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Physical Anthropometry in Estimation of Stature: A Systematic Review

Pinki Rai¹, Ashima Das², Ajay Kumar Agrawal³, Diksha Arora⁴

¹PhD Scholar, Department of Anatomy, SGT Medical College and Hospital, Gurugram, India; ²Associate Professor, Department of Anatomy, SHKM Government Medical College, Nuh, Haryana, India; ³Lecturer, Department of Anatomy, KD Dental College, Mathura, UP, India; ⁴Lecturer, Department of Anatomy, PDM Dental College, Bahadurgarh, India.

ABSTRACT

The spectrum of medical science is very broad and it seems to embrace almost every field of scientific study. The tools and techniques vary from as basic anthropometric measurement to as advanced as studying genes depending upon the field of medical science. Anthropometry is mainly covered under the departments of Anatomy and forensic and/or criminology units. Stature has been estimated by various researchers using arm span, hand length, length of the foot, length of fingers, demi-span, sitting height and many more. This review was aimed to study various parameters used for stature estimation and finding out the most supported one. This systematic review has included studies which have primarily focused on measurement of height with any other correlate to getting a brief account of anthropometric data on stature. The articles were sorted out using various databases which include Google Scholar, Scopus, Research Gate, PubMed and MEDLINE. All the articles were reviewed twice and most relevant articles were included and analyzed. Out of different parameters used for predicting the stature of an individual, the arm-span is the most efficient and accurate. Arm span can be used for prediction of the stature of the particular population.

Key Words: Arm span, Demi span, Sitting height, Stature estimation, Hand and foot length

INTRODUCTION

Anthropometric measurement is becoming very popular nowadays in various disciplines such as in medical science, forensic science, anthropological science etc for many years. This measurement can be helpful to interpret different organ functional tests or understanding patient's states easily in medical science.¹ Manmade and natural destructive events such as flooding, tsunamis, earthquakes, plane crashes, train crashes and terrorist attacks are responsible for many deaths where sometimes fragmented or dismembered humans are found. In that case, identification of the physical identity of anyone is very difficult.² Through an anthropometric tool called stature, physical identity can be easily recognized. Anthropometric measurement includes various body parts like the length of long bones, arm span, length of the hand, foot length, demi-span, etc. This in-depth study of literature aims to make a systematic review to find out reliable anthropometric dependent stature estimation variables for using different purposes. Among the parameters described, the most reliable was found to be the use of arm span for stature

estimation. However, the correlation coefficient is varied for different races.³

This is a systematic review and here the literature searches were comprehensive. For searching articles, the database includes Google scholar, Scopus, Research Gate, PubMed and MEDLINE and where the keyword was anthropometry, Stature, arm span, models and related topics where the duplicates were sorted out by using Endnote X7 software for managing references. Title and abstracts were screened carefully and studies that are related to the study were included. Initially, 50 articles were selected, 15 of them were found unrelated, 11 were duplicate and 4 were not full-text hence excluded from the study. Only full-texted articles were included and otherwise excluded and disagreement was also resolved through discussions. All articles that are included in this review were checked twice by authors.

Twenty articles were finally selected for this study. These were with different anthropometric variables such as arm span, knee height, sitting height, forearm length, demi span, bi-axillary length, humeral length, hand length, thigh length, foot length, weight, standing height, half arm span,

Corresponding Author:

Pinki Rai, PhD Scholar, Department of Anatomy, SGT Medical College and Hospital, Gurugram, India.
Contact: 9050675237; Email: pinkiraishkmgmc@gmail.com

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leg length were examined in the estimation of stature from different previous studies and summary are given in table 1 and table 2 with details. Among all anthropometric variables, arm span is most reliable for the estimation of stature.¹⁻⁴ In another study, it also found that standing height and arm span measurement were also proved to be an ideal tool for estimating the stature of individuals.² The sitting height, standing height and arm span and leg length could be applied for the quantification of age-related decline in stature and the identification of individuals with abnormalities of growth and skeletal development.⁵⁻⁷ It also identified that the height to span ratio less suitable method of estimation of height than the using regression equation for the same.⁸ Forearm morphology helped in the estimation of stature and there was a relation between them. Some factors interfered with the anthropometric dependent stature measurement.^{3,8}

These factors included patient's vertebral anomalies, paralysis, limb debility, and other associated conditions, but in this case, measurement of nutritional status can be possible with these type of patients.^{3,7,9}

Arm-span studies

Arm-span studies were grouped together and critically analyzed. There were varying sample sizes among these studies. Any kind of skeletal deformity was a prevalent exclusion parameter in all studies. Some of them had studied multiple parameters for comparison but the main focus was on reliability of arm span in determining the stature in that particular population.^{1,9} Development of the separate model for stature has also been suggested.¹⁰ The data used for analyzing literature has been summarized in the Table 1.

Table 1: Summary of arm span data used in stature estimation.

Anthropometric variables	Study Samples		Inclusion/Exclusion criteria	Details in the Stature	References
	Size	Type			
Arm span	1475	Pulmonary patients relatives, school children and teachers	Exclude: chest, spine and or limb deformities	Height estimated from arm span, performs much better than arm span to predict pulmonary function parameters	Golshan, Amra and Hoghog, 2003. ¹
Arm span	631	Patients	Exclude: aged 15 years or less, structural defects, chest or upper limb deformities, Marfan's syndrome, acromegaly, dwarfism and kyphoscoliosis	Height to span ratio less suitable method of estimation of height than the use of regression equation	Aggarwal et al., 2000 ⁸
Arm span	285	Students	-	Separate height models development is necessity for ethnic difference measurement	Bjelica et al., 2012 ¹¹
Arm Span	212	Students	Exclusion: Body height affected physical deformities	Separate height models development is necessity for ethnic difference measurement	Popovic et al. 2016 ¹⁰
Arm Span	517	Patients	Absence of any spinal and other abnormality with limbs	Regression is the most appropriate methods of estimating height from the arm span	Chhabra. 2008 ¹²
Arm Span	150	MBBS students	-	Reliable body parameter for estimating the height of an individual with high accuracy	Shah et al. 2013 ⁴
Arm Span	394	Students	Exclude: physical deformities that could affect body height or arm span, and without informed consent	Separate height models development is necessity for ethnic difference measurement	Popovic et al. 2013 ¹³
Arm span	626	Students	Children	Equation dependent children height estimation whom height cannot be reliably measured was established	Zverev and Chisi, 2005 ⁶
Arm Span	200	Medical students	Inclusion: 21-23 year of age Exclusion: orthopaedic problems and metabolic disorders	Arm span had a significant correlation in the estimation of stature	Mandhana et al. 2020 ¹⁴

The majority of the studies mentioned in table:1 favoured the efficacy of arm span in predicting stature^{1,4,12,14} but to use it independently as a tool was not justified.^{6,10,13}

Stature estimation

The studies using multiple parameters to depict height of an individual were grouped. Critical analysis of this part of the literature was interesting and more reliable as the sample siz-

es were enough to interpret the outcomes. The studies have supported the racial, gender and age-related differences in the prediction of a statute using different parameters. Among all other parameters, arm span had a comparatively more accurate estimation of stature and varied from population to population. Various parameters which were used along with arm-span are summed up in the table:2 with details mentioned in literature.

Table 2: Summary of multiple variables that are used in stature estimation

Anthropometric variables	Study Samples		Included/including criteria	Details in the Stature	References
	Size	Type			
Arm span, knee height and sitting height	110	55 years old or older	Include: live alone or with family, healthy, were still able to stand up straight and to spread both arms perfectly	Measurement difficulties were found for older actual height if they had vertebrae disorder, paralysis, disability, and other conditions, but nutritional status can be measured	Fatmah, 2010 ⁹
Arm span and foot length	1000	Randomly selected people	Include: Ijaws and Ikwerre individuals	Racial differences were found among individuals male vs male and female vs female	Ogoun et al, 2013 ¹⁵
Forearm length	300	MBBS students	Individuals had no skeletal or pathological changes	Forearm morphology helps in the estimation of stature and there is a relation between them.	Mohanty et al. 2013 ³
Height, demi-span, biaxillary length, humeral length, forearm length, hand length, thigh length, knee height and foot length	200	Healthy Thai volunteers	Exclude: less than 18 years old, amputated extremity(s), incapability of ambulation, failure to lie down, chronic diseases such as liver cirrhosis, kidney failure, chronic use of steroid and edematous limb.	Demi-span, sitting height, knee height and their combination could be applied to height prediction in the adult	Chittawatanarat et al. 2012 ⁶
Arm span, knee height and sitting height	200	Senior citizens	Include: men and women, aged over 60 years, able-bodied, stand still and resided in Jakarta and Depok	Arm span, knee height and sitting height can be used for assessing elders nutritional status	Fatmah and Erwin. 2012 ⁷
Arm span, foot length	400	Student	-	Deviation of the height calculated using arm span from the actual height of were found to be less as compared to the height calculated using the foot length	Singh et al. 2012 ⁵
Hand length	150	Medical students	Include: Asymptomatic, apparently healthy, adolescent and adult	Strong correlation between stature and hand length	Patel et al. 2014 ¹⁸
Physical statures	6,981	Randomly selected individuals	-	no clear relationship between reductions in height and measures of childhood SES or childhood health	Fernihough & McGovern, 2015 ¹⁹
Weight, standing height, arm span, half arm span, demi span and knee height	200	Out-patients, staff and residents	Include adults, elderly people without limb abnormalities, kyphosis, edema or dehydration, using diuretic drugs.	Standing height and arm span ideal technique for estimating the stature of individuals	Shahar and Pooy, 2003 ²

Table 2: (Continued)

Anthropometric variables	Study Samples		Included/including criteria	Details in the Stature	References
	Size	Type			
Sitting height, standing height, arm span and leg length	505	Randomly selected women	Include: healthy women in the age group of 20–29	All tested variables can be used in the quantification the age-related loss in stature and the identification of individuals with abnormal growth of the skeleton.	Mohanty et al. 2001 ⁷
Height and foot length	100	Medical students	Inclusion: female students Exclusion: skeletal deformities	Regression equation derived from data predicted the stature very well	Soontnoore et al. 2013 ²⁰

Demi-span, sitting height, knee height and their combination could be applied to height prediction of adult individuals with acceptable error. In another study, it was also revealed that hand length was strongly correlated with the stature.¹⁸ It also found that separate height models development was necessary for ethnic difference measurement.^{10,11,13} Ogoun et al. 2013 reported that individuals with racial differences were different in anthropometric parameters too.¹⁵ Erwin & Fatmah observed that the arm span, knee height and sitting height can be used for assessing elder's nutritional status.¹⁷ Among all statistical methods, regression is the most appropriate method for estimation of height from the arm span.¹²

CONCLUSION

Recently, stature estimation is very necessary for easy identification or detection of individuals or patients in clinical and non-clinical settings. A review of various body parameters for anthropometric dependent stature estimation was the main objective of this study. Among all anthropometric variables, the arm span is more accurate and reliable variable for stature estimation, but, some authors also provided contradictory information about this statement. However, the stature varies among different populations so no standard formula can be applied to all. But for a particular population, the results are more or less similar. Moreover, according to the above discussion, anthropometry is very useful for the prediction of stature estimation but the results vary population to population.

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