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REVIEW PAPER

Standing Height and its Estimation Utilizing Arm Spam and Foot Length Measurements in Dinaric Alps Population: A Systematic Review

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Abstract

Several researches have reported the benefits of using various body parameters in predicting standing height, and arm span happened to be one of the most reliable ones in adults, while foot length measurement is the most reliable predictor during adolescent age. On the other hand, it is well-known that the tallness and body proportions are specific in the area covered by Dinaric Alps. Therefore, the purpose of this study was to investigate the potential relationship between arm span and foot length measurements and body height in Dinaric Alps population. The most visible electronic database (Google Scholar) was searched for original research articles available until April 2018. Then research findings were summarized and relationship between arm span and foot length measurements and body height in Dinaric Alps population were identified, as well as areas of future research were recommended. The assessment of body height 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 true height of an individual, while foot length was very close. However, the studies sampled with the populations which live at Dinaric Alps Mountains have specific estimates. Therefore, all the above-mentioned has confirmed the necessity for developing separate body height models for each population on account of ethnic as well as regional differences.

Key words: *standing height, tue height, growth, estimation, arm spam, foot length*

Introduction

A great number of studies have shown that body height measurement is a valuable factor which is highly affective on the state of nutrition in adults (cited in Arifi et al., 2017a; Popovic, & Bjelica, 2016), as well as for estimating the growth rate in children, evaluating the basic energy needs, adjusting the physical capacity measures, as well as for estimating the amount of taking certain medications and a number of other things, such as muscle strength assessment, metabolic processes, lung capacity, and the like. (Golshan, Amra, & Hoghogi, 2003; M. Golshan, Crapo, Amra, Jensen, & R. Golshan, 2007; Mohanty, Babu, & Nair, 2001; Ter Goon, Toriola, Musa, & Akusu, 2011).

However, according to Quanjer and his associates (2014), body height cannot always be accurately determined, primarily in cases such as paralysis, fractures, amputations, and various deformities such as scoliosis and kyphosis. For this reason, it is necessary to evaluate the relative body height from other reliable anthropometric indicators such as hand and foot length, knee height, forearm length, chest length, sitting height, blade length, arm length, and a number of other less reliable indicators (as cited in Gardasevic, Rasidagic, Krivokapic, Corluka, & Bjelica, 2017; Popovic, 2017; Masanovic, 2017). Accordingly, all anthropometric indicators used as an alternative to estimating relative body height are of great importance in all the above listed cases when the body height is significant but cannot be measured by a standard method. It is also important to point out that all of these should and have to be applied in sports sciences, since the importance of body height is highly important and affective on the success in various sports disciplines (Popovic, 2017).

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A significant number of studies have indicated the usefulness of different body parameters in assessing relative body height (Popovic, Arifi, & Bjelica, 2017a, Popovic, & Bjelica, 2017, Popovic, Gardasevic, Masanovic, Arifi, & Bjelica, 2017b) and it was found that arm span was the most reliable of all of them (Jalzem, & Gledhill, 1993; Mohanty et al., 2001; Ter Goon et al., 2011), while foot length measurement is the most reliable predictor during adolescent age, due to the fact that ossification and maturation occur earlier in the foot than the long bones and standing height could be more accurately predicted from foot measurement as compared to long bones during adolescent age (Singh, Kumar, Chavali, & Harish, 2012). On the other hand, it is widely known that body height and body proportions are specific when talking about populations living on Dinaroids. Therefore, the main objective of this study is to explore the potential relationship between arm span and foot length measurements and body height in the given area.

Method

The most apparent electronic database of scientific papers, "Google Scholar", was used in this research, while all the materialsthat entered the analysis were available until the 30th of April 2017. The field of research of the above mentioned electronic database of scientific papers is related to the determination and compilation of potential relations between arm span and foot length measurements and body height in subjects who have lived and are living in the area of mountain wreaths named Dinaroids. In the search of the mentioned database, the following keywords were used: "hand length", "foot length", "body height", "dinaric alps" and "anthropometric measures", while the author reviewed and made a further selection of the papers, and rejected all that did not follow the criteria. Later on, according to the criteria (that the population is from the territory of the Dinaroids, and that a linear regression analysis was applied in the work that determined the relationship between arm span and foot length measurements and body height, which is the main goal of this study (Moher et al., 2009), he performed the systematic analysis of the materials in accordance with the principles of "Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA)".

Results

The initial research included 44 quotations that made up the basic database. Then a program called "Reference Manager" was used for referencing all the quotations to be included in the program database for easier analysis. 25 papers out of the total base were excluded from the further analysis because they did not fit into the purpose of this research, while 19 papers went into shortlist after they have been systematically analyzed in detail (Tables).

Table 1. Sistematic analysis of the relationship between body height and arm span at the national level

Autor(s)	The aim of The research	Sampled subjects	Statistic analysis	Results
Arifi et al. (2017a)	Determination of the relationship between body height and arm span	830 boys and 793 girls of high schools in Kosovo	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Bjelica et al. (2012)	Determination of the relationship between body height and arm span	187 male students and 107 female students of the University of Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Popovic (2016)	Determination of the relationship between body height and arm span	981 boys and 1107 girls of high schools in Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Popovic et al. (2016)	Determination of the relationship between body height and arm span	114 male students and 125 female students od the University of Macedonia	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Popovic et al. (2013)	Determination of the relationship between body height and arm span	318 male students and76 female students of the University of Serbia	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Quanjer et al. (2014)	Determination of the relationship between body height and arm span	1503 persons who are residents on three continents (Europe, Asia and Africa)	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.

In this systematic analysis, 43.18% of the total number of preliminary studies coincided with the objective of this study, and the main conclusions based on detailed systematic analysis were that the relationship between both anthropometric indicators (arm and foot length) ranged from one racial or ethnic group to another, which was previously known, and was applied in detail to the ethnic differences between the populations living in the areas that were in the focus of the author's research.

Table 2. Sistematic analysis of the relationship between body height and arm span at the regional level

Autor(s)	The aim of The research	Sampled subjects	Statistic analysis	Results
Arifi et al. (2017b)	Determination of the relationship between body height and arm span	90 boys and 87 girls of high schools in the north region of Kosovo	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Bubanja et al. (2017a)	Determination of the relationship between body height and arm span	593 girls of high schools in the middle region of Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Gardasevic et al. (2017)	Determination of the relationship between body height and arm span	193 students of the University of the Federal entity of Bosnia and Hercegovina	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Milasinovic et al. (2016a)	Determination of the relationship between body height and arm span	87 boys of high schools in the south region of Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Milasinovic et al. (2016b)	Determination of the relationship between body height and arm span	149 girls of high schools in the south region of Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Popovic et al. (2015)	Determination of the relationship between body height and arm span	178 male students and 34 female students of the University of RepublikaSrpska in Bosnia and Hercegovina	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.
Vujovic et al. (2015)	Determination of the relationship between body height and arm span	593 girls of high schools in the middle region of Montenegro	Linear regression analysis	It was found that arm span is the most reliable indicator of body height assessment. It has also been established that there are differences in relation to ethnicity.

On the other hand, it has been found that there are deviations from the regional fragmentation of samples analyzed in the countries that gravitate in the area of the Dinaric, which is a remarkable contribution to science, primarily because it could point to the potential ethnic diversity of the population that believes it belongs the same ethnic group may indicate that regional division also influences the relationship between body height and hand range as one of the most important or most important predictors when determining the relative body height of the adult concerned, as well as the relationship between the body height and the foot length as one of the most important or most important predictors when determining the relative body height of the adolescents.

It is interesting that a significant number of research presentations at scientific conferences were not found in the subject search, especially when presentations at the annual scientific conferences organized in Serbia, Slovenia, Croatia and Montenegro are taken into account (Bjelica, Popovic, & Akpinar, 2014; 2015; 2016; 2017) but it was confirmed that all these researches that have been found (Popović, Bjelica, Petković, Muratović, & Georgiev, 2014; Popović, Milašinović, Matić, Gardašević, & Bjelica, 2016; Popović, Milašinović, Jakšić, Vasiljević, & Bjelica, 2016; Popović, Bjelica, Milašinović, & Gardašević, 2016; Milašinović, Popović, Bjelica, & Vasiljević, 2016; Popović, Bjelica, Milašinović, Gardašević, & Rašidagić, 2016; Popovic, & Bjelica, 2016), have later been published in magazines in full text, so that the subject analysis did not lose significance.

Table 3. Sistematic analysis of the relationship between body height and foot length at the national level

Autor(s)	The aim of The research	Sampled subjects	Statistic analysis	Results
Popovic et al. (2017a)	Determination of the relationship between body height and foot length	338 boys and 326 girls of high schools in the north region of Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.
Masanovic et al. (2018ba)	Determination of the relationship between body height and foot length	185 boys and 179 girl of high schools in the eastern region of Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.
Masanovic et al. (2018b)	Determination of the relationship between body height and foot length	87 boys and 90 girls of high schools in the north region of Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.
Popovic et al. (2017b)	Determination of the relationship between body height and foot length	830 boys and 793 girls of high schools in Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.
Masanovic et al. (2018c)	Determination of the relationship between body height and foot length	100 boys and 93 girls of high schools in the central region of Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.
Masanovic et al. (2018d)	Determination of the relationship between body height and foot length	120 boys and 105 girls of high schools in the southern region of Kosovo	Linear regression analysis	It was found that arm span was the most reliable indicator of body height assessment, while foot length was very close. It has been established that there are differences in relation to ethnicity.

Discussion

Since it is known that the highest people live in the Dinaroids area (Grasgruber et al., 2017), and that individuals have specific body proportions, for example, Montenegrins as the tallest people in the world from the beginning of the 20th century, with an average height of 177 centimeters who had significantly longer legs and significantly shorter hands (Popović, 2017), it was logical to assume that the ratio of body height and anthropometric indicators, which are used as an alternative to assessing relative body height has a different proportion. As it has already been established in a significant number of studies, the ratio of arm span and foot length measurements and body height varies from race to race and from ethnic group to ethnic group, it was clear that something would be confirmed in Montenegro (Bjelica et al., 2012), in Serbia (Popovic et al., 2013), as well as in Kosovo (Arifi et al., 2017a). Namely, all the studies that aimed at determining the relationship between arm span and foot length measurements and body height in the Dinaroids area have undoubtedly proved that it is necessary to create new coefficients necessary for determining relative body height through other anthropometric parameters that we apply when the body height can not be measured the standard way, and that has already been explained in detail in the introduction of this study.

As all the populations in the area of Dinaroids showed similar characteristics, several detailed studies were soon carried out on the territory of Bosnia and Herzegovina, Macedonia and Albania, all areas that, partly or completely, lie on the slopes of Dinaroids, as it was expected that it will be necessary to establish new and unique coefficients for assessing relative body height through other anthropometric parameters, arm span and foot length in the first place that have proven to be the most reliable indicators in adults and adolescents. These assumptions have been confirmed, in other words, in all the mentioned countries, specific relations have been established when the body height and arm span or the length of the foot are concerned, but it is interesting to point out that in Serbia only the student population, which is believed to have specific demographic characteristics is measured (Popovic et al., 2013), and it is recommended to do further research of the general population in order to determine whether the evidence obtained on the student population is valid for the general population. On the other hand, in Montenegro, matching results were obtained on the student and general population, while the differences were obtained when the regions were in question: the northern, middle and southern regions (Popovic, 2016). When it comes to Kosovo, regional differences when the arm span and foot length measurements and body height

are in question also occur, which was the case in Montenegro too (Arifi et al., 2017).

It is also important to mention Albania here, where the students have beenthe subjects of anthropometric measurements, and wherethe preliminary results indicated that there are specifics among the Albanians. The most interesting thing is that Albanians areon average about 5 centimeters lower than Kosovars (J. Jarani, personal communication), even though they are believed to belong to the same ethnicity. Results like these indicate that the political definition of a nation or ethnic group in the Western Balkans area does not always have to go hand in hand with the indicators we receive in biological research. As for Macedonia, which lies in the Carpathians to a large extent,specifics are also notedamong the student population that has been measured, but the significantly lower body height instructs us to scale the entire population and do a regional analysis, since a multiethnic society and two mountain wreaths unambiguously demand it from us. In the end, the specifics obtained among the population of Bosnia and Herzegovina are, at least confusing, because differences in the measurement of the general population and students have been found (Grasgruber et al., 2017; Popovic et al., 2015; Gardasevic et al., 2017), while there was no difference between students from all three entities, which leads to similar conclusions as when the populations in Kosovo and Albania are in question.

All in all, it is evident that there are many specifics in body height and body proportions in populations living in the area covered by Dinaroids, and it is necessary that the coefficients for the estimation of relative body mass are calculated carefully and thoroughly, first of all in order not to make omissions that could result in fatal consequences in all of the foregoing cases that depend on the above assessment.

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Conflict of Interest
The authors declare that there are no conflict of interest.

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