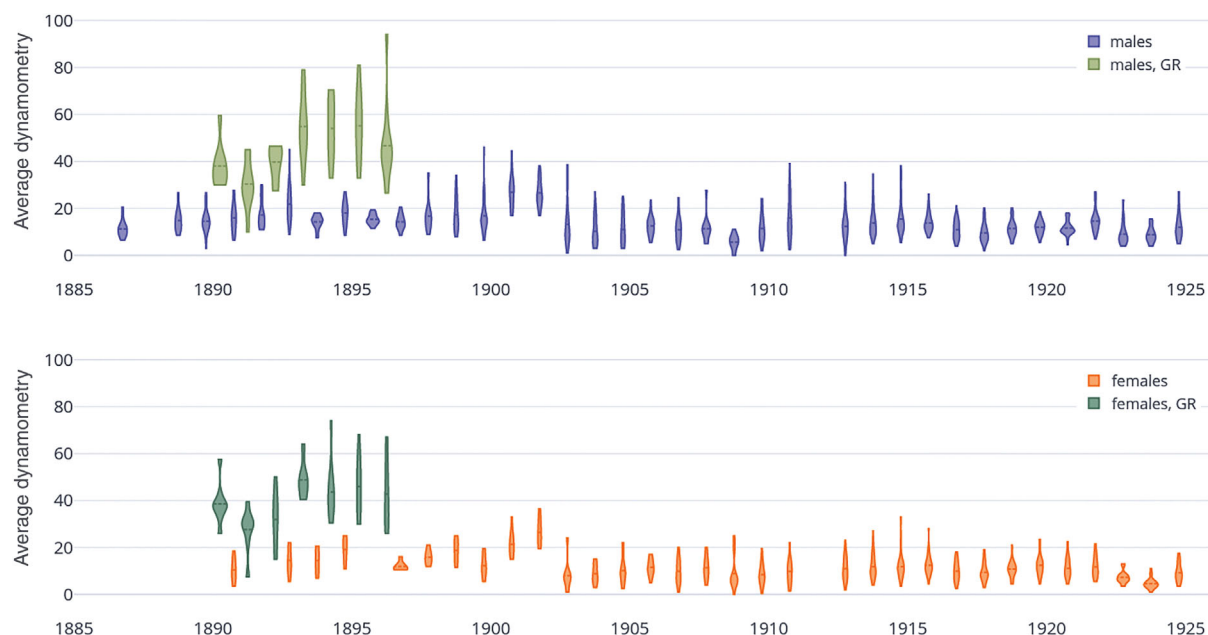
Town of origin	Camp ID	Year	N males	N females	Source
Madrid	AAILE 22	1914	26	21	t
Madrid	AAILE 23		28	22	t
Madrid	AAILE 24		29	19	t
Madrid	ILE 31		28	28	r
Madrid	ILE 32	1915	28	27	r
Madrid	ILE 33		27	28	r
Madrid	ILE 34		29	28	r
Madrid	AAILE 25		24	18	t
Madrid	AAILE 26	1916	21	7	t
Madrid	ILE 35		24	28	r
Madrid	ILE 36		30	30	r
Madrid	ILE 37		25	25	r
Madrid	ILE 38	1917	27	26	r
Madrid	Junta de Damas 1		4	4	u
Madrid	ILE 39		27	24	r
Madrid	ILE 40		24	28	r
Madrid	ILE 41	1919	26	24	r
Madrid	ILE 42		26	24	r
Madrid	ILE 43		21	21	r
Madrid	ILE 44		20	21	r
Madrid	ILE 45	1921	20	21	r
Madrid	ILE 46		23	20	r
Madrid	ILE 47		19	20	r
Madrid	ILE 48		16	12	r
Madrid	ILE 49	1923	12	13	r
Madrid	ILE 50		13	12	r
Madrid	ILE 51		17	13	r
Madrid	ILE 52		14	15	r
Madrid	ILE 53	1925	20	18	v
Madrid	ILE 54		11	20	v
<b>Total</b>			<b>1467</b>	<b>951</b>	

Source: a, CNE (1908); b, Wilhelmi de Dávila (1891); c, Cunillera y Oceti (1892); d, Del Castillo Tejada (1893); e, SCEV (1897); f, SEAPS (1894); g, SCEL (1897); h, AAILE (1898); i, AAILE (1899); j, AAILE (1901); k, Sáez y Romero (1930), pp. 94–100; l, Expedición marítima (1901); m, AAILE (1903); n, AAILE (1904); o, AAILE (1905); p, AAILE (1907); q, Ballester de San Martín (1907); r, MPN (1925); s, AAILE (1912); t, AAILE (1936); u, López Álvarez and García Gómez (1918); v, MPN (1926).

first cohort (Figure 1) children attending the first seven camps in Granada (held between 1890 and 1896) display dynamometry values significantly higher than the rest of the camps in the same cohort period, as well as those in the later two cohorts. The violin plots in that figure show distribution of numeric data for one or more groups using density curves. Width of each curve corresponds to the approximate frequency of data in each region (Yi, 2019). In view of these discrepancies detected in the series from

Granada, we decided to exclude from all further analyses data from those seven camps. As a consequence, the sample was reduced to 2268 schoolchildren (1394 boys and 874 girls).

To achieve the established objectives, we then statistically compared the new Cohort 1 to the other two cohorts; significant differences were verified between such first period and the second and third cohorts. Since these latter two were, in turn, very similar, we decided to



**FIGURE 1** Distribution of dynamometry data, average from both hands (kg) in each camp (measured at entry). Upper panel, males; lower panel, females. Data from camps in Granada are displayed separately (GR, shades of green). The violin plot reflects distribution: width of the profile is proportional to data frequency for that dynamometry value, starts at the minimum value, ends at the maximum one, and includes a horizontal line at the mean value

discard Cohort 1 and combine Cohorts 2 and 3 for comparisons with data from the current century. This definitive data set includes 1901 subjects (1080 males and 821 females) and spans from 1900 to 1925.

For the historical series, we calculated means, medians, standard deviations, percentile distributions, and significance for dynamometric measurements of both hands, in correlation with age and with height categories. To verify any possible differences in dynamometric values among the three cohorts as well as from the contrast with contemporary series, previous Kolmogorov–Smirnov normality tests were run, and later the Kruskal–Wallis test for  $k$  independent samples or Mann–Whitney  $U$  test for just two samples. Statistical analyses were performed using SPSS 24.0.

### 3 | RESULTS

After setting the cohorts and body height categories defined in the previous section, possible changes of dynamometry values (mean of both hands) at camp entry were ascertained in correlation with the camp year. Figure 1 clearly shows that all measurements in individuals attending the camps in Granada are quite higher than those from the rest of cohorts. We hypothesize that this might have happened if measurements in the Granada camps were taken reading the traction force gauge

rather than the compressive force gauge (see the discussion section).

In order to statistically check such differences, Cohort 1 was split into two subgroups, one with measurements in the Granada camps, the other with the remainder camps in the same period. Using the Kolmogorov–Smirnov test, we first confirmed that dynamometric values from both populations are not normally distributed, in both sexes. We then applied Mann–Whitney's  $U$  test, as a function of age, ratifying that both in males and females there are significant differences in most age groups (with  $p < .001$  in some and  $p < .05$  in others). There are some exceptions for the highest and lowest ages where the number of data is scarce in the Granada group. Taking this into account, we chose to remove data taken in the Granada camps from Cohort 1 for all subsequent analyses.

To confront these historical data with contemporary ones, the first approach was to find out whether to use the combination of all camps or else to use only data from one or two cohorts. Once the Kolmogorov–Smirnov test reported that data were not normally distributed, the Kruskal–Wallis test was applied to all three cohorts separately, as a function of age and of height category at camp entry. This proved significant differences between the categories as well as among age groups, for both sexes ( $p < .001$  in some cases and  $p < .05$  in others).

From these results, pairwise differences between cohorts were analyzed and Mann–Whitney's  $U$  test was again applied between Cohorts 2 and 3, always as a function of age and height. This confirmed that in males there are only significant differences between hand grip values from both cohorts in two out of the 14 body height categories and age groups ( $p < .05$  in both cases). In females, however, no significant differences are evident for any height category and the only exception is for the 11 years old group ( $p < .05$ ).

Along with the same approach, the same statistical testing was applied to compare Cohorts 1 and 3. Here, in contrast, significant differences are found in both sexes for the majority of age and height categories ( $p < .001$  in some cases and  $p < .05$  in others). Taking all these calculations into account, we decided to omit Cohort 1 and combine data from Cohorts 2 and 3 for performing dynamometric comparisons between camp schoolchildren (beginning of the 20th century) and more current data (21st century).

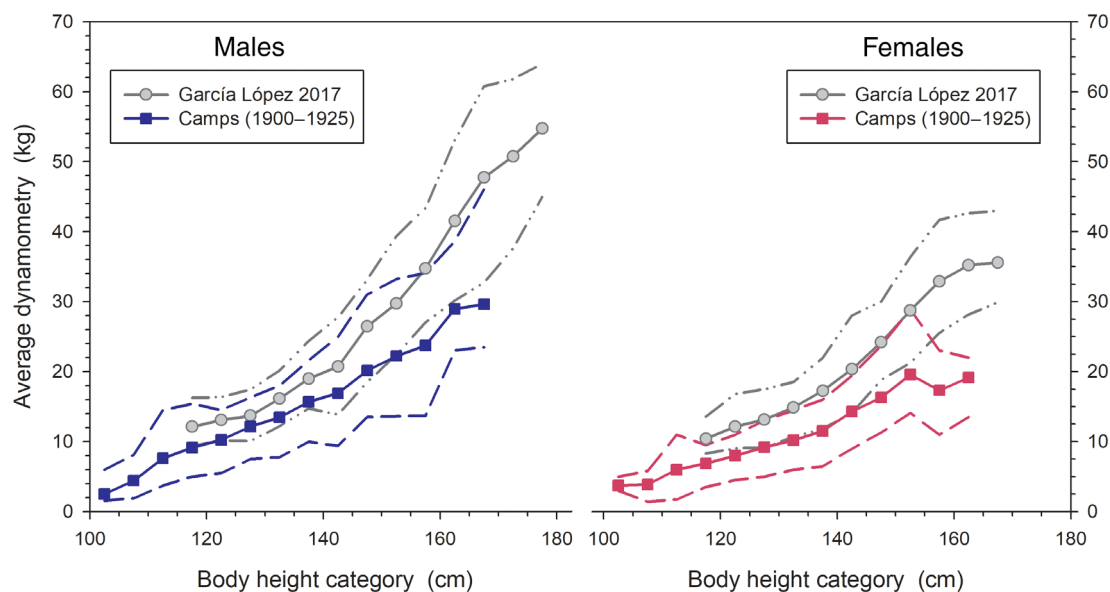
Once the final sample set was selected, by combining Cohorts 2 and 3, a descriptive analysis was addressed with dynamometric values averaged from both hands as measured at camp entry. With respect to the established body height categories, means and percentiles 10 and 90 were calculated for both sexes separately and then compared to data published by García López et al. (2017). Looking at Figure 2, two relevant aspects may be highlighted: first, with respect to body height in itself and second, to the average dynamometry from both hands.

Regarding the first one, it may be appreciated that in both sexes at the camps there are three height categories in the lower end (from 100 to 114.9 cm), which have no individuals in the contemporary sample. The same happens in the upper range, since in the first quarter of the 20th century data are missing from 170 to 170.9 in males and for ranges above 165 in females. This obviously reflects, on the one hand, the short stature of children attending the camps and, on the other, relevant differences between past and modern data.

If we now compare the dynamometry measurements proper (Figure 2), it may be confirmed that the former is rather lower than the latter, as it happens with body height. At the same time, it can be corroborated that differences in mean dynamometry between the camps and more current populations are stronger for girls than for boys and, in turn, increase with the increase in stature.

Secular changes in dynamometry with regards to age are manifested when we compare data obtained in the camps to reference values published by Marrodán Serano et al. (2009). Tables 2 and 3 show how values are significantly lower for schoolchildren from the previous century, in all ages but 6 years old, possibly influenced by the very low number of subjects who could be measured at this age.

It is likewise verified in the tables that hand grip force increases with age, both in camps and in children from the beginning of the 21st century, although in a more evident way for boys than girls. Finally, it is essential to note that the highest increase in hand grip strength differs in



**FIGURE 2** Comparison, as a function of body height categories, of both hands average dynamometry at the entry to camps (1900–1925) against data from the study by García López et al. (2017). Data were pooled into height categories in 5 cm intervals: from 100.0 to 104.9 cm, and so forth. Symbols correspond to mean value, while dashed lines mark the p10 and p90 percentiles



**TABLE 2** Comparison of left hand dynamometry values between the first quarter of the 20th century and the modern sample

Age	Males					Females				
	Camps (1900–1925)		Marrodán Serrano et al. (2009)		<i>p</i>	Camps (1900–1925)		Marrodán Serrano et al. (2009)		<i>p</i>
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
6	9.7	7.2	8.6	2.0	#	4.5	0.7	7.5	1.9	#
7	5.4	3.6	8.8	1.9	***	4.6	1.6	8.8	2.1	***
8	7.1	3.8	10.1	2.8	***	6.2	3.6	9.6	2.5	***
9	8.9	4.5	11.7	3.0	***	7.1	3.5	11.2	2.6	***
10	10.6	4.6	14.0	3.3	***	7.8	3.0	13.0	3.4	***
11	11.4	4.8	17.3	3.0	***	9.3	3.8	16.1	3.8	***
12	13.7	6.0	20.3	5.4	***	10.5	3.6	18.4	4.1	***
13	15.6	6.6	23.4	5.5	***	12.7	4.4	20.5	3.8	***
14	18.2	7.6	30.0	8.1	***	15.3	4.8	21.5	4.1	***
15	24.0	8.7	33.4	7.3	***	17.4	5.9	23.0	4.5	***
16	24.4	8.6	36.4	6.4	**	18.9	5.6	22.7	4.8	#

Abbreviation: SD, standard deviation.

#*p* > .05; \**p* < .05; \*\**p* < .005; \*\*\**p* < .001.**TABLE 3** Comparison of right hand dynamometry values between the first quarter of the 20th century and the modern sample

Age	Males					Females				
	Camps (1900–1925)		Marrodán Serrano et al. (2009)		<i>p</i>	Camps (1900–1925)		Marrodán Serrano et al. (2009)		<i>p</i>
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
6	9.0	5.2	9.0	2.1	#	5.0	0.0	8.0	1.9	#
7	5.9	4.0	9.1	2.1	***	4.7	1.5	8.9	2.1	***
8	8.4	4.2	10.6	2.9	***	7.2	3.8	10.1	2.5	***
9	10.0	4.6	12.0	2.8	***	7.9	3.6	11.4	3.0	***
10	12.2	5.1	15.0	3.2	***	8.7	3.0	13.9	3.2	***
11	13.0	5.1	17.9	3.3	***	10.0	3.8	16.9	3.9	***
12	15.7	6.4	21.7	5.1	***	11.8	3.4	19.3	4.5	***
13	18.0	7.1	24.9	5.7	***	14.3	4.4	21.8	3.8	***
14	20.7	7.6	31.3	6.3	***	16.8	5.7	23.2	4.4	***
15	26.7	9.1	35.1	6.9	***	19.7	6.4	23.6	4.0	***
16	28.0	10.7	37.6	7.3	*	21.1	5.9	24.4	4.8	*

Abbreviation: SD, standard deviation.

#*p* > .05; \**p* < .05; \*\**p* < .005; \*\*\**p* < .001.

both epochs, being in this century between 13 and 14 years of age for boys and 11–12 for girls, while in the past population it happened for boys between 14 and 15 and for girls from 13 to 14 years old.

## 4 | DISCUSSION

We have only considered the dynamometric and body height measurements taken when the children entered

the camps, and not when they finished the stay, since it reflects the original situation of the attendees, more representative of their physical condition before any possible effects of the healthier regime during the stay (Rodríguez Pérez, 2004). Indeed, in former studies, it has already been proved that some parameters at the camp exit were superior (González Montero de Espinosa et al., 2018).

One of the limitations of this work is that the documents we gained access to lack any information of how measures were taken, which type of instruments were

used, or which was the dominant hand of each subject. Additionally, data were collected in different places and by different persons, who had not received previous training. To the contrary, the special relevance of these values relies on them being unpublished, this work meaning the rescue of historical data from Spanish populations encompassing the first quarter of the 20th century. At the same time, it must be highlighted that there are scarce publications with data from that epoch, much less so with information from females. All this makes the current analysis a contribution not only to physical anthropology but also to the history of science.

As we have already hinted, we hypothesize that the elevated values in the mean hand grip dynamometry among the seven camps that took place in Granada might be attributed to measurements having been taken as traction force rather than compressive force. This is not wholly speculative since one of the most used dynamometers then was Régnier's, which bears two graduated scales aimed at measuring both kinds of strength. The suggestion is endorsed by the narration in a PhD thesis (Martín Barrales, 1902) prepared in the same town where those camps were held. The author asserts (p. 19) that when he used the dynamometer he mistakenly registered "the number of kg marked by the most eccentric needle among the two in the quadrant of the dynamometer, which expresses the traction force and not the compressive force."

In relation to confrontation between the hand grip values (mean of both hands) in the camps and more current data (García López et al., 2017) it can also be noted that the age of the 2017 sample spans from 6 to 15, while the range in the camps object of the current work extended from 6 to 16 years old. This leads to a double reflection, one with respect to body height, the other to dynamometric values. Stature is much lower in the campists than in current schoolchildren since values are lower, by 10 cm in the lower edge for both sexes and in the higher limit by 10 or 5 cm, respectively, for males and females. Such low stature has already been described and its secular trend analyzed in former studies (González Montero de Espinosa et al., 2000). Low values are not restricted to body height, but also to other anthropometric variables measured in the same summer camps, as our group has reported before (Herráez et al., 2019; Herráez et al., 2021). A feasible reason for this may be that in the period under analysis, first quarter of the 20th century, there was a profound scarcity in life conditions and a high prevalence of malnutrition among the least favored subpopulations, with a low socioeconomic level (Cámara et al., 2019). This was patent among the scholar population who lived crowded in large cities, in badly ventilated and illuminated lodgings, with frequent

problems like scrofula and rickets. All this may be verified in the notice issued by the national authority, which dictated the objectives and procedures to be followed in these summer school camps (Dirección General de Instrucción Pública was the precursor of the later Ministry of Education; DGIP, 1894).

It must be equally emphasized the low values of dynamometry found among male and female campists, which could be related not only to the already mentioned economical status, but also to the absence of physical exercise, which negatively affects the physical condition of the subjects (López Gallego et al., 2016). This fact was pointed out by authors coetaneous with the camps, who criticized public schools in large towns for not having the minimal conditions of hygiene and lacking a gymnasium, playground, or even a garden (Salcedo y Ginestal, 1900). Another factor that may influence the reduced hand grip is the incidence of malnutrition, either moderate or severe, above 50% (González Montero de Espinosa et al., 2018), which suffered the children attending the camps. Along this line, there are investigations (Secker & Jeejeebhoy, 2007) that demonstrate the correlation between the low physical ability of schoolchildren and inadequate nutrition, a fact that the authors claim had not been proved before.

The divergence between hand grip strength in the past and current studies might be attributed in turn to either a secular trend or the different moment of pubertal growth spurt. Some studies point that there is a correlation between dynamometry and the degree of sexual maturation in both sexes (Bahamonde Pérez et al., 2007). On the other hand, it must not be overlooked that, as it has been already commented, for the historic series there is no record of the protocols used for measuring anthropometric variables, the instruments employed, or the qualification of the persons performing the measurements, while contemporary publications do specify these details.

Finally, it must be noted that even though some international studies exist which analyze the secular evolution of hand grip strength in relation to socioeconomic status, such as one focused among schoolchildren and adolescents in Guatemala (Mansukoski et al., 2020), this kind of precedents are lacking among Spanish populations. In addition to belonging to different population groups and different epochs, the Guatemalan study was longitudinal, while data from our camps were transversal. All this makes any comparison unfeasible. It is however interesting to mention a research done in our country (Moliner-Urdiales et al., 2010), which indicates that young Spaniards displayed lower dynamometric values in 2006 and 2007 than 5 or 6 years earlier. In view of the apparent contradiction with the results arising from the current work, it would be relevant to perform more analyses of this kind.



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## CONFLICT OF INTEREST

The authors declare no conflict of interest with this work.

## AUTHOR CONTRIBUTIONS

**Angel Herráez:** Data curation (equal); formal analysis (equal); methodology (equal); software (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Maria Dolores Marrodán:** Conceptualization (equal); formal analysis (equal); investigation (equal); methodology (equal); resources (equal); supervision (equal); validation (equal); writing – review and editing (equal). **Marisa González-Montero de Espinosa:** Conceptualization (equal); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal).


## DATA AVAILABILITY STATEMENT

Research data are not shared.

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