Height trends in males and females from the island of Crete and its prefectures at the turn of the 20th century

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Abstract
This paper aimed to validate the hypothesis that at the beginning of the 20th century, the island of Crete maintained better living conditions in comparison with the rest of Greece. We analysed trends in adult height in both sexes following two steps. In the first, height was considered by sex and birth cohorts for the island as a whole. In the second, the same approach was applied to study the phenomenon in the four prefectures of the island. Average heights were 155.4±6.2 cm and 168.7±6.4 cm in females and males, respectively, and the trend in time constantly increases in the latter. The distribution of stature in the four prefectures of the island highlighted the significantly taller stature of the males in Chania, compared to the other three. Our findings report higher average statures compared to those of Cretan conscripts born between 1927 and 1945. Our results confirm that the Cretans were wealthier at the turn of the 20th century, before being annexed to Greece. Moreover, they suggest that the taller statures of the males in the prefecture of Chania may reflect protection action of isolation to the introduction of infectious diseases related to trade flows.

KEYWORDS: height trends, Crete prefectures, first half of the 20th century

Introduction
The primary interest of anthropology is to define the relationship between human populations and their environments, which can be done by highlighting long-lasting consequences of geographic and cultural isolation and the effects of different subsistence and/

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or economic regimens. These are derived from the study of the genetic, physiological and cultural mechanisms at the basis of the geographic micro-differentiation of the studied populations. This approach benefits from the simultaneous analysis of many anthropological variables that can present variations in their frequencies among the different groups. In particular, this is the case when utilising anthropometric traits, the most representative of which are stature and weight.

Their changes through generations reflect their eco-sensitivity, thus serving as indicators of a changing environment. In time, the study of height and its intergenerational changes has become of interest in several fields of research, as they are considered useful indicators of population health in epidemiological studies (Batty et al. 2009; Koch 2011; Jordan et al. 2012; Russ et al. 2014; Tyrell et al. 2016). They often constitute the only source for research into the development of living standards in Countries and in periods that lack written sources (Steckel 2001; Hermanussen 2003; Giannecchini & Moggi-Cecchi 2008; Baten et al. 2009; Stock & Migliano 2009; Moradi 2010; Cogneau & Rouanet 2011; Baten & Blum 2014; Akachi & Canning 2015; Danubio et al. 2016, 2017). Interestingly, the analysis of height and its trend in time has also been shown to have implications in sexual and survival success (Jousilahti et al. 2000; Pawlowski et al. 2000; Nettle 2002; Peracchi 2008; Manfredini et al. 2013).

The topic has been widely studied in men in Western countries, and there is a vast literature regarding it. Many biological and environmental causes have been considered to be at the basis of the observed trends, although there is strong evidence indicating a good agreement with the different levels and speed of socio-economic development of each country (NCD Risk Factor Collaboration 2016; Perkins et al. 2016). Regarding the environmental factors, the most relevant ones responsible for changes in living conditions are nutritional increases, both quantitative and qualitative, improvement and diffusion of healthier hygiene, increased incomes, the cultural and educational levels of the parents, and the abolition of child labour. These factors all contributed to the eradication and elimination of infectious diseases and to decreased infant mortality (Komlos 1994; A'Hearn 2003; Danubio et al. 2003; Silventoinen 2003; Komlos & Baten 2004; Steckel 2008).

The studies were recently extended to women's height and its secular changes due to the availability of data from health or national surveys, both for industrialised and developing Countries (Komlos & Kriwy 2002; Garcìa & Quintana-Domeque 2007; Haghdoost et al. 2008; Webb et al. 2008; Moradi 2010; Garenne 2011; Akachi & Canning 2015; Bogin et al. 2017), which made it possible to investigate this issue and to highlight important and interesting results that have since opened new lines of research. In particular, women's height shows a reduced intensity of secular changes compared to those reported in men, and this condition appears widespread, thus indicating that biological factors are involved together with socio-economic and cultural ones (Silventoinen et al. 2001; Silventoinen 2003; Wells 2007, 2012; Mark 2014; Yang et al. 2015; Bogin et al. 2017; Danubio & Masedu 2018).

This paper investigates height trends in an original dataset of males and females from the island of Crete. The data were derived from individual forms pre-typed and handwritten in 1942 by Lidio Cipriani, who recorded the main personal information and

stature, sitting height, and six measures of the head and face. The purpose is to evaluate modes and intensity of changing mean height values in the two sexes in the first half of the 20th century on the island, a period characterised by many different social situations. Crete has been an important crossroads between the Central and Eastern Mediterranean Sea and where important commercial routes developed towards the Middle East, Greece and the rest of the Mediterranean basin, and Egypt for many centuries (Chaniotis 1999; Mafrici 2010). The island has benefited from a climate that favoured the development of agriculture and pastoralism with the relative production of products to be exported, thus ensuring certain widespread prosperity in ancient times (Magoulis & Maniadis 2017). The island has also been characterised by periods of great turbulence in recent centuries before its union with Greece was internationally recognised in 1913. At the beginning of the 20th century, according to Detorakis (1994), the island, due to its productivity, maintained its wealth compared to the rest of Greece. However, during the Second World War, the Cretan population experienced a long period of turbulence, which also continued in the post-war period (Beevor 1991; Kiriakopoulos 1997).

Our data refer to people born at the turn of the 20th century who experienced different social conditions, but who were possibly maintaining their living standards. Therefore, the current study aims to verify such a hypothesis by analysing the phenomenon in both sexes. Moreover, given the peculiar geographic and orogenic characteristics of the island, we studied the phenomenon in the four regional units of it: the prefectures of Lasithi, Heraklion, Rethymno, and Chania (Figure 1). Crete is long, narrow and extremely mountainous with four major mountain groups: the White Mountains to the west, with at least 20 mountain peaks over 2200 metres high; the central part of the island is dominated by Mount Ida (2456 m), the highest of Crete; the Lasithian Mountains in the eastern part of the island with a maximum altitude of 2148 metres and the Mountains of Siteia further to the east with a maximum altitude of 1476 metres. Mountains cover 52% of the Cretan land in contrast with lowlands that cover only 3.6% of the land.

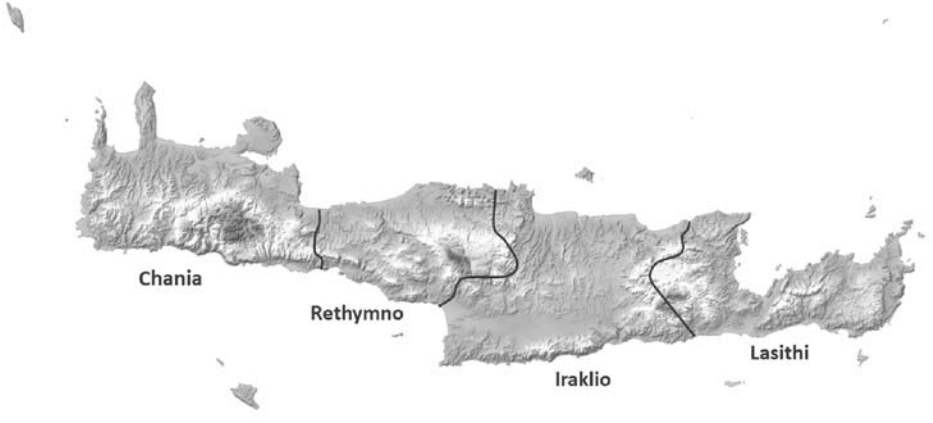

Figure 1: Geographic map of the island of Crete and its four prefectures

Materials and methods

The dataset

The original dataset includes 2475 anthropological forms handwritten by Cipriani, who compiled them in 1942 during his mission to the villages on the island of Crete. The forms are organised in three sections and their accurate description, together with considerations on the reliability of the data, is reported in Danubio et al. (2012). Cipriani recorded only the main personal information and stature, sitting height, and six measures of the head and face., Prof. Moggi-Cecchi, the owner of the individual forms compiled by Lidio Cipriani, asked the Italian Institute of Anthropology to include them in its digital archive containing anthropometric data of individuals of both sexes, which mainly contains data of historical populations measured in the first half of the 20th century by Italian anthropologists. Cipriani's forms were photocopied, and their data were digitised. The original forms are stored in the *Istituto di Antropologia* of the University of Florence and are available for consultation, upon request.

The database comprises 2063 adult males, 264 adult females, 134 subjects who were less than 20 years of age and 14 males aged more than 80 years who were excluded from analyses. Even though the female sample is small, this is the only data on female stature of the island at that time.

To evaluate changes of mean statures and to reduce possible effects of age misreporting, the dataset was analysed by 10-year age classes. The first age group was 20.0-29.9 years (birth cohort 1922-1913), and the last was 60 years and over (birth cohort 1882 and before). Although we are aware of the effects of age-related shrinking that occurs after 40 years of age (Arking 1998; Sorkin et al. 1999; Webb et al. 2008; Malina et al. 2010), we decided not to apply corrective formulas in order to allow comparisons with coeval data reported in the literature which do not use those corrections.

The data were analysed in two steps. In the first, height was considered by sex and birth cohorts for the island as a whole, whereas in the second, according to the birthplace, the same approach was applied to study the phenomenon in the four prefectures.

Statistical analyses

A graphical preliminary explorative data analysis assessed the Gaussian distribution of height both in the males and in the females. The analysis reported sample descriptive statistics. To assess the overall impact on the stature of the population in the considered birth cohorts, a two-way ANOVA was carried out. The same was used to evaluate differences among prefectures and the age groups within them. In the case of significant differences in the ANOVA, pairwise comparisons based on Tukey's HSD were used for post hoc analysis. The analysis was performed using the STATA statistical software (version 14).

Results

Height analysis of the Cretan sample

The mean age of the sample is 38.02±13.16 years in the females and 39.53±15.10 years in the males and the descriptive statistics by sex and birth cohorts are listed in Table 1, whereas results of the contrasts' analysis with Tukey's HSD are listed in Table 2.

Table 1: Descriptive statistics of height (cm) in the Females and Males from the Island of Crete by birth cohorts

Birth cohorts (age class)	Females N	Females mean	Females SD	Males N	Males mean	Males SD
1882 and before (60.0 and over)	29	151.8	5.0	313	166.7	6.1
1892-1883 (50.0 - 59.9)	28	152.1	6.0	240	167.9	6.3
1902-1893 (40.0 - 49.9)	60	156.0	5.6	351	168.4	6.0
1912-1903 (30.0 - 39.9)	67	155.9	6.0	514	169.0	6.4
1922-1913 (20.0 - 29.9)	80	156.9	6.4	645	169.8	6.4
Total	264	155.4	6.2	2063	168.7	6.4

Table 2: Results of contrasts' analysis by means of Tukey's HSD in the females (F) and males (M).

Birth cohorts	1882 and before	1892-1883	1902-1893	1912-1903	1922-1913
1882 and before	-				
	-				
1892-1883	(F) 1.000	-			
	(M) 0.169	-			
1902-1893	(F) 0.015	(F) 0.035	-		
	(M) 0.002	(M) 0.798	-		
1912-1903	(F) 0.015	(F) 0.036	(F) 1.000	-	
	(M) 0.000	(M) 0.110	(M) 0.638	-	
1922-1913	(F) 0.001	(F) 0.002	(F) 0.901	(F) 0.856	-
	(M) 0.000	(M) 0.000	(M) 0.009	(M) 0.236	-

The average value of height in the global dataset is 155.4±6.2 cm in the females. The distribution among age classes shows a threshold separating the two elder groups (birth cohorts 1892 and before) from those aged 20 to 49 years, who were born from 1893 to 1922. The mean values of stature in the first two birth cohorts are approx. 4 cm lower on average compared to the others and, indeed, these values of height differ statistically from those of the remaining three younger groups (Table 2). These significant differences may be due both to small numbers in the elder age classes or may reflect the effect of age

shrinking. However, and regarding the latter, Sorkin et al. (1999) extensively studied the impact of ageing on height shrinking in Western populations and provided formulas that result in a "general" correction of height of 0.75 cm after 40 years in both sexes, and of 2 cm in females aged 60 compared to the height of individuals at 20 years of age. The remaining birth cohorts, referring to women born from 1893 to 1922, show similar values of stature ranging from 155.9±6.0 (30.0-39.9 yrs.) cm and 156.9±6.4 cm in the youngest and the slight differences observed are not statistically significant.

Concerning the males, the average value of height in the global dataset is 168.7±6.4 cm. Mean heights across age classes show an increasing trend from the elder to the youngest birth cohorts, from 166.7±6.1 cm in those aged 60.0 and over to 168.7±6.4 cm in the 20.0-29.9 age class. After pairwise comparisons based on Tukey's HSD (Table 2), the observed differences were found to be statistically significant among the birth cohort of 1882 and before and the three younger ones, and among those aged 20.0-29.9 years (birth cohort 1922-1913) and those aged 40.0 years and over (birth cohorts 1902-1893 and 1892-1883). The final result of the observed trend is a gain of 3.2 cm in 40 and more years.

Height analysis by geographic areas

Mean values of height according to sex in the four prefectures of the island are listed in Table 3. Observed variations of mean values of height in the females were not significant ($p=0.137$), whereas in the males they were statistically significant ($p<0.001$) in Chania compared to all other prefectures.

Table 3: Mean values of height (cm) in both sexes in the four Prefectures of Crete.

Perfectures	Females			Males		
	N	mean	SD	N	mean	SD
Lasithi	92	155.8	6.4	542	168.2	6.2
Heraklion	5	161.5	7.2	368	168.2	6.2
Rethymno	41	154.9	5.9	391	168.2	6.1
Chania	101	155.9	5.4	591	170.1	6.7

Table 4 and Table 5 show the distribution of the trait in the male cohorts in each prefecture and the results of contrast analysis by applying Tukey's HSD, respectively. In the long term, the trend is tending to increase in all prefectures, albeit with short term fluctuations. In particular, mean values of height recorded in the older birth cohort in the Lasithi prefecture differ significantly from all other values in the following birth cohorts. In the Irakleion prefecture, the average height of the 1892-1883 birth cohort is significantly different from those of the 1902-1893 and 1922-1913 birth cohorts. In the Rethymnos prefecture, the only significant difference is between the older and the 1912-1903 birth cohorts. Finally, variations of height in the Chania prefecture show significant values among the younger (1922-1913) and the older (1882-and before) and the 1902-1893 birth cohort. In general, and interestingly, the Chania prefecture shows a clear increasing trend, which becomes more evident starting from those born at the turn of the 20th century.

Table 4: Descriptive statistics of height (cm) by birth cohorts in the Males in the four Prefectures of the Island of Crete.

Birth cohorts (age class)	Lasithi			Heraklion			Rethymno			Chania		
	N	mean	sd	N	mean	sd	N	mean	sd	N	mean	sd
1882 and before (60.0 and over)	80	165.4	6.2	50	166.9	5.9	80	166.3	6.1	86	167.8	6
1892-1883 (50.0 - 59.9)	63	168.4	5.4	45	165.5	5.8	48	167.1	6.3	64	169.9	6.9
1902-1893 (40.0 - 49.9)	102	168.5	5.5	61	169.9	6.6	60	167.7	5.6	91	168.7	6.3
1912-1903 (30.0 - 39.9)	141	169.2	6.7	103	167.7	6.2	97	170.0	6.1	127	169.9	6.5
1922-1913 (20.0 - 29.9)	156	168.6	6.2	109	169.4	5.6	106	168.7	5.7	223	171.8	6.8

Table 5: Results of contrasts' analysis by means of Tukey's HSD in the Cretan males.

Birth cohorts	1882 and before	1892-1883	1902-1893	1912-1903	1922-1913
1882 and before	-				
	-				
	-				
	-				
1892-1883	L. 0.029	-			
	H. 0.771	-			
	R. 0.949	-			
	C. 0.312	-			
1902-1893	L. 0.005	L. 1.000	-		
	H. 0.081	H. 0.002	-		
	R. 0.643	R. 0.985	-		
	C. 0.881	C. 0.824	-		
1912-1903	L. 0.000	L. 0.922	L. 0.929	-	
	H. 0.941	H. 0.232	H. 0.181	-	
	R. 0.001	R. 0.054	R.0.150	-	
	C. 0.149	C. 1.000	C. 0.691	-	
1922-1913	L. 0.001	L. 1.000	L. 1.000	L. 0.921	-
	H. 0.108	H. 0.002	H. 0.992	H. 0.235	-
	R. 0.056	R. 0543	R. 0.847	R. 0.557	-
	C. 0.000	C. 0.240	C. 0.002	C. 0.075	-

L. = Lasithi; H. = Heraklion; R. = Rethymnos; C. = Chania

Discussion

The literature mainly reports data on Greece as a whole, which we report here to provide a broad overall picture.

The paper by Bertsatos and Chovalopoulou (2017) reports estimated height from femur lengths in a skeletal collection of individuals of Greek nationality and of known

sex and age, whose births span from 1879 to 1965. The sample is small, but their results are robust, and they show lower mean values of height than the ones in our study, but in line with the evidence of an increasing trend in both sexes at the turn of the 20th century. In this regard, it must be remembered that in the conscripts' lists provided in Valaoras (1968), the Cretans and the Macedonians are the tallest and that the author underlines the role of environmental factors such as the different characteristics of the morphology of the country to be at the basis of these differences in height. Indeed, Crete at the time was in a more favourable condition compared to the rest of Greece (Detorakis 1994), thus ensuring better living conditions for its population.

Concerning the females, for the second half of the 20th century, Garcìa and Quintana-Domeque (2007) revised the data on height in ten European countries for birth-cohorts between 1950 and 1980 from the European Community Household Panel (ECHP), Eurostat. They report an average height of the Greek birth-cohort 1950-55 of 163.3 cm that reached 165.9 cm in the birth cohort 1976-1980; thus, the gain is +2.6 cm. The value recently reported by Bogin et al. (2017) referring to Greek women born in 1996, derived from the NCD Risk Factor Collaboration (2016), is 164.9 cm, 1 cm lower than the above findings for the birth cohort 1976-1980. Data in the literature regarding Cretan women are sporadic (Manios et al. 2005; Tsakiraki et al. 2011). The most interesting for our purposes is that of Tsakiraki et al. (2011), who reported the average stature of 80 mothers and 80 daughters of Cretan origin from all over the island in health-nutrition research. Mothers average 57 years of age (average year of birth: 1952), and their mean height is 162.0 cm, whereas the daughters' mean age is 33.5 (average year of birth: 1976) and mean height is 165.0 cm. The latter value is in line with the coeval Greek values, whereas the former appears more than 1 cm lower compared to the one reported by Garcìa and Quintana-Domeque (2007). This difference can suggest a delayed recovery after the Second World War on the island compared to the rest of the country, and, looking back to our data in Table 1, it also suggests that it took about 30 years for height to gain approximately 5 cm.

As far as the males are concerned, the mean value in our global sample (168.7±6.4 cm) is perfectly comparable with the value of 168.5± 6.3 reported by Roberts (1954) in a sample of 1946 adult males (birth cohort 1870-1880), measured at the beginning of the 20th century by anthropologist Charles Henry Hawes. The analysis by birth cohorts in our sample shows that stature has been increasing since the last two decades of the 19th century. In Figure 2, we compared this trend with those derived from Cretan conscript lists, aged 20 years, born from 1927 to 1945 (Valaoras 1968) and the Cretan conscripts born from 1979 to 1989, derived from the dataset referring to all Greek conscripts measured in 2006 and 2007 (Papadimitriou et al. 2008). This figure is interesting as it shows that men born at the end of the 19th century/beginning of the 20th century were experiencing increases in mean values of height and that this trend was interrupted and reversed in the following twenty years (1927-1945) in which height averaged 167.3 cm. Another interesting fact is the consistent increase of the trait in the second half of the 20th century. Papadimitriou et al. (2008) reported that all Greek conscripts born from 1979 and 1989 averaged 178.1 cm and that, after comparison with the value of 175.7 cm from a previous study conducted in 1990 (Georgiadis et al. 1993), concluded that Greek conscripts' mean

height increased by almost 8 cm from 1968 to 1990 and that the trend was still ongoing, albeit at a slower rate. Indeed, the mean value reported by Papadimitriou et al. (2008) is in line with those reported by Garcìa and Quintana-Domeque (2007), but it differs from the value of 177.3 cm, recently reported by Bogin et al. (2017) for Greek men born in 1996.

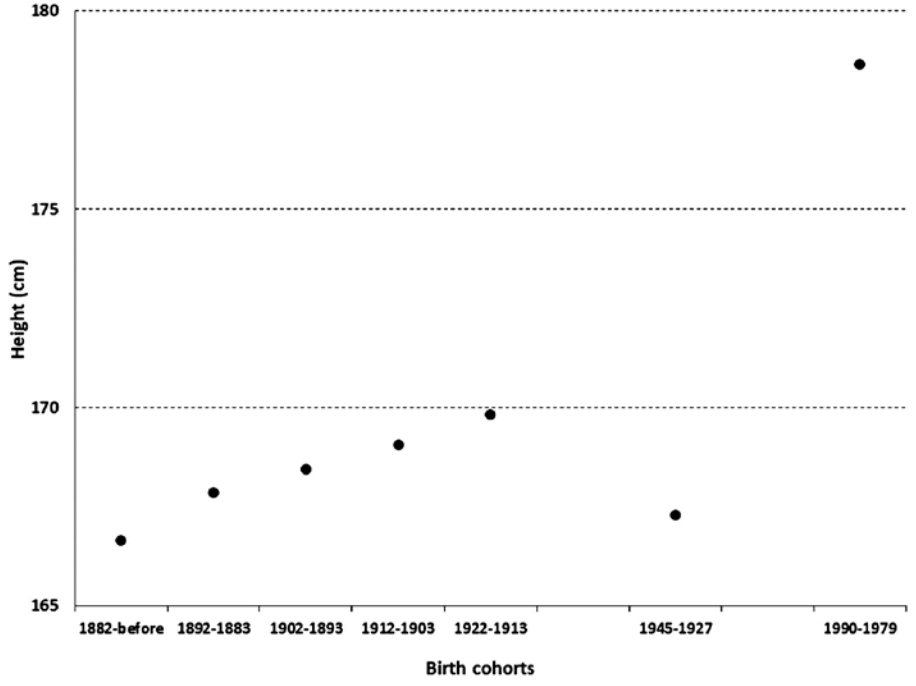

Figure 2: Trend of mean values of height of Cretan males, by seven birth cohorts (1882-before, 1892-1883, 1902-1893, 1912-1903 and 1922-1913: Present Study; 1945-1927: Valaoras, 1968; 1990-1979: Papadimitriou & Fytadinis, p.c.)

Concerning the analysis conducted according to geographic areas, the distribution of stature in the four prefectures of the island highlighted the significantly taller stature of the males in Chania compared to the other three, where mean values of the island itself are very similar to each other. The same has been reported by Roberts (1954) on Hawes' data, and the author has advanced various interpretative hypotheses of the phenomenon, from genetic drift to differential invasion flows, one from the Mediterranean and people from southern Asia Minor to the eastern part of the island and another of taller North African people (mainly from Egypt and Libya) who settled in the north-west mountainous part of the island. However, none of them convinced the author, who concluded that some other causes must have been acting in the microgeographic differentiation of the western and eastern Cretan populations.

Indeed, there is another aspect to be taken into consideration that may be explanatory: the peculiar orography of Chania characterised by the presence of the highest

number of mountain peaks over 2200 metres, which however did not prevent the development of local crop production, could have favoured geographic isolation from the rest of the island. The history of Crete testifies the relative prosperity of the island which, together with its strategic position in the Mediterranean Sea, has always favoured trade flows. This could have exposed the coastal populations to the introduction of infectious diseases and, in contrast, could have guaranteed effective protection against them for the groups in the isolated mountainous settlements of the prefecture of Chania. This fact and the availability of local resources may have provided better living conditions during growth, thus explaining the taller mean heights of the adults compared to the rest of the inhabitants of the island. Evidence of this protective effect of isolation has been reported in several high-altitude populations (Danubio et al. 2016).

In conclusion, our study highlights two main points in the recent history of Crete. Firstly, at the turn of the 20th century, the Cretan inhabitants were experiencing a positive secular trend of height increase, reaching higher mean values compared to those found in the males born in the first half of the 20th century. This fact is related to the deteriorations of living conditions associated with the historical turbulence caused by the Second World War and the subsequent Greek Civil War (Close 2013; Magoulis & Miniadis 2017). Secondly, within this general context, there were significant regional differences: those born in the north-western prefecture of Chania were found to be significantly taller compared to those in the other three prefectures with homogenous mean values of height, which might reflect the protective action of isolation against the introduction of infectious diseases related to trade flows which were more consistent in the other lowland prefectures of Crete (Ahmed et al. 2007; Wolfe et al. 2007; Malina et al. 2018).

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Declaration of conflicting interests

The authors declared no potential conflicts of interest.

Author contributions

MED and MC designed the study. MC organised and edited the data, while FM analysed the data. GF provided elaborations on Cretan conscripts from the National lists. MED, MC, and FM drafted the manuscript. All authors have read and approved the final version of the manuscript.

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Povzetek

V prispevku želimo potrditi hipotezo, da je otok Kreta na začetku 20. stoletja ohranjal boljše življenjske pogoje v primerjavi s preostalo Grčijo. Analizirali smo trende v višini odraslih pri obeh spolih in sicer v dveh korakih. V prvem je bila višina analizirana glede na spol in rojstne kohorte za celoten otok. V drugem primeru je bil uporabljen enak pristop pri preučevanju pojava v štirih prefekturah otoka. Povprečna višina je bila 155,4 ± 6,2 cm, pri ženskah pa 168,7 ± 6,4 cm, pri tem pa se je trend s časom nenehno povečeval. Porazdelitev telesne višine v štirih prefekturah je pokazala, da so najvišjo telesno višino dosegali samem Chaniju. Naše analiza prikazuje višjo povprečno telesno višini kot podatki o kretskih nabornikih, rojenih med letoma 1927 in 1945. Naši rezultati potrjujejo, da so bili Krečani pred priključitvijo Grčiji na prehodu v 20. Stoletja, premožnejši. Poleg tega kažejo, da višja telesna višina moških v prefekturi Chania odražajo zaščitno delovanje izolacije pred vnosom nalezljivih bolezni, povezanih s trgovinskimi tokovi.

KLJUČNE BESEDE: trendi višine, prefekture na Kreti, prva polovica 20. stoletja

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