British Journal of Bio-Medical Research Vol.03, Issue 04, Pg.983 - 999, July - August 2019

Available Online at http://www.bjbmr.org

BRITISH JOURNAL OF BIO-MEDICAL RESEARCH

Cross Ref DOI: https://doi.org/10.24942/bjbmr.2019.529 Volume 03, Issue 04, July -August 2019

ISSN:2456-9739

Research Article

Use Of Arm-span In Nutritional Assessment Of Elderly And Non-ambulatory Individuals Of Tribal Area Of Central India

Shweta B. Shambharkar[1], Bharti Yadav[2], Manoj Talapalliwar[3] ,Vinaram P Rukhmode[4]

[1]Assistant Professor, Dept. of Anatomy, Govt. Medical College, Gondia, Maharashtra (India).
[2]Student, Second M.B.B.S., Govt. Medical College, Gondia, Maharashtra (India).
[3]Associate Professor, Dept. of Community Medicine, Member of Medical Education and Technology Cell, Govt. Medical College, Gondia, Maharashtra (India).
[4]Professor and Head, Dept. of Anatomy, Govt. Medical College, Gondia, Maharashtra (India).

ARTICLE INFO

Article History:
Received on 09th July 2019
Peer Reviewed on 24th July 2019
Revised on 15th August 2019
Published on 29th August 2019

Keywords:
Arm-span, BMI, BMI-Ht, BMI-As, Elderly

ABSTRACT

Background: The use of body mass index (BMI) in the elderly is limited by the measurement of height which is often unreliable. Arm-span approximates to height at maturity. As stature varies with age owing to spinal deformities like kyphosis, scoliosis or alterations in shape of vertebral discs, it is necessary to estimate true height, which can be done by establishing the relationship between arm-span and height as an effective surrogate measure to calculate BMI. **Objective:** To evaluate the use of arm-span as an alternative to standing height for calculation of BMI amongst older individuals. **Study design:** The study is an observational cross-sectional study carried out among 400 geriatric populations attending tertiary care teaching institute of tribal area of central India. BMI based on height (BMI-Ht) and BMI based on arm-span (BMI-As) were calculated and compared using regression equations. **Result:** The mean arm-span (164.99 in men and 153.65 in women) was seen to be more than the mean height (160.87 in men and 151.22 in women) in both genders. There was a strong correlation between height and arm-span in both the genders. The BMI-As (18.336 in men and19.282 in women) was lower than the BMI-Ht (19.247 in men and 19.922 in women) in both the genders. As per BMI arm-span, the proportion of malnutrition was higher as compared to BMI-height. **Conclusion:** Arm-span could be a better alternative to height in calculating BMI and so the nutritional status, assessing pulmonary function, body surface area for drug dosage, renal clearance, and other purposes.

Corresponding Author: *Shweta B. Shambharkar, Assistant Professor, Dept. of Anatomy, Govt. Medical College, Gondia, Maharashtra (India).*

INTRODUCTION

Obtaining accurate height estimate is important for calculating nutritional status[1,2] using body mass index [BMI], basal energy expenditure, basal metabolic rate, pulmonary function, vital capacity[3], determining body surface area for drug dosages, nutrient requirements[4] and renal clearance, creatinine height index, and other patient care issues. However, measuring height can be difficult for older individuals, who cannot stand, or who have various physical anomalies such as spasticity, contractures, fractures, amputations, scoliosis, kyphosis, paralysis, or osteoporosis. Standing height is also difficult to obtain in hospitalized and bedridden patients. Investigators have assessed the validity of arm-span, demi-span, half arm-span, knee-height, foot length as potential height estimates for use in these groups in lieu of standing height[5]. Arm-span could be a better alternative instead of height in calculating BMI and so the nutritional status. Poor nutritional status is common among the elderly, and is associated with increased morbidity and mortality. Yet, until recently, there has been little research on the nutritional status of the elderly. Ageing is accompanied by changes in the body composition and stature. Functional decline is a reality for the elderly. Using height in calculating BMI could be inappropriate because of height loss with ageing due to compression of vertebrae, thinning of vertebral disc, kyphosis, genu valgum and varus deformities due to decreased muscle strength and osteoporosis; and so, inability to stand erect or steadily due to pain. It might be that by using height in calculating BMI, the prevalence of chronic energy deficiency in elderly is under-estimated. Arm-span is relatively independent of ageing because the length of long bones i.e. those in arms and legs, do not change with age, unlike vertebral height and spine length; and is highly related to the height of an individual. Therefore, to predict the prevalence of undernutrition in elderly it may be more reliable to use armspan[6]. Most of the studies that looked at the association between arm-span and height have focused on Caucasian subjects.Some studies in India from Darjeeling (West Bengal) and Karnataka have reported on the relationship between arm-span and height. However, these were carried out in younger people. In India, there are limited published data in elderly persons to study this relationship[7].

AIMS AND OBJECTIVES:

1. To evaluate the use of arm span as a proxy for height in the assessment of nutritional status of elderly using body mass index (BMI).
2. To find the correlation between the arm span and standing height.

METHODOLOGY:

1. **Study design:** This is an observational cross-sectional study carried out in 400 men and women above 50 years attending tertiary care teaching institute of tribal area of central India.
2. **Study setting:** The out-patient and in-patient departments of Kunwar Tilak Singh (KTS) Government hospital and Medical College.
3. **Study population:** All men and women attending out-patient and in-patient departments of tertiary care teaching hospital (KTS), Gondia, Maharashtra, India, above 50 years of age.
   a) **Inclusion criteria:** All men and women above 50 years, non-ambulatory individuals, those with hemiparesis, paraparesis, patients with lower limb deformities like kyphoscoliosis, valgus and varus deformity of lower limbs, club foot, poliomyelitisetc.
   b) **Exclusion criteria:** All young and adult individuals less than 50 years, children, pregnant women, significant edema, metabolic diseases, cancers, muscular pathology, abnormally short individuals with congenital disorders like Turner's syndrome, Achondroplasia; abnormally long individuals like Marfan's syndrome, Klinefelter's syndrome; individuals with upper limb deformities like cubitus valgus or varus, orthopedic conditions like joint stiffness, elbow joint

contractures, any pathological condition of upper limb; individuals who refused to give written consent were excluded from the study.

4. **Sample size:** It was calculated using 95% confidence interval, as 400, amongst which 225 were men and 175 were women.
5. **Data collection:** Data was collected in the period of two months from 1st May to 30ieth June, 2018. In our study, a predesigned pretested questionnaire was used. Face to face interview was taken to ask the relevant information. In case, the participant is unable to answer, the accompanying person was interviewed.
6. **Sampling procedure:** We evaluated 10 patients every day from our tertiary care hospital in the period of two months.
7. **Materials used**: Digital weighing machine was used to calculate weight in kilograms. Stadiometer was used to calculate standing height in centimeters with the participant standing without footwear against the scale, upright, looking straight ahead at Frankfurt's plane. Calibrated steel tape was used to calculate height in non-ambulatory individuals and the arm-span in all the study subjects in centimeters. Arm-span was measured with participants standing against the wall, looking straight eye level, with arms abducted at 90^0 at shoulder level and palms' facing forwards; then the flexible steel tape was extended from the tip of the middle finger of one hand straight across the chest to the tip of the middle finger of the other hand.
8. **Data analysis:** Descriptive statistics like mean (SD) of weight, height, arm-span, and BMI were calculated by gender wise distribution. BMI based on height was calculated for both genders and defined as BMI-Ht=weight/height^2 (kg/m^2). BMI based on arm span was calculated and defined as BMI-As=weight/armspan^2 (kg/m^2). Confidentiality was strictly adhered to and identification number rather than names were used during the analysis. Comparison was done using regression equations. Correlation were tested between height and arm-span and the BMI-As and BMI-Ht using Pearson's product moment correlation coefficient(r). Linear regression analysis was performed to estimate the change of height with one unit change of arm-span; as well as to correlate BMI-Ht and BMI-As. Using BMI, nutritional status of individuals was assessed and categorization was done as malnourished, normal, overweight and obese. An agreement was established between BMI-Ht and BMI-As. We established cut-off values for arm-span and tested its accuracy, as height has established standard cut-off values; but as arm-span shows significant difference with height and its cut-off values are not established to categorize the nutritional status with respect to BMI-As.
9. **Ethical consideration:**

The study is an observational cross-sectional study community-based study carried out in tribal area of central India. Prior approval of institutional ethics committee was taken. The study population included men and women above 50 years and non-ambulatory individuals attending tertiary care teaching institute of tribal area of central India. A total of 400 population by taking minimum 50% prevalence sample size was calculated. Written informed consent was taken from all the participants and they were informed about their voluntary participation. The study period was two months between 1stMay 2018 to 30thSeptember 2018. The study is focused on relationship between height and arm-span. The relationship is not affected by socio-economic and related factors.

IMPLICATIONS: The study will investigate the relationship between height and arm span in elderly and non-ambulatory elderly individuals. The feasibility of arm-span measurement in immobile elderly individuals will be studied as proxy measure to standing height. It will be helpful in assessing the nutritional status in elderly and non-ambulatory individuals.

RESULTS: A total of 400 elderly persons participated in the study, amongst which 225(56.25%) were men and 175(43.75%) were women. The mean and standard deviation of anthropometric variables of individuals by gender are presented inTable.1. The mean age of men and women was 61.26(9.347) and 59.14(8.733) years respectively. The mean height and arm-span amongst men were 160.87(7.873) and 164.99(9.233) respectively while the mean height and arm-span amongst women were 151.22(7.134) and 153.65(7.907) respectively. This shows that the mean arm-span was significantly more than the mean height in both the genders. Men had a higher mean arm-span and height as compared to women. Similarly, the mean BMI-Height was 19.247(3.311) in men and 19.922(3.726) in women; and the mean BMI-Arm-span was 18.336(3.289) in men and 19.282(3.640) in women. Statistically significant differences were observed between the body mass index (BMI) derived using height and arm-span amongst both genders. BMI derived using arm-span was lower than the BMI derived using height in both the genders.

Table: 1. Mean and Standard Deviation (SD) age and anthropometric values by gender

	Men (n=225)		**Women (n=175)**	
Particulars	Mean	SD	Mean	SD
Age in yrs	61.26	9.347	59.14	8.733
WT (kg)	49.85	9.519	45.55	9.262
HT (cm)	160.87	7.873	151.12	7.134
Arm Span(cm)	164.99	9.233	153.65	7.907
BMI-ht (kg/m^2)	19.247	3.311	19.922	3.726
BMI-as (kg/m^2)	18.336	3.289	19.282	3.6404

There was a strong correlation between arm-span and height when analyzed by gender ($p<0.001$). Regression analysis was done for men and women separately and variance(R-square) was calculated. R-square indicates the proportion of variability in height which can be explained by arm-span. It was seen that R-square was higher in men than in women. For every unit of increase of arm-span in men, there was 0.876cm significant increase in height ($p<0.001$). In women, height increased significantly by 0.848cm per 1cm increase in arm-span ($p<0.001$)-Table.2.

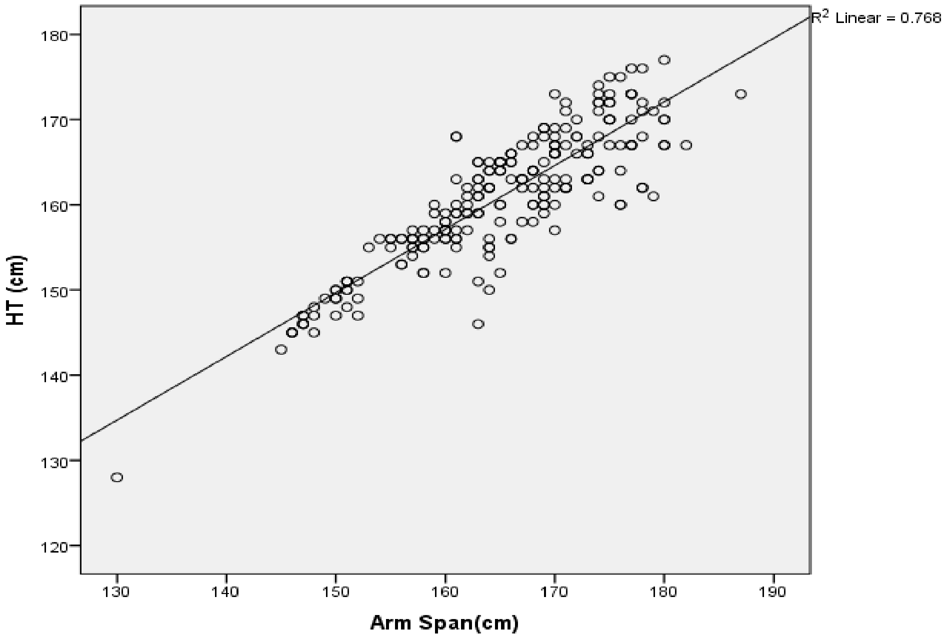
Table: 2. Mean anthropometric values and correlation coefficients by gender

Particulars	Arm-span	Height	Difference(95%CI)	Pearson Correlation(r)	t value*
Men					
Length(cm)	164.99	160.87	4.12	0.876	13.861
BMI(kg/m^2)	18.336	19.247	-0.911	0.955	13.848
Women					
Length(cm)	153.65	151.12	2.53	0.848	8.075
BMI(kg/m^2)	19.282	19.922	-0.64	0.960	7.944

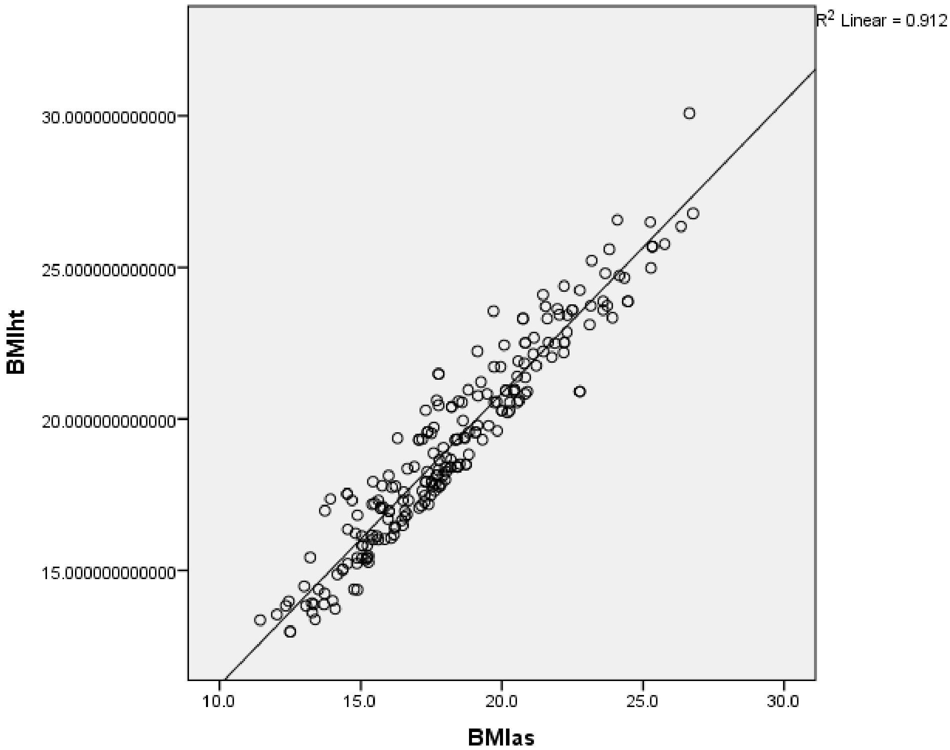
**$p<0.001$ for all variables.*

The present study has shown that there was strong correlation between arm-span and height among both men and women- Graph 1 to 4. r^2 for men was 0.768 and for women, r^2 was 0.719. A linear relationship is seen between the two variables: arm span-height and BMI-arm span – BMI-height.

Graph 1. Showing linear relationship between height and armspan in men

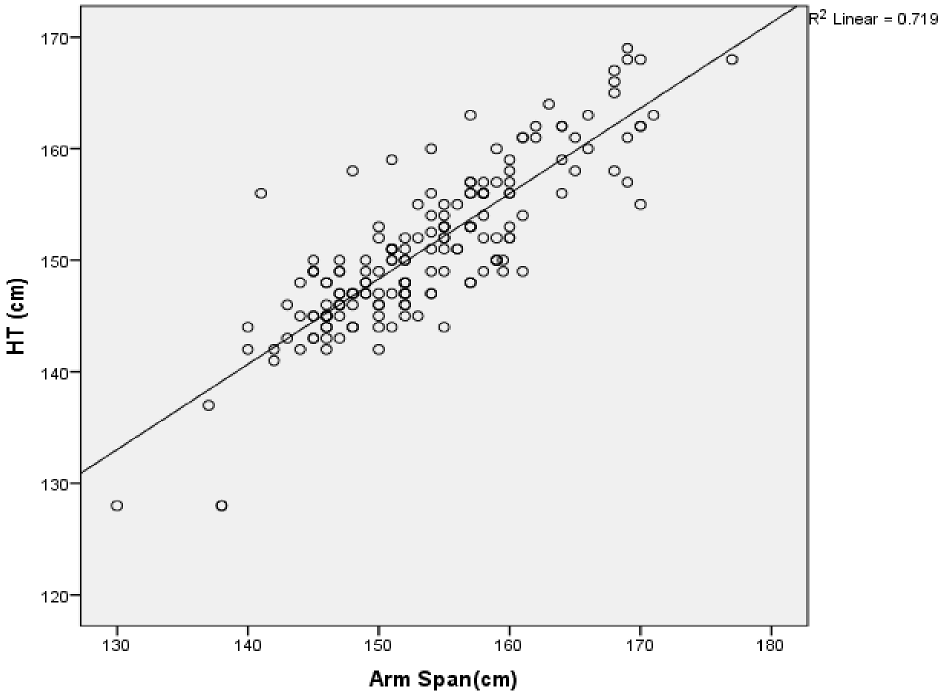


Graph 2. Showing linear relationship between BMI-Ht and BMI-As in men

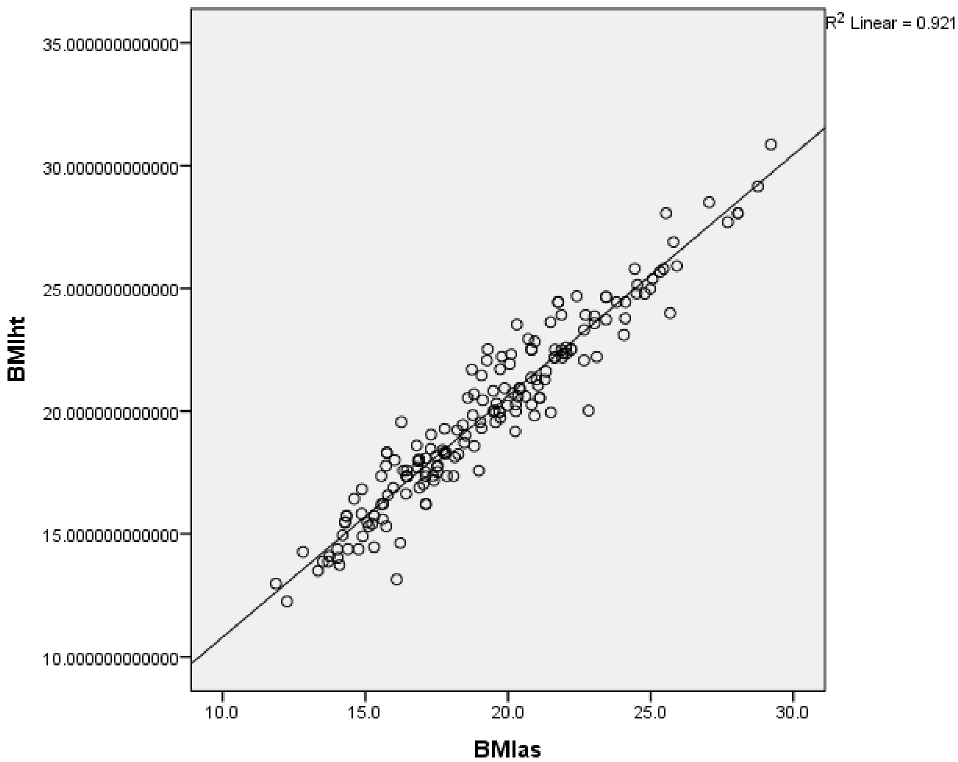


.

Graph 3. Showing linear relationship between height and armspan in women



Graph 4. Showing linear relationship between BMI-Ht and BMI-As in women



Graph 1: The correlation(r) between arm-span and height among men was 0.876.
Graph 2: The correlation(r) between BMI-arm span and BMI-height among men was 0.955.
Graph 3: The correlation(r) between arm-span and height among women was 0.848.
Graph 4: The correlation(r) between BMI-arm span and BMI-height among women was 0.960.

The BMI derived using length of arm-span was significantly ($p<0.001$) lower than the BMI derived using height in both the genders. While the correlation between BMI-height and BMI-arm span was 0.955 and 0.960 amongst men and women respectively.

The nutritional status of older adults as per the BMI calculated using both arm-span and height is presented in Table.3. The categorization of individuals according to nutritional status was done as: Malnourished, Normal, Overweight and Obese as per WHO standards. When categorized using BMI-arm span, the proportion of malnutrition was higher as compared to BMI-height. While the proportion of overweight and obese was higher when categorized using BMI-height as compared to BMI-arm span.

Table: 3. Nutritional Status of elderly as per BMI calculated using both height and arm-span

Particulars	No.	Malnourished	Normal	Overweight	Obese	Pearson c^2
Men						
BMI-As	225	58.2	37.8	4	0	299.443
BMI-Ht	225	48.2	46.8	4.5	0.5	
Women						
BMI-As	175	44.8	47.7	7.5	0	274.682
BMI-Ht	175	41.4	50.6	7.5	0.6	
Pooled						
BMI-As	400	52.4	42.1	5.5	0	572.993
BMI-Ht	400	45.2	48.5	5.8	0.5	

The agreement between the BMI-arm span and BMI-height was established as presented in Table.4. The agreement between the BMI-arm span and BMI-height was high among the normal subjects than with other categories, with measure of agreement Kappa being 0.818 which is significant statistically ($p<0.001$).

Table:4. Agreement between BMI-Arm span and BMI-Height by gender

BMI-Arm span	BMI-Height				
	N	Malnourished	Normal	Overweight	Obese
Men					
Malnourished	131	107	24	00	00
Normal	83	00	80	03	00
Overweight	08	00	00	07	01
Obese	00	00	00	01	00
Pooled	222	107	104	10	01
Women					
Malnourished	78	71	07	00	00
Normal	83	01	80	02	00
Overweight	13	00	01	11	01
Obese	00	00	00	00	00
Pooled	174	72	88	13	01
Total					
Malnourished	209	178	31	00	00

Normal	166	01	160	05	00
Overweight	21	00	01	18	02
Obese	00	00	00	00	00
Pooled	396	179	192	23	02

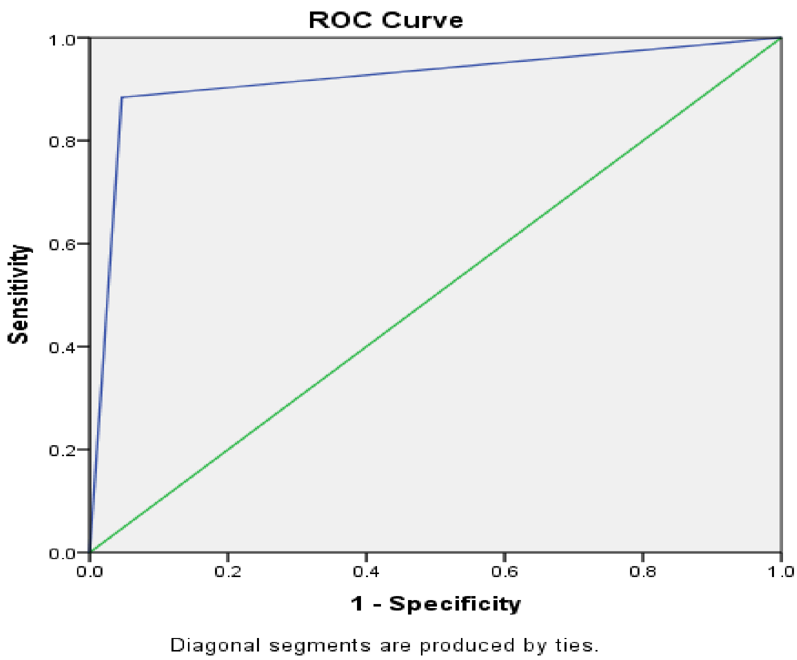
The cut-off values for BMI-height are already established to categorize the individuals according to their nutritional status; but as we have observed the differences in lengths of arm-span and height, more so in elderly when compared with other studies carried in younger population, we derived BMI-arm span cut-off values equivalent to BMI-height cut-off values using linear regression as presented in Table.5.

Table.5. Derivation of BMI-Arm-span cut-off values equivalent to BMI-Height cut-off values

BMI-Height	BMI-Arm-span
18.5	BMI-As=0.234+0.947*(BMI-Ht) =0.234+0.947*18.5 =17.75
25	BMI-As=0.234+0.947*(BMI-Ht) =0.234+0.947*25 =23.909
30	BMI-As=0.234+0.947*(BMI-Ht) =0.234+0.947*30 =28.644

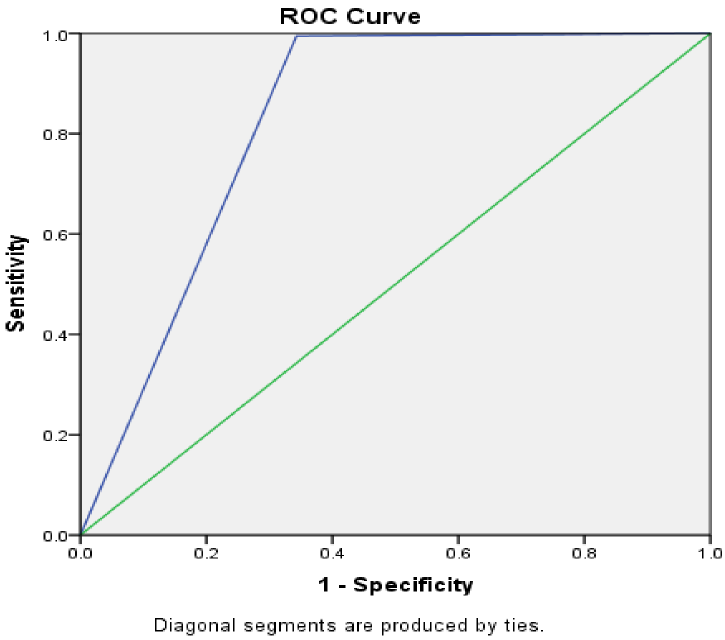
The cut-off values for BMI-Armspan thus obtained were 17.75 for malnourished, 23.909 for normal and 28.644 for overweight. The accuracy of these cut-off values was tested using ROC curves presented in Fig.1 to 3.

Fig.1. Estimation of area under curve (AUC) through ROC curve for BMI-As (17.75) equivalent to BMI-Ht(18.5)



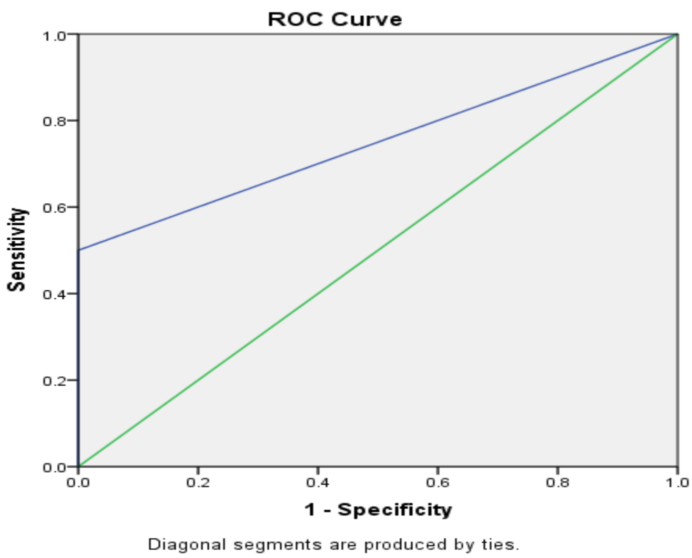
The area under curve (AOC) in Fig.1 is 91.8%, which means the accuracy is 91.8%.

Fig.2. Estimation of area under curve (AUC) through ROC curve for BMI-As(23.909) equivalent to BMI-Ht(25)



The area under curve (AOC) in Fig.2 is 82.6%, which means the accuracy is 82.6%.

Fig.3. Estimation of area under curve(AUC) through ROC curve for BMI-As(28.644) equivalent to BMI-Ht(30)



The area under curve (AOC) in Fig.3 is 75%, which means the accuracy is 75%.

DISCUSSION:

Kwok T etal[8] in 1991 studied the relationship between height and arm-span in 101 elderly men and women. A comparison of BMI by height and arm-span was made. The correlation between height and arm-span was 0.93. The mean difference between BMI-Ht and BMI-As was 1.79 (SD 1.11); so concluded that arm-spans is a reliable and practical estimate of height in the non-ambulant elderly. B Rabe etal[6], in a study "Body mass index of the elderly derived from height and from arm-span" undertook a study on

69 elderly (36 women and 33 men) aged 60-69 years in Indonesia. The inter-relationships of height and arm-span were examined. The correlation coefficient for the regression of the two measures were $r=0.83$ and $r=0.81$ ($p<0.001$) for women and men respectively. Substituting the arm-span term in the denominator to compose a Body Mass using Arm-span (BMA) Index, they observed for this population a 32% increase in estimates for Chronic Energy Deficiency (CED) for women and 24% increase in estimates of CED for men. Corresponding estimates for obesity rates declined by 45% and 81% respectively. de Lucia E et al[9] in 2002, studied a total of 1706 Ethiopians i.e. 884 males and 822 females aged 18-50 years from four different ethnic groups. BMI using height and arm-span were calculated and compared. BMI-Ht (0.83-0.9) and BMI-As (0.89-0.97) were highly correlated in the ethnic groups. They concluded that arm-span can be used as a proxy for height to estimate BMI, but the two measures varies considerably with ethnicity and sex. Dr. N Arlappa et al[10] in 2011-12 discussed that the conventional height is not a reliable anthropometric measurement for the assessment of nutritional status of older adults, where the BMI-height model overestimated the nutritional status of older adults compared to the BMI- arm span model. Therefore, arm span is the best alternative to height for calculation of body mass index (BMI) in older adults. A community-based cross sectional study was carried out during 2011-12 among 400 (Men: 180; Women: 220) urban geriatric population (age 60-years and over)of the town of Khammam in Telangana, India. Weight, height and arm-span were measured with standard procedures. Nutritional status of older adults was calculated by body mass index (BMI) classification using both height and arm span. Height data were obtained for 141 wheelchair users by Froehlich-Grobe et al[5]. Height estimates included asking for self-report and measuring recumbent length, knee height, and arm-span. Findings indicated that the four measures yielded significantly different height estimates and BMI values for both men and women. For both sexes, arm-span resulted in the longest estimate and measured recumbent length the shortest, with the reverse pattern for BMI values. The common variance estimates were outstanding for recumbent length (92%) and knee height (>83%) and very good for self-report (>75%), while the common variance for arm-span was poor (<42%). In a study "Relationship between height and arm-span of elderly persons in an urban colony of New Delhi" by Anil Kumar Goswami et al[7], a community based cross-sectional study was conducted on 711 elderly (298 men and 431 women). Arm-span and height of persons 60 years and above were measured. The mean arm-span (160+/_11.3cm) of the participants was more than the mean height (152+/_9.1cm). Men had higher mean arm-span and height as compared to women. There was a strong correlation between arm-span and height when analyzed by gender ($p<0.001$). The overall regression coefficient was 0.73 for men which indicate that for every unit of increase in arm-span, there was 0.73cm significant increase in height. In women, height increased significantly by 0.70cm per 1cm increase in arm-span. They concluded that there was strong association between arm-span and height among both men and women. V Hirani and J Mindell[11] examined differences between measured height and demi-span equivalent height (DEH) among people aged≥65 and investigated the impact on body mass index (BMI) of using DEH. The height measurement was lower than the DEH from age group 70–74 years onwards in men and in each age group in women. The prevalence of underweight was lower when using measured height than when using DEH in women aged ≥65, particularly in those aged 80 years and over. The prevalence of overweight and obesity was higher using measured height than DEH in women aged≥65. They confirmed in a large nationally representative sample that demi-span measurement may be a useful estimate of stature in people (particularly women) aged ≥65 for BMI calculations. In a study "Relationship between arm-span and height among elderly persons in a rural area of Ballabgarh, Haryana, India, by Jamir L et al[12], a total of 528 elderly persons (237 men and 291 women) enumerated in the three randomly selected villages. The mean arm-span (164.4+/_11.1cm) of the elderly participants was higher than the mean height (156+/_9.1cm). Males had a higher mean arm-span (173.6+/_7.6cm) and height (163+/_6.8cm) as

compared to females (arm-span 156.8+/_6.9cm; height 150.1+/_5.6cm). Arm-span was consistently more than height in all age groups with an average difference in mean arm-span and height of 8-9cm. Arm-span correlated well with height in all age groups; whereas for every 1cm increase in arm-span, there was 0.69cm increase in height, keeping gender constant. Hence, they concluded that arm-span is a good predictor of height among elderly persons. However, their study findings may be limited to rural settings. In a study "The relationships between height and arm-span, mid-upper arm and waist circumferences and sum of four skin folds in Ellisras rural children aged 8-18 years" by KD Moyenki and MM Sekhotha[13], they undertook study at 22 schools randomly selected within Ellisras area, Limpopo Province, South Africa. The sample population comprised 1769 children (911 boys, 858 girls) aged 8-18 years. Mean height (137.6 to 162.2cm) was found to be higher than arm-span(125.7 to 157.4cm) throughout all age groups for Ellisras rural boys and girls with difference ranging from 4 to 11.5 cm. Height and arm-span showed a highly significant ($p<0.001$) relationship with correlation coefficient ranging from 0.74 to 0.91 in both boys and girls throughout the age range. They concluded that arm-span was a significant predictor of height in all the age groups for both boys and girls. Melo et al[14] compared the values obtained through methods directed to height and body weight estimates in relation to measurements taken from hospitalized adult. Study participants were 142 adults of both genders. Anthropometric measurements of body weight, height, knee height, arm length, span, demi-span, recumbent height, calf, arm and abdominal circumferences and subscapular skin fold thickness were taken. The estimated height by the formula
that utilizes the variable knee height among men was the only measurement which did not represent significant differences. Other methodologies for estimating body weight and height presented significant differences, which suggest that new studies using other methodologies are necessary. Hickson and Frost[15] found moderate correlation between direct height measurements and other methods for estimating height: half arm-span ($r = 0.86$; $p < 0.01$), arm-span ($r = 0.87$; $p < 0.01$) and knee height ($r = 0.89$; $p < 0.01$). One of the most prominent physiological changes of the aging process is found in body composition, such as diminution in height[16]. The process, which is different in men and women, begins around the age of 40, with a height reduction of 2 to 3cm per decade increasing progressively with age[17,18]. Physiological changes and illness characteristics associated with aging are important factors among the possible causes of height reduction, including: flattening of the vertebrae, reduction in intervertebral disc thickness, dorsal kyphosis, scoliosis, bowing of the legs, and flattening of the plantar arch[18]. However, when *used alone,* this index is deemed to have limited effectiveness as a good indicator of nutritional status in the elderly because it does not reflect body fat redistribution and excludes height reduction[16,19]. Reduction in height may lead to an overestimation of BMI, with consequent overestimation of overweight and underestimation of underweight. The possible impact of height on BMI indicates that there is a need to develop alternative ways of estimating height among elderly who were bedridden, confined to wheelchairs, and unable to stand for benchmarking[20]. Improving estimations of height allows for a more accurate definition of BMI. Several alternative methods for estimating height are mentioned in the literature, such as measurements of arm-span[8,21,22], half arm-span[23,24] and knee height[4,25].

The present study was aimed at assessing the relationship between height and arms pan of elderly. Older people are becoming an increasingly important proportion of the population of developing countries, yet little information exists on their nutritional status[26]. The use of alternative measurements of stature such as arm span were easier to obtain in older people and may be more accurate than standing height measurement. Inaccurate height measurements can lead to discrepancies in BMI. Height may underestimate the prevalence of underweight and overestimate the prevalence of overweight[11]. Several studies have shown that height reduces with advancing age[18,19] and height loss is even greater after 80 years. Arm length is less affected than the height by the ageing process, so it should be considered as an alternative to stature when assessing the nutritional status of elderly[1].

In the present study, the mean height and arm span amongst men were 160.87(7.873) and 164.99(9.233) respectively while the mean height and arm span amongst women were 151.22(7.134) and 153.65(7.907) respectively. This shows that the mean arm span was significantly more than the mean height in both the genders. Men had a higher mean arm span and height as compared to women. Similarly, the mean BMI-Height was 19.247(3.311) in men and 19.922(3.726) in women; and the mean BMI-Arm span was 18.336(3.289) in men and 19.282(3.640) in women. Statistically significant differences were observed between the body mass index (BMI) derived using height and arm span amongst both genders. BMI derived using arm-span was lower than the BMI derived using height in both the genders. Goswami etal[7] in his study observed that the mean arm span was more than the mean height in all age groups. This was true for both men and women. A study from rural Haryana reported that the mean arm span (164.4 ± 11.1 cm) was higher than the mean height (156.1 ± 9.1 cm). Arm span was found to be consistently more than height in all the age groups, with an average difference in the mean arm span and height of 8–9 cm. Similar findings were also reported from studies by Chilima and Ismail[26]. KD Monyeki etal[13] recorded longer mean height than arm span among Ellisras rural children. Similar results were reported by Lucia etal[9]for the four ethnic groups Oromo, Ambara, Tigre and Somali in Ethiopia. Furthermore, Yabanci etal[27] reported shorter arm span compared with height among Turkish children aged 7–14 years. The results of the present study exhibit different trends from earlier reports. In Malawian children and Indian children arm span was found to be higher than height[2,28,29]. The relationship between arm span and height as well as estimation of height from long skeletal bones amongst different age groups and gender was studied by different authors in India. However, such studies were not readily available amongst the geriatric population in India. Arlappa N[10] studied the relationship between length of the arm span and standing height amongst the older adults in India. In general, significant ($p<0.001$) differences were observed between the mean arm span and height as well as in BMIs calculated using both arm span and height amongst older adults of both genders. The length of the arm span in both genders was significantly ($p<0.001$) higher than their standing height and the difference was relatively higher amongst men (10.8 cm) as compared to women (9.2 cm). The difference between arm span and height amongst Malaysian elderly men (7.7 cm) and women (6.1cm) was comparable to our study[50]. However, Kwok et al[8] (2001) reported no difference between the length of the arm span and height amongst Chinese elderly men (6.4cm) and women (6.3cm). While, in general, Allen[31] (1989) reported the mean difference between arm span and height as 4.7 cm (range -5 to + 17) amongst the elderly.

There was a strong correlation between arm span and height when analyzed by gender ($p<0.001$). Regression analysis was done for men and women separately and variance(R-square) was calculated. R-square indicates the proportion of variability in height which can be explained by arm span. It was seen that R-square was higher in men than in women. For every unit of increase of arm span in men, there was 0.876cm significant increase in height ($p<0.001$). In women, height increased significantly by 0.848cm per 1cm increase in arm span. The correlation(r) between arm span and height among men was 0.876. The correlation(r) between BMI-arm span and BMI-height among men was 0.955. The correlation(r) between arm span and height among women was 0.848. The correlation(r) between BMI-arm span and BMI-height among women was 0.960.

The BMI derived using length of arm span was significantly ($p<0.001$) lower than the BMI derived using height in both the genders. While the correlation between BMI-height and BMI-arm span was 0.955 and 0.960 amongst men and women respectively. Arlappa N[10]observed that the correlation coefficients between arm span and height were higher amongst men ($r = 0.82$) compared to women ($r=0.68$) and the corresponding figures reported by Fatmah[32] (2010) for the elderly in Indonesia were 0.79 for men and 0.84 for women[32]. The corresponding figures for Bosnia and Herzegovinian adults were 0.876 and 0.887, respectively[33]. Similarly, Kwok and Whitelaw[8] also reported higher correlation (0.93) between height and arm span amongst older people. Goswami et al[7] study findings from regression analysis showed age and gender wise variations in height that could be predicted by arm span. Similar findings were also seen from a previous study among rural elderly population in Haryana[12]. The overall regression coefficient in study by Goswami et al[7]for men indicated that for every unit of increase in arm span of men, there was a 0.73cm significant increase in height. This was similar to the findings from the rural study[12]. In women, height increased significantly by 0.70 cm per 1 cm increase in arm span in this study which is also similar with that seen from the rural population[12]. This indicates that irrespective of the difference in population groups, whether urban or rural, the rate of change of arm span and height is constant which is an important finding of the study. Monyeki et al[13] found a significant strong correlation was recorded between height and arm span, waist circumference, MUAC (mid upper arm circumference) and sum of four skin folds in the present study among boys and girls. Similar trends were reported among Turkish children aged 7–14 years for height, arm span and MUAC[27]. In other studies, too, height and arm span were reported to be strongly correlated[34,35,37].

B Rabe found that the high correlation between height and arm span of 0.83 for females and 0.81 for males, found in the sample of Indonesian elderly, confirmed that arm span approximates the same rank-ordering of a population as height.

The nutritional status of older adults as per the BMI calculated using both arm span and height is presented in Table.3. The categorization of individuals according to nutritional status was done as: Malnourished, Normal, Overweight and Obese as per WHO standards. When categorized using BMI-arm span, the proportion of malnutrition was higher as compared to BMI-height. While the proportion of overweight and obese was higher when categorized using BMI-height as compared to BMI-arm span. Arlappa N[10]observed that there was over estimation of nutritional status amongst the older adults when BMI was calculated using height, where the prevalence of overweight/obesity (BMI $\geq$ 25.0) using standing height was 52.1% as against the only 27.6%, using arm span ($p<0.001$). Similarly, a higher proportion of older adults with CED were misclassified as normal weight and normal weight subjects as overweight using height to calculate BMI. This could be attributed to substantial reduction in the standing height amongst the older adults. Several studies have shown that height reduces with advancing age[18,19] and that height loss is even greater after 80 years[37]. Therefore, calculation of nutritional status of aged people using standing height is not reliable anthropometric measurement. Nishiwaki et al[38] also opined that inaccurate BMIs lead to substantial numbers of older adults being misclassified as normal weight or overweight, which can cause significant distortions in data on the impact of underweight and overweight on health outcomes. Siqueira V de[39] also reported that use of the WHO equation (using height) significantly increases the prevalence of overweight, thereby masking the diagnoses of underweight. B Rabe[6] in his study observed that according to the classification system of James etal[40], about one-third of the examined female and male subjects had CED whereas a little less than one-third of the elderly were obese. The total percentage of the female population in some stage of chronic energy deficiency would rise from 32 to 47% if arm span is, indeed, a more valid representation of the biologically relevant length of an older, shortened individual. Estimates of obesity of any grade, on the other hand falls from 31 to 17% in this gender. For men, the proxy use of arm span raises the overall apparent CED prevalence from 33 to 42%, while lowering that of obesity from 21 to 3%.

The agreement between the BMI-arm span and BMI-height was high (Table.4) among the normal subjects than with other categories, with measure of agreement Kappa being 0.818 which is significant statistically ($p<0.001$).

The cut-off values for BMI-height are already established to categorize the individuals according to their nutritional status; but as we have observed the differences in lengths of arm-span and height, more so in elderly when compared with other studies carried in younger population, we derived BMI-arm-span cut-off values equivalent to BMI-height cut-off values using linear regression. The area under curve

(AOC) in Fig.1 is 91.8%, which means the accuracy is 91.8%.The area under curve (AOC) in Fig.2 is 82.6%, which means the accuracy is 82.6%.The area under curve (AOC) in Fig.3 is 75%, which means the accuracy is 75%.Similar study was carried out by Arlappa N[10]who observed that since there was a significant difference in agreement between the different categories of nutritional status assessed using both height and arm span amongst older adults, they derived the BMI-Arm span cut-off values equivalent to known BMI-height cut-off values using regression analysis. The sensitivity between BMI-arm span cut-off values and BMI-height cut-off values ranged from 0.76 to 0.88 for any BMI category, while the specificity ranged from 0.90 to 0.99. As reported by Fatmah[32], the sensitivity of predicted body height from arm span to assess the nutrition status compared to the normal nutrition in elderly male and female is high[28].

Froehlich et al[5] commented in their study that by obtaining an accurate height estimate for individuals with severe mobility impairments who use wheelchairs is challenging, as the impairment typically precludes people from standing for measurement with a stadiometer. Further, having an accurate estimate is important for use in equations related to patient care such as determining appropriate drug dosages, assessing pulmonary function, and measuring BMI. Evidence supports arm span as a reasonably accurate height estimate for ambulatory young and middle-aged[41,42] and ambulatory older adults[8]. Although arm span estimates a person's maximum achievable height, several factors may affect the estimate for those with mobility impairment. People with early onset disability likely never achieved their "maximal" height, in part due to lack of weight bearing on the long leg bones. Also, those with more severe mobility impairment may have physical anomalies, such as joint contractures that restrict full body extension or bone demineralization that contribute to discrepancies between arm span and body length. Monyeki[13] et al's findings of the Ellisras do not differ with other investigations worldwide. In Montenegrins the use of arm span was very effective to determine the height of female and male communities in the surrounding areas, even though it may differ in ethnic and racial groups[42,43]. In all of the estimations of body height from various anthropometric measurements, it is important to emphasize that arm span has been the most reliable indicator for predicting the body height of an individual[44]. Arm span can be a reliable method used to measure height for disabled, old-aged and deformed individuals[34,15]

WEAKNESS: The more study sample should be included for comprehensive study. Whether obesity is because of fat distribution or muscle distribution cannot be commented; hence some alternative to weight should also be assessed, as that of waist-hip ratio.

STRENGTH: The measurement tools and calibration were accurate.

CONCLUSION: Due to the anthropometric changes that take place with increasing age, there is a progressive loss of height. Arm span could be used instead of height, as an alternative measurement in nutritional studies in elderly persons. As arm span, as an anthropometric measure, remains unchanged over time, it could be used instead of height, as an alternative index to the conventional body mass index. There is a need of alternative anthropometric measurement to height for the accurate assessment of nutritional status amongst older adults. Since arm length is less affected than the height by the aging process, it should be considered as an alternative to stature when assessing the nutritional assessments of the elderly 6, 58. In India, many of the elderly are at an increased risk of malnutrition, be it underweight or obesity. Therefore, emphasis should be laid on developing proper methods for measuring basic indicators of nutrition.

RECOMMENDATION: More studies should be undertaken with regard to nutritional status of elderly to find alternative indices for both height and weight, as both seem to be unreliable with increasing age.

SUMMARY: The use of body mass index (BMI) in the elderly is limited by the measurement of height which is often unreliable. Arm span approximates to height at maturity. It may, therefore, be an alternative to height in calculating BMI and so also the nutritional status. The study is an observational cross-sectional study carried out among 400 geriatric population attending tertiary care teaching institute of tribal area of central India. Weight, Height and Arm-span were calculated as per standard techniques; height and arm-span compared; BMI based on height (BMI-Ht) and BMI based on arm-span (BMI-As) were calculated and compared using regression equations. The mean arm-span (164.99 in men and 153.65 in women) was seen to be more than the mean height (160.87 in men and 151.22 in women) in both genders. There was a strong correlation between height and arm-span in both the genders. The BMI-As (18.336 in men and19.282 in women) was lower than the BMI-Ht (19.247 in men and 19.922 in women) in both the genders. As per BMI-arm-span, the proportion of malnutrition was higher as compared to BMI-height. Therefore, arm-span could be a better alternative to standing height in calculating body mass index for assessing nutritional status and for other clinical implications in elderly and non-ambulatory individuals.

REFERENCES:

1. Mitchell CO, Lipschitz DA. Detection of protein-calorie malnutrition in the elderly. Am J Clin Nutr. 1982 Feb;35(2):398–406.
2. Datta Banik S. Arm span as a proxy measure for height and estimation of nutritional status: a study among Dhimals of Darjeeling in West Bengal India. Ann Hum Biol. 2011 Nov;38(6):728–35.
3. McPherson JR, Lancaster DR, Carroll JC. Stature change with aging in black americans. J Gerontol. 1978 Jan;33(1):20–5.
4. Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc. 1985 Feb;33(2):116–20.
5. Froehlich-Grobe K, Nary DE, Van Sciver A, Lee J, Little TD. Measuring height without a stadiometer: empirical investigation of four height estimates among wheelchair users. Am J Phys Med Rehabil. 2011 Aug;90(8):658–66.
6. Rabe B, Thamrin MH, Gross R, Solomons NW, Schultink W. Body mass index of the elderly derived from height and from armspan. Asia Pac J Clin Nutr. 1996 Jun;5(2):79–83.
7. Goswami AK, Kalaivani M, Gupta SK, Nongkynrih B, Pandav CS. Relationship between height and arm span of elderly persons in an urban colony of New Delhi. Indian J Public Health. 2018 Apr;62(2):159–62.
8. Kwok T, Whitelaw MN. The Use of Armspan in Nutritional Assessment of the Elderly. J Am Geriatr Soc. 1991 May 27;39(5):492–6.
9. de Lucia E, Lemma F, Tesfaye F, Demisse T, Ismail S. The use of armspan measurement to assess the nutritional status of adults in four Ethiopian ethnic groups. Eur J Clin Nutr. 2002 Jan 31;56:91.
10. Arlappa N, Aatif Qureshi I, Philip Ravikumar B, Balakrishna N, Arbaab Qureshi M. Arm Span Is An Alternative To Standing Height For Calculation Of Body Mass Index (BMI) Amongst Older Adults. Jahan-mihan A, editor. IJN. 2016 Mar 28;2(1):12–24.
11. Hirani V, Mindell J. A comparison of measured height and demi-span equivalent height in the assessment of body mass index among people aged 65 years and over in England. Age Ageing. 2008 May;37(3):311–7.
12. Jamir L, Kalaivani M, Nongkynrih B, Misra P, Gupta SK. Relationship between arm span and height among elderly persons in a rural area of Ballabgarh, Haryana. Indian Journal Medical Specialties. 2013;4(2):248–52.
13. Monyeki KD, Sekhotha MM. The relationships between height and arm span, mid-upper arm and waist circumferences and sum of four skinfolds in Ellisras rural children aged 8-18 years. Public Health Nutr. 2016 May;19(7):1195–9.
14. Ferreira-Melo AP, Kuerten-de-Salles R, Vieira FGK, Ferreira MG. Comparative analysis of height estimation methods in hospitalized adults and elders. Nutr Hosp. 2017 Feb 1;34(1):116–21.
15. Hickson M, Frost G. A comparison of three methods for estimating height in the acutely ill elderly population. J Hum Nutr Diet. 2003 Feb;16(1):13–20.
16. Sampaio LR. Nutritional evaluation and ageing. Rev Nutr. 2004;17(4):507–14.
17. Sánchez-García S, García-Peña C, Duque-López MX, Juárez-Cedillo T, Cortés-Núñez AR, Reyes-Beaman S. Anthropometric measures and nutritional status in a healthy elderly population. BMC Public Health. 2007 Jan 3;7:2.

18. Perissinotto E, Pisent C, Sergi G, Grigoletto F, ILSA Working Group (Italian Longitudinal Study on Ageing). Anthropometric measurements in the elderly: age and gender differences. Br J Nutr. 2002 Feb;87(2):177–86.
19. Marcato DG, Sampaio JD, Alves ERB, Jesus JSA de, Fuly JTB, Giovaninni NPB, et al. Sitting-height measures are related to body mass index and blood pressure levels in children. Arq Bras Endocrinol Metabol. 2014 Nov;58(8):802–6.
20. Cad. Saúde Pública, Rio de Janeiro, 28(1):125-134, jan, 2012
21. Haboubi NY, Hudson PR, Pathy MS. Measurement of height in the elderly. J Am Geriatr Soc. 1990 Sep;38(9):1008–10.
22. Garcia AN de M, Romani S de AM, Lira PIC de. Anthropometric indicators in the nutritional assessment of the elderly: a comparative study. Rev Nutr. 2007;20(4):371–8.
23. Bassey EJ. Demi-span as a measure of skeletal size. Ann Hum Biol. 1986 Sep;13(5):499–502.
24. World Health Organization. Management of severe malnutrition: a manual for physicians and other senior health workers. Geneva: World Health Organization; 1999.
25. Acuña K, Cruz T. Nutritional assessment of adults and elderly and the nutritional status of the Brazilian population. Arq Bras EndocrinolMetab 2004; 48:345-61.
26. Chilima DM, Ismail SJ. Anthropometric characteristics of older people in rural Malawi. Eur J Clin Nutr. 1998 Sep;52(9):643–9.
27. Yabanci N, Kiliç S, Simşek I. The relationship between height and arm span, mid-upper arm and waist circumferences in children. Ann Hum Biol. 2010 Jan;37(1):70–5.
28. Lohman TG, Roche AF, Martorell R, Others. Anthropometric standardization reference manual. Vol. 177. Human kinetics books Champaign; 1988.
29. Ozaslan A, Koç S, Ozaslan I, Tuğcu H. Estimation of stature from upper extremity. Mil Med. 2006 Apr;171(4):288–91.
30. Shahar S, Pooy NS. (2003) Predictive equations for estimation of stature in Malaysian elderly people. Asia Pac J ClinNutr. 12 (1), 80-84.
31. Allen SC. The relation between height, armspan and forced expiratory volume in elderly women. Age Ageing. 1989 Mar;18(2):113–6.
32. Fatmah F. Predictive equations for estimation of stature from knee height, arm span, and sitting height in Indonesian Javanese elderly people. Int J Med Med Sci. 2009;1:456–61.
33. Popovic S, Bjelica D, Tanase GD, Milasinovic R. Body Height and Its Estimation Utilizing Arm Span Measurements in Bosnian and Herzegovinian Adults. Montenegrin Journal of Sports Science and Medicine. 2015;4(1):29–36.
34. Yousafzai AK, Filteau SM, Wirz SL, Cole TJ. Comparison of armspan, arm length and tibia length as predictors of actual height of disabled and nondisabled children in Dharavi, Mumbai, India. Eur J Clin Nutr. 2003 Oct;57(10):1230–4.
35. Zverev Y &Chisi J (2005) Estimating height from arm span measurement in Malawian children. CollAnthropl29, 469–473.
36. Marcato DG, Sampalo JD, Alves ERB et al. (2014) Sittingheight measures are related to body mass index and blood pressure in children. Arq Bras EndocrinolMetab58, 802–806.
37.Dey DK, Rothenberg E, Sundh V, Bosaeus I. Height and body weight in the elderly. I. A 25-year longitudinal study of a population aged 70 to 95 years. European Journal of [Internet]. 1999; Available from: https://www.nature.com/articles/1600852
38. Nishiwaki Y, Michikawa T, EtoN,Takebayashi T. (2011) Body mass index misclassification due to kyphotic posture in Japanese community-dwelling adults aged 65 years and older. J Gerontol Series A. BiolSci Med Sci. 66(3),326-31.
39. Siqueira V de O, Costa BV de L, Lopes ACS, Santos LC dos, Lima-Costa MF, Caiaffa WT. Different equations for determining height among the elderly: the Bambuí Cohort Study of Aging. Cad Saude Publica. 2012 Jan;28(1):125–34.
40. James WPT, Ferro-Luzzi A, Waterlow JC. Report of a Working Party of the

International Dietary Energy Consultative. Eur J Clin Nutr. 1988;42:981.
41. Brown JK, Whittemore KT, Knapp TR. Is arm span an accurate measure of height in young and middle-age adults? Clin Nurs Res. 2000 Feb;9(1):84–94.
42. Brown JK, Feng J-Y, Knapp TR. Is self-reported height or arm span a more accurate alternative measure of height? Clin Nurs Res. 2002 Nov;11(4):417–32.
43. Coon CS (1975) The Races of Europe, p. 18. Westport, CT: Greenwood Press.
44. Mohanty SP, Babu SS, Nair NS. The use of arm span as a predictor of height: A study of South Indian women. J Orthop Surg . 2001 Jun;9(1):19–23.

How to cite this article:
Shweta B. Shambharkar, Bharti Yadav, Manoj Talapalliwar,Vinaram P Rukhmode. ***Use Of Arm-span In Nutritional Assessment Of Elderly And Non-ambulatory Individuals Of Tribal Area Of Central India.*** **Br J Bio Med Res , Vol.03, Issue 04, Pg.983-999, July - August 2019. ISSN:2456-9739 Cross Ref DOI : https://doi.org/10.24942/bjbmr.2019.529**

Source of Support: Nil **Conflict of Interest:** None declared.