Nationwide Stature Estimation From Armspan Measurements in Albanian Youngsters

Estimación de Estatura a Nivel Nacional a Partir de Mediciones de Envergadura en Jóvenes Albaneses

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SUMMARY: The purpose of this research is to examine stature in both Albanian sexes as well as its association with arm span, as an alternative to estimating stature. A total of 445 individuals (266 boys and 179 girls) participated in this research. The anthropometric measurements were taken according to the protocol of ISAK. The relationships between stature and arm span were determined using simple correlation coefficients at a 95 % confidence interval. Then a linear regression analysis was carried out to examine extent to which arm span can reliably predict stature. Results displayed that Albanian boys are 176.57±7.36 cm tall and have an arm span of 179.98±9.41 cm, while Albanian girls are 166.84±9.28 cm tall and have an arm span of 167.53±10.34 cm. The results have shown that both sexes made Albanians a tall nation but not even close to their male compatriots from Kosovo that are almost 3 centimeters taller, while the results in female population are opposite. Moreover, the arm span reliably predicts stature in both sexes, which confirms a high R-square (%) for the boys (73.4) as well as for the girls (78.8).

KEY WORDS: Prediction; Measurement; Arm Span; Arm Span; Albania.

INTRODUCTION

Albania (in local language: Republika e Shqipërisë) is a unitary parliamentary constitutional republic that has been a sovereign country since 1912, when it declared independence from Ottoman Empire, while it was recognized officially by the major European powers in 1913 (Institute of Statistics, Institute of Public Health/Albania & ICF Macro, 2010). According to the same source, the history of Albania is diverse and very turbulent but, nowadays Albania is a full member of NATO and European Union candidate country, and the further political stability might be promised. From the geographical point of view, Albania is a small country covers the area of 28,748 square kilometers and it spreads on the southern Balkan Peninsula in south-eastern Europe. This country is characterized by three geographic areas: Mountainous, central and costal, it borders with four countries: It shares its borders with Montenegro (172 km), Kosovo (115 km), Macedonia (151 km) and Greece (282 km), while the coastline is 487 km long on the Adriatic and the Ionian Sea. From the demographic point of view, the total population of Albania is 3,069,275 inhabitants (Institute of Statistics, Institute of Public Health/Albania & ICF

Macro). According to the same source, the largest ethnicity and majority in the country is the Albanian ethic group, representing 98 percent of the total population, followed by small groups of Greeks, Macedonians, Vlachs, Roma, Bulgarians and Serbs. On the other hand, the religion issue is very important in the Balkan area, and it is important to mention that Albania is constitutionally a secular country, and it is quite neutral among the religion question. However, the Albanian population, according to the Albanian Census in 2011 (Institute of Statistics, Institute of Public Health/Albania & ICF Macro), pointed out the most-commonly practiced religion is Islam (56.70 %), then Catholicism (10.03 %), Orthodoxy (6.75 %), Bektashi (2.09 %) and other Christians (0.14 %), while some of them declared themselves as non-affiliated believers (5.49 %), undeclared (13.79 %) and Atheists (2.5 %).

The researches, carried out by European anthropologists a century ago, have proved the assumption that the tallest people living in the Dinarides (Pineau *et al.*, 2005). As modern Albanians, like their neighbors from Kosovo

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(Arifi *et al*., 2017), with a northern part fall into this racial classification, it was believed by the authors of this study that Albanian adults might be equally tall with their compatriots from Kosovo (boys: 179.5 cm; girls: 165.7 cm) as well as very close to the tallest nations such as Bosnian and Herzegovinians (boys: 183.9 cm; girls: 171.8 cm), Dutch (boys: 183.8 cm; girls: 170.7 cm), Montenegrins (boys: 183.4 cm; girls: 169.4 cm) and Serbians (boys: 182.0 cm; girls: 166.8 cm). However, the rest of Albanian country did not fall into the mentioned classification, so the variations are expected. Compared to the Western European countries, Albania, as most of Western Balkan countries, keeps poor records, and the expected data about the average stature among Albanian populations are so beneficial as well as its relationship with arm span measurements, mostly by virtue of measurement of stature`s importance in many settings (Popovic *et al*., 2015).

Scientific literature provided us with the findings that the measurement of stature is a vitally important variable when assessing nutritional status (Masanovic *et al*., 2019), as well as, when assessing the growth of children, evaluating the basic energy requirements, adjusting the measures of physical capacity and predicting the drug dosage and setting standards of physiological variables (e.g. muscle strength, metabolic rate, lung volumes and glomerular filtration). However, the exact stature, according to Quanjer *et al*. (2014), cannot always be identified and resolved in the usual way (e.g. paralysis, fractures, amputation, scoliosis and pain). Because of these factors, an estimate of stature has to be acquired from other reliable anthropometric indicators such as hand and foot lengths, knee height, length of the forearm, length of the sternum, vertebral column length, sitting height, length of scapula, arm span as well as cranial sutures, skull, facial measurements et cetera (precisely described in Popovic *et al*., 2017a; Popovic, 2019). Therefore, all these anthropometric indicators, which are used as an alternative to estimate stature, are very important in predicting loss in stature connected with aging. Also, to diagnose individuals with disproportionate growth abnormalities and skeletal dysplasia or stature loss during surgical procedures on the spine (Mohanty *et al*., 2001), as well as to anticipate stature in many older people as it is very difficult to measure it precisely, and sometimes impossible because of mobility problems and kyphosis (Hickson & Frost, 2003).

According to the previously mentioned, the researchers of this study believed it would be reasonable to find the benefit of using various body indicators in estimating stature in the Albanian population. Additionally, couple of researches have reported the benefit of using various body parameters in predicting stature, and arm span happened to be the most reliable one (Jarzem & Gledhill, 1993; Mohanty *et al*.; Hickson & Frost; Ter Goon *et al*., 2011). However, the relationship of arm span and stature was found to vary in different ethnic and racial groups (Steele & Chenier, 1990; Reeves *et al*., 1996; Brown *et al*., 2002; Bjelica *et al*., 2012; Popovic *et al*., 2013, 2016; Popovic, 2018), while the research conducted by Quanjer *et al*. has reported that the arm span to stature ratio changes non-linearly with age and differs between boys and girls. Even though many studies with this essence are available on Western populations, only narrow data is available on Albanian subjects. Considering rather sparse recent scientific literature, the purpose of this research was to examine the stature in both Albanian sexes and its association with arm span.

MATERIAL AND METHOD

The nature of this research gave extension to 445 youngsters (266 boys and 179 girls) from three Albanian cities: Tirana, Elbasan and Shkoder to be subjects. Two reasons qualified the selected individuals, the first is related to the fact that the growth of an individual ceases by this age, while the second is related to the fact that there is no age-related loss in stature at this age. The average age of the male subject was 21.74±3.13 years old (range 18-41 years), while the average age of the female subject was 21.01±2.12 years old (range 18-36 years). It is important to underline that the researchers have excluded from the data analysis the individuals with physical deformities as well as those without informed consent. The exclusion criterion was also being non-Albanian.

Although photogrammetric anthropometry is an accurate way nowadays, this is not valid for arm span measurement (Penders *et al*., 2015) and the anthropometric measurements, including stature and arm span, were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (Marfell-Jones *et al*., 2006). The trained measurers have measured selected anthropometric indicators (same measurer for each indicator), while the quality of their performance was evaluated against the prescribed "ISAK Manual". Lastly, the age of the each subject was reached directly from the birthdays.

The analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0. Means and standard deviations (SD) were obtained for both anthropometric variables. A comparison of means of stature and arm spans within each sex group and between sexes was performed using a t-test. The relationships between stature and arm span were determined using simple correlation coefficients at ninety-five percent confidence interval. Then a linear regression analysis was carried out to examine the extent to which the arm span can reliably predict stature. Statistical significance was set at p<0.05.

RESULTS

A summary of the anthropometric measurements in both sexes is shown in Table I. The mean of the arm span for boys was 179.98±9.41 cm, which was 3.41±2.05 cm more than the stature and statistically significant (t=-4.646, p<0.000), and for girls it was 167.53±10.34 cm, which was 0.69±1.06 cm less than the stature and statistically insignificant (t=0.958, p<0.511). The sex difference between stature and arm span measurements was statistically significant (stature: t=12.283; p<.000, and arm span: t=13.142; p<.000).

In Table II, the simple correlation coefficients and their ninety-five percent confidence interval analysis between the anthropometric measurements are displayed. The associations between stature and arm span were significant (p<0.000) and high in this sample, regardless of sex (boys: 0.857; girls: 0.888).

The results of the linear regression analysis are shown in Table III. The first of all models were extracted by including age as a covariate. However, it was found that the contribution of age was insignificant and therefore the age was dropped and estimations were derived as a univariate analysis. The high values of the regression coefficient (boys: 0.857; girls: 0.888) signify that arm span notably predicts stature in both Albanian sexes (boys: t=26.977, p<0.000; girls: t=25.681, p<0.000), which confirms the R-square (%) for the boys (73.4) as well as for the girls (78.8).

The associations between arms span measurements and stature among the above models is sketched as a scatter diagram (Fig. 1).

Table I. Anthropometric measurements of the study subjects.

Subjects	Stature Range (Mean±SD)	Arm span Range (Mean±SD)
Male	154.0 - 198.3 (176.57 ± 7.36)	137.0 - 202.0 (179.98 ± 9.41)
Female	147.0 - 2 00.0 (166.84 ± 9.28)	147.0 - 203.0 (167.53 ± 10.34)

Table II. Correlation between stature and arm span of the study subjects.

Subjects	Correlation Coefficient	95 % confidence interval	Significance p-value
Male	0.857	0.794–0.920	<0.000
Female	0.888	0.820–0.956	<0.000

Table III. Results of linear regression analysis where the arm span predicts the stature

Subjects	Regression Coefficient	Standard Error (SE)	R-square (%)	t-value	p-value
Male	0.857	3.797	73.4	26.977	0.000
Female	0.888	4.282	78.8	25.681	0.000
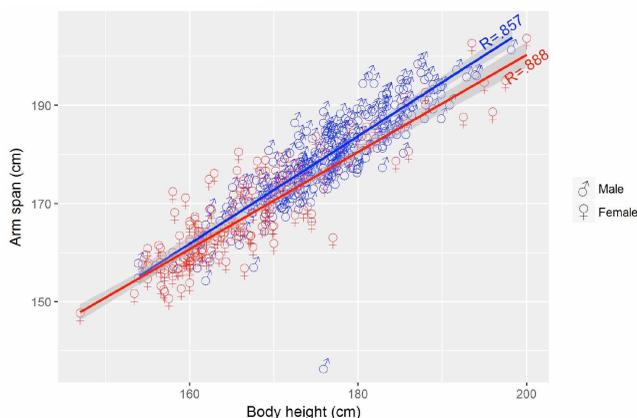
Fig. 1. Scatter diagram and relationship between arm span measurements and stature among both sexes.
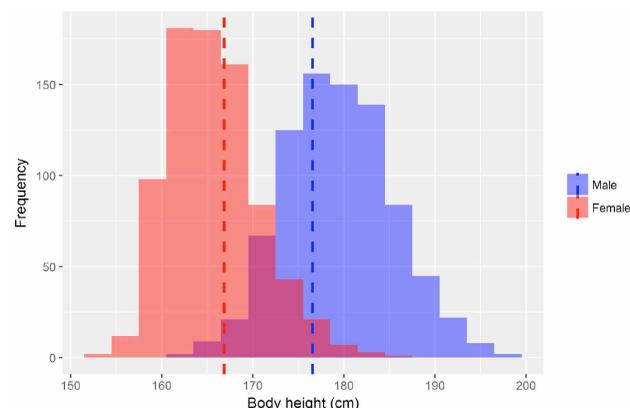
Fig. 2. Density of stature among both sexes.

DISCUSSION

This research enriches very important update of average stature among both Albanian sexes. The results proved that Albanian boys with an average tallness of 176.57 cm are tall nation but not close to the top tallest in the Europe (Table IV), given 183.8 cm of the Dutch (Schönbeck *et al.*, 2013), 183.3 cm of the Montenegrins (Popovic, 2018), 182.8 cm of the Bosnian and Herzegovinians (Mrehic *et al.*, 2016), and 181.7 cm of the Belgium population (NCD Risk Factor Collaboration, 2016). The average stature of Albanian boys is also not close enough to 181.6 cm of the Estonians, 181.4 cmof the Denmark population, 181.3 cm of the Lithuanians, 180.8 cm of the Croatians, 180.6 cm of the Icelanders and Serbians (Dagbjartsson *et al.*, 2000; Tutkuviene, 2005; NCD Risk Factor Collaboration), as well as several other nations, including their male compatriots from Kosovo (Arifi *et al.*) who were 179.52 cm tall. Hence, it is the fact that previously presented results made Albanians the tall nation but not even close to being among the top tallest male nations in the Europe and the World.

With regards to the opposite sex, the average stature of Albanian girls were 166.84 cm on average and this result proved that Albanian girls are tall but not as tall as 169.8 cmof the Latvians (NCD Risk Factor Collaboration), 169.4

cm of the Montenegrins (Popovic, 2018), 168.7 cm of the Dutch and Estonians (NCD Risk Factor Collaboration), and several other nations ranked in the top 10 tallest female nations (Table V), however, oppositely from the male population, taller than their female compatriots from Kosovo (Arifi *et al.*) who were 165.72 cm tall.

However, there is a hypothesis that both sexes from Albania did not reach their full genetic potential yet, since various environmental factors controlled their development (politically isolated country, poor economic situation et cetera) in the last couple of decades. Consequently, the researchers are of the opinion that these circumstances had a negative bearing on the secular trend in Albania and surrounding countries alike, while it is expected that the secular changes influencing stature will ascend in the following two or three decades, comparing it to developed countries where this trend has already completed such as Dutch (Schönbeck *et al.*).

It is also interesting to mention that the frequency of very tall individuals appears to be distinctive for the Albanian boys, since 2.3 percent measured 190 cm or more in stature. If specified percent in Albanian would be compared to 20.2 % in the Bosnian and Herzegovinians (Popovic *et al.*, 2015), 20 percent in the Netherlands (Pineau *et al.*), 18.2 % in Montenegro (Popovic, 2018) and 14 % in Serbia (Popovic *et al.*, 2013), it would imply that the frequency of very tall

Table IV. An update of top 10 tallest male nations on the Earth.

#	Country	Average Stature (cm)	Source
1	Netherland	183.8	Schönbeck *et al.,* 2013
2	Montenegro	183.3	Popovic, 2018
3	Bosnia and Herzegovina	182.8	Mrehi *et al.,* 2016
4	Belgium	181.7	NCD Risk Factor Collaboration, 2016
5	Estonia	181.6	NCD Risk Factor Collaboration, 2016
6	Denmark	181.4	NCD Risk Factor Collaboration, 2016
7	Lithuania	181.3	Tutkuviene, 2005
8	Croatia	180.8	NCD Risk Factor Collaboration, 2016
9	Iceland	180.6	Dagbjartsson *et al.,* 2000
10	Serbia	180.6	NCD Risk Factor Collaboration, 2016

Table V. An update of top 10 tallest female nations on the Earth.

#	Country	Average Stature (cm)	Source
1	Latvia	169.8	NCD Risk Factor Collaboration, 2016
2	Montenegro	169.4	Popovic, 2018
3	Netherland	168.7	NCD Risk Factor Collaboration, 2016
4	Estonia	168.7	NCD Risk Factor Collaboration, 2016
5	Czech Republic	168.5	NCD Risk Factor Collaboration, 2016
6	Serbia	167.7	NCD Risk Factor Collaboration, 2016
7	Slovakia	167.5	NCD Risk Factor Collaboration, 2016
8	Lithuania	167.5	Tutkuviene, 2005
9	Slovenia	167.4	Starc & Strel, 2011
10	Denmark	167.2	NCD Risk Factor Collaboration, 2016

individuals in Albanian boys does not appear often as in the neighboring countries and the Netherlands, and this amount is much closer to the nations from the neighborhood which gravitate out of the Dinaric Alps mountain chains such as 2.7 in Macedonia (Popovic *et al.*, 2016), 5.1 in Kosovo (Arifi *et al.*) as well as 1.5 % in France (Pineau *et al.*). With regards to the frequency of very tall female individuals, it appears to be characteristic of the Albanian girls, since 8.9 percent measured 180 cm or more in stature (Fig. 2) that is also much more opposite than what is the case with male Albanian population. If specified percent in Albanian would be compared to 14 % in the Bosnian and Herzegovinians (Popovic *et al.*, 2015) from one side, and 5 % in Montenegro (Popovic, 2018), 3 % in Serbia (Popovic *et al.*, 2013) and 0.8% in Kosovo (Arifi *et al.*), it would imply that the frequency of very tall individuals in Albanian girls appear to be interesting for the further investigation, mostly due to the reason the high percent of 180 cm and taller might be a beneficial fact in talent identification for various sports that requires specific tallness.

In the study conducted by Arifi *et al.*, it clearly explained that the assessment of stature using various anthropometric measures is very typical from the past centuries and it has been attempted to be studied by many researchers. However, it is important to underline that the arm span has been obtained as the most reliable body indicator for predicting the stature of an individual (Mohanty *et al.*; Ter Goon *et al.*). In parallel, it is important to emphasize that the individual and ethnic variations referring to stature and its association with arm span were already examined in Europeans (Reeves *et al.*) and Africans (de Lucia *et al.*, 2002), while Mohanty *et al.* have quoted that the estimating equation varies from ethnic group to ethnic group as well as race to race. In Steele & Chenier's research, the arm span was nearly 8.3 cm than the stature for Blacks (105.36 % stature), whereas for Whites this difference was only 3.3 cm (102.04 % stature). Mohanty *et al.* have observed in their research that the arm span was nearly 2.5 cm than the stature in South Indian girls (101.4 % stature), which is similar to that observed in the Whites. In Ter Goon *et al.*'s research, arm span was 5.8 cm than stature for Nigerian boys (103.3 % stature), whereas for Nigerian girls this difference was only 4 cm (102.5 % stature), which is similar to that observed in whites, although they are black. The most recent research carried out by Popovic (2018) noted that the arm span was 1.2 cm than stature for Montenegrin boys (100.7 % stature), whereas for Montenegrin girls this difference was only 1.3 cmbut in favor of stature (99.3 % stature). Then Popovic at al. (2013) noted that arm span was 2.8 cm than stature for Serbian boys (101.5 % stature), whereas for Serbians girls this difference was only 0.15 cmbut also in favor of stature (98.7 % stature). Gardasevic *et al.* (2017) also noted that arm span was 1.81 cm than stature

for Bosnian and Herzegovinian boys (101.0 % stature), whereas for Bosnian and Herzegovinian girls (Popovic *et al.*, 2015) this difference was only 1.97 cm but also in favor of stature (98.9 % stature). Popovic *et al.* (2016) have also confirmed that arm span was 0.68 cm than stature for Macedonian boys (100.4 % stature), whereas for Macedonian girls this difference was only 0.17 cmbut also in favor of stature (99.9 % stature). Arifi *et al.* have also confirmed that arm span was 1.68 cm than stature for Kosovan boys (101.0 % stature), whereas for Kosovan girls this difference was only 0.12 cmbut also in favor of stature (99.9 % stature), while Quanjer *et al.* has highlighted the stature estimated from the predicted arm span to stature ratio may differ by up to ten percent from actual stature. All above-mentioned have confirmed again the necessity for developing separate stature models for each population on account of ethnic differences, while some of latest studies found the regional differences among the same ethnic groups (Milasinovic *et al.*, 2016a,b; Popovic *et al.* 2017b; Masanovic *et al.*, 2018), which cause the need for additional caution. Therefore, the main goal of this research was to test the hypothesis if above-mentioned facts are true for the Albanians, due to the previous scientific evidences (Mohanty *et al.*) that it might vary among various ethnic groups and races. Hence, in the present research it was remarked that the arm span was 4.41 cm than the stature in boys (101.9 % stature), while it was 0.69 cm than the stature in Albanian girls (100.4 % stature) that is quite opposite from the previous findings in the neighboring countries and the first time founded that armspan has a higher value than the stature. The arm span to stature ratio in Albanian boys is quite closer to other Europeans comparing to the data reached in the measurement of Western Balkan populations, such as the Montenegrins (Bjelica *et al.*), as well as Serbians (Popovic *et al.*, 2013), Bosnian and Herzegovinians (Popovic *et al.*, 2015), Kosovans (Arifi *et al.*) and Macedonians (Popovic *et al.*, 2016), while the arm span/stature ratio and stature in general speaking in Albanian girls has specific values comparing to all available data.

The results of the previous research are also similar to the correlation obtained in the present research (boys: r=0.857; girls: r=0.888). For instance, Hickson and Frost observed that the correlation was r=0.86, while in Mohanty *et al.*'s research (2001) correlation was r=0.82, and in Zverev (2003) research, correlation was r=0.87 for boys and r=0.81 for the girls. In the most recent research, Arifi *et al.*'s study reported that the correlation was r=0.794 for boys and r=0.766 for girls and Popovic's research (2018) noted that correlation was r=0.82 for boys and r=0.83 for the girls, while Ter Goon *et al.* noted that correlation was r=0.83, Bjelica *et al.* reported that the correlation was r=0.861 for boys and r=0.809 for girls, while in Popovic *et al.* (2013) research, correlation was r=0.814 for boys and r=0.822 for the girls and from 2016

correlation was r=0.879 for boys and r=0.839 for the girls. As the correlation between arm span and stature was high and significant in both Albanian sexes, the arm span measure therefore seems to be a reliable indirect anthropometric indicator for estimating stature in both sexes of Albanian population and quite different from other populations.

The results of this study confirm the necessity for developing separate stature models for both sexes in Albania at large (especially in female population); however, the researchers must underline that further studies should consider dividing the population of this country to regional subsamples and analyze it separately, just to be sure there are no geographical differences (such as type of the soil) influencing the average stature in both Albanian sexes as well as its association with arm span. This concern is based on the fact that entire Albania is divided into three specific geographic areas: mountainous, central and costal and previous experience that taller people will on maintains can be the reason we reached shorter people over here. The obvious limitation of this study is the fact that both sexes of Albania did not reach their full genetic potential yet, since various environmental factors controlled their development. Further continuous monitoring is necessary, mostly due to the reason it is expected the secular changes influencing stature will ascend in the following two or three decades. Lastly, the body proportion measurement using photogrammetric anthropometry that is an accurate way nowadays but it is not valid for arm span measurement and it is recommended to keep the old fashion method of measuring this body proportion.

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RESUMEN: El objetivo de esta investigación fue examinar la estatura en individuos de ambos sexos albaneses, además de su asociación con la extensión del brazo, como una alternativa a la estimación de la estatura. Un total de 445 individuos (266 niños y 179 niñas) participaron en esta investigación. Las medidas antropométricas se tomaron de acuerdo con el protocolo de ISAK. Las relaciones entre la estatura y el brazo se determinaron utilizando coeficientes de correlación simples en un intervalo de con-fianza del 95 %. Luego se realizó un análisis de regresión lineal para examinar en qué medida el brazo puede predecir de manera confiable la estatura. Los resultados muestran que los niños albaneses miden 176,57 ± 7,36 cm de alto y tienen una medida del brazo de 179,98 ± 9,41 cm, mientras que las niñas albanesas miden 166,84 ± 9,28 cm de alto y tienen una medida del brazo de 167,53 ± 10,34 cm. Los resultados han demostrado una altura importante en ambos sexos de la población albanesa. Sin embargo, se observó que respecto de la altura los varones de Kosovo miden casi 3 centímetros más, mientras que en la población femenina se observó lo contrario. Además, la extensión del brazo predice de manera confiable la estatura en ambos sexos, lo que confirma un alto R-cuadrado (%) para los varones (73,4) y para las mujeres (78,8).

PALABRAS CLAVE: Predicción; Medición; Lapso del brazo; Lapso del brazo; Albania.

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