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Cut-off of Anthropometric Measurements and Nutritional Status among Elderly Outpatients in a Tertiary Health Care Center in Telangana

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ABSTRACT

Introduction: *Geriatric population is most vulnerable to various emerging communicable and non-communicable diseases due to various socio-economic, physiological, psychological and nutritional risk factors. Adequate nutritional status is utmost important in older age as it helps in maintaining the immune response and preventing the morbidities and mortalities in this age. Thus, the opportunistic screening of malnutrition among geriatric population gives an extra edge for achievement of healthy ageing in the elderly. The objective of the present study was to assess the nutritional status among the elderly population and provide cut-off values of various anthropometric measurements for detecting the risk of malnutrition among old age people.*

Materiala and methods: *The present cross-sectional study was carried out among people aged ≥ 60 years who visited the geriatric clinic of a tertiary health care center between May and December 2021. The nutritional status of the 468 selected elderly was assessed using the Mini Nutritional Assessment (MNA) tool and various anthropometric measurements. Receiver operating characteristic (ROC) curve and Youden index were used to determine the cut-off values of anthropometric measurements. Correlation between various anthropometric parameters was studied. Data was analyzed using SPSS* vs. *20 software.*

Results: *Out of the 468 subjects, around one third had a risk of malnutrition and 7% malnutrition as per the MNA scale. Cut-off values of triceps skinfold thickness, neck circumference and arm muscle circumference were 12.5 cm, 32.5 cm, 18.3 cm and 11.5 cm, 35.5 cm, 21.2 cm for detecting malnutrition and risk of malnutrition, respectively. Neck circumference was found to be the most suitable measurement, with a cut-off value of 32.5 cm and 35.5 cm for detecting malnutrition and risk of malnutrition, respectively, as it possessed the highest Youden index and AUC.*

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Conclusion: *The prevalence of malnutrition was found to be low in the present study setting. Our findings firmly established that the neck circumference could be used as a simple, rapid, non-invasive and valid screening tool, with high sensitivity and specificity for detecting the risk of malnutrition in geriatric clinics or primary health care settings.*

Keywords: nutrition status, elderly, anthropometric measurements, cut-off value, Telangana.

INTRODUCTION

The world is witnessing a demographic transition since the last few decades due to the unprecedented increase in human longevity in the 20th century. This transition has caused a striking magnification in the prevalence of older persons globally. The World Health Organization (WHO) initiated an action plan and started working on multiple fronts to ensure healthy ageing in the upcoming decades (1). Most populated nations such as the Chinese and Indian ones are witnessing a widened elderly population burden at present. In India, the elderly population is increasing geometrically and almost tripled in last 50 years, amounting to 60.2 million (2). Such a large, exponential and ubiquitous growth has resulted in an increase in the proportion of old people (> 60 years) from 7.7% in 2001 to 8.94% in 2016 (3).

Malnutrition is one of the important issues in the elderly population, which must not be neglected as it is associated with several comorbidities. In the elderly, diagnosing the risk of malnutrition is a challenging task which leads to inadequacy of macro- as well as micro-nutrients in this age group. To provide optimal health and prevent several deficiencies, health ailments and disorders among elderly people, timely detection of malnourishment risk is of the utmost importance. Various determinants, including socio-economic condition, income source, dietary habits, family support, orthopedic, oral, cardiovascular and neurodegenerative diseases, play a key role in the nutritional status of the elderly (4). Lack of screening for malnutrition by health care workers is one of the prime factors which affect the health and nutrition status of the elderly (5).

At present, non-invasive techniques to study the body composition are used for nutritional assessment (6). In this context, nutritional assessment through anthropometric measurements represents an important component for the elderly population (7). The reference values of older adults' anthropometric measurements cannot be used for the geriatric population because of the significant differences in weight and posture loss as well as muscle volume and adipose tissue loss due to senility (8). Regular collection of anthropometric data for keeping up to date with trends of health and nutrition related indicators through periodical surveys is recommended by WHO experts (9).

The objective of the present study was to assess the nutritional status of the elderly, to determine the cut-off values of anthropometric measurements for detecting the malnutrition risk among elderly people in accordance with mini nutritional assessment scale and to provide evidence for the utility of anthropometric parameters as a screening tool. ❑

MATERIAL AND METHODS

Study design and setting

The present research was a hospital based cross-sectional study conducted in the geriatric clinic of AIIMS Bibinagar, India, which is a tertiary health care organization providing health care services to 7.7 million people of Yadadri Bhuvanagiri district of Telangana state (10). As *per* the latest 2011 census, the above-mentioned district has a rural population of 6, 47,688 people (84% of the entire district population) and an urban population of 1,23,165 persons (2). Individuals aged 60 years and older of both genders who were attending the geriatric clinic of AIIMS, Bibinagar, India, during the study period (May to December 2021) and disability-free persons (Barthel index of > 20 (11) were included in the study. Old persons with end stage illness, cancer, active infections

and hospitalization during the last three months were all excluded.

The sample size was calculated using the formula "Estimating the sensitivity of a new test" with a sensitivity of 80%, desired precision of 4% and desired confidence level of 95%. The calculated sample size was 384. Considering a non-response rate of 20%, the desired sample size is 460 (N Master 2.0) (12). Consecutive sampling was used to recruit study participants until the achievement of sample size.

Study instruments

The following anthropometric measurements were used in the present study:

- *weight* – a portable scale with a 125 kg maximum capacity and a +/ - 100 g error margin was used; individuals had to remove shoes and heavy cloths prior to weighing;
- *height* – taken when subjects stood with their scapula, buttocks and heels resting against a wall, the neck was held in a natural non-stretched position with the inferior orbital border in the same horizontal plane as the external auditive conduct (Frankfort's plane), the heels were touching each other, the toe tips were forming a 45-degree angle;
- *knee–heel length* – the distance from the bottom of the foot on the heel to the anterior surface of the ankle joints of each knee (flexed 90 degree);
- *body mass index (BMI)* – calculated according to the body weight (kg) divided by height (m) squared.
- *Chumlea equations for women (a) and men (b)* used to estimate the height and weight of individuals who were not able to stand (13):

a) weight = (AC x 0.98) + (CC x 1.27) + (ST x 0.4) + (KH x 0.87) - 62.35
height = [knee height (cm) × 1.91] – [age (years) × 0.17] + 75.0

b) weight = (AC x 1.73) + (CC x 0.98) + (ST x 0.37) + (KH x 1.16) - 81.69
height = [knee height (cm) × 2.08] +59.01

- *calf circumference (CC)* – determined at the widest part of the calf;
- *mid-arm circumference (MAC)* – measured at the midpoint of the relaxed, non-dominant arm between the tip of the acromion and the olecranon process;
- *triceps skinfold thickness (TST)* – measured using skinfold calipers at the level of the midpoint between the acromion and the radius on the midline of the posterior surface of the arm;
- *arm muscle circumference (AMC)* – calculated as MAC - (∏ x TST) (14);
- *neck circumference (NC)* – measured immediately below the larynx (thyroid cartilage) and perpendicular to the longitudinal axis of the neck;
- *Mini Nutritional Assessment (MNA) scale* – designed to assess the nutritional status of older people; it consists of three categories based on the malnutrition indicator score: normal (24-30 points), at risk of malnutrition (17-23.5 points) and malnutrition (< 17 points) (15).

All data were collected by trained nursing officer using valid and calibrated instruments. The same sets of instruments were used throughout the data collection period.

Data analysis plan

Data were entered in MS Excel vs. 2019 and analyzed using IBM SPSS software version 20. Categorical variables were analyzed by χ^2 test and continuous variables by t-tests. Pearson's correlation coefficient was used for testing the association between continuous variables. We took dependent variable as the MNA score and independent variables as anthropometric parameters and linear regression was performed. Gender and age adjusted regression analyses for each anthropometric indicator were done. Regression analysis was repeated 100 times with each equation and 468 cases were re-sampled with replacement for each equation. We determined sensitivity and specificity for each anthropometric indicator using receiver operating characteristic (ROC) curves according to the MNA scores. Youden Index, area under the curve (AUC) by ROC curve as well as sensitivity and specificity were used to determine the optimal cut-off points for anthropometric measurements. The level of significance was set at 0.05.

Ethical issue

Ethical approval was taken from the Institutional Ethics Committee (IEC) of All India Institute of Medical Sciences (AIIMS), Bibinagar, India (IEC Ref No: AIIMS/BBN/IEC/APR/7021/38-A Dated: 07-07-2021). Informed written consent was taken from all participants after explaining them the study purpose in the local language. Participants who were identified as having malnutrition received health education and dietary counselling. ❑

TABLE 1. Distribution of study participants according to sociodemographic characteristics (n=468)

Demographic variable		No. (%)
Age in years	60-69	319 (68.2)
	70-79	116 (24.8)
	≥ 80	33 (7.1)
Gender	Female	174 (37.2)
	Male	294 (62.8)
Level of education	Illiterate	290 (62)
	Primary	42 (9.0)
	Middle	28 (6.0)
	Secondary	61 (13.0)
	Higher secondary	28 (6.0)
	Graduate	17 (3.6)
	Postgraduate and higher	2 (0.4)
Occupation	Not working	187 (40.0)
	Working	281 (60.0)
Monthly income in rupees	< 10,000	338 (72.2)
	≥ 10,000	130 (27.8)
Residence	Rural	420 (89.7)
	Urban	48 (10.3)
Marital status	Married	431 (92.1)
	Widowed/Widower	29 (6.2)
	Single	6 (1.3)
	Divorced	2 (0.4)
Nutritional status	At risk of malnutrition	156 (33.3)
	Malnourished	34 (7.3)
	Normal nutritional status	278 (59.4)

RESULTS

In the present study, data were collected from 468 participants who visited our geriatric clinic. Subjects' mean age (±SD) was 66.9 years (±6.7) and their age ranged between 60-90 years. The majority of participants were male (62.8%) and illiterate (62%). Most of participants were living in rural area (89.7%) and had a monthly income lower than 10,000 rupees (72.2%). Out of all participants, one third were at risk of malnutrition and about 7% had malnutrition based on MNA scale (Table 1).

Table 2 shows the association between the nutritional status and sociodemographic factors. We found a statistically significant association between the nutritional status and age groups, education level, occupation, income and marital status (p-value <0.005). Participants' gender and residence were not associated with the nutritional status.

ROC analysis was performed to determine the cut-off values of different anthropometric measurements among male and female participants for detecting malnutrition and the risk of malnutrition. As shown in Table 3 and Figure 1, NC and TST had a good predictive power, with an AUC of 0.986 and 0.999 for males and females, respectively, and a high Youden index for detecting malnutrition. For male subjects, the NC cut-off of

TABLE 2. Association of nutritional status with sociodemographic variables

Variables		Nutritional status			Chi square	P-value
		At risk of malnutrition No. (%)	Malnourished No. (%)	Normal No. (%)		
Age (years)	60-69	92 (28.8)	17 (5.3)	210 (65.8)	18.208	0.0001
	≥ 70	64 (43)	17 (11.4)	68 (45.6)		
Gender	Female	61 (35.1)	15 (8.6)	98 (56.3)	1.39	0.499
	Male	95 (32.3)	19 (6.5)	180 (61.2)		
Level of education	Secondary and above	25 (23.1)	2 (1.9)	81 (75)	15.783	0.0001
	Till secondary	131 (36.4)	32 (8.9)	197 (54.7)		
Occupation	Working	86 (30.6)	13 (4.6)	182 (64.8)	11.72	0.003
	Not working	70 (37.4)	21 (11.2)	96 (51.3)		
Income in rupees	< 10,000	120 (35.5)	31 (9.2)	187 (55.3)	11.211	0.004
	≥ 10,000	36 (27.7)	3 (2.3)	91 (70.0)		
Residence	Rural	142 (33.8)	32 (7.6)	246 (58.6)	1.461	0.482
	Urban	14 (29.2)	2 (4.2)	32 (66.7)		
Marital status	Married	142 (32.9)	27 (6.3)	262 (60.8)	9.521	0.009
	Single/Widower/Widowed/Divorced	14 (37.8)	7 (18.9)	16 (43.2)		

Variable		AUC (CI)	P-value	Cut-off	Sensitivity	Specificity
MALNOURISHED						
MALE	**TST**	0.748 (0.969, 0.857)	0.0001	10.5	69.50%	63.20%
	NC	0.986 (0.972, 1.000)	0.0001	31.5	87.60%	100%
	AMC	0.919 (0.870, 0.968)	0.0001	19.6	79.30%	94.70%
FEMALE	**TST**	0.991 (0.974, 1.000)	0.0001	13.5	98.10%	93.30%
	NC	0.969 (0.943, 0.996)	0.0001	32.5	84.30%	100%
	AMC	0.819 (0.735, 0.904)	0.0001	16.6	76.70%	73.30%
Total	**TST**	0.752 (0.687, 0.817)	0.0001	12.5	53.50%	88.20%
	NC	0.980 (0.968, 0.993)	0.0001	32.5	85.40%	100%
	AMC	0.864 (0.819, 0.909)	0.0001	18.259	75.60%	91.20%
AT RISK OF MALNUTRITION						
MALE	**TST**	0.866 (0.823, 0.909)	0.0001	10.5	91.70%	71.10%
	NC	0.935 (0.910, 0.960)	0.0001	35.5	82.20%	57%
	AMC	0.949 (0.926, 0.972)	0.0001	21.515	86.10%	94.70%
FEMALE	**TST**	0.817 (0.756, 0.879)	0.0001	17.5	73.50%	77.60%
	NC	0.903 (0.860, 0.946)	0.0001	34.5	86.70%	75%
	AMC	0.956 (0.931,0.981)	0.0001	18.316	82.70%	94.70%
Total	**TST**	0.704 (0.654, 0.754)	0.0001	11.5	73.70%	54.70%
	NC	0.923 (0.901, 0.946)	0.0001	35.5	79.10%	86%
	AMC	0.911 (0.887, 0.936)	0.0001	21.23	71.90%	95.80%

TABLE 3. Distribution of cut-off values of anthropometric measurements as *per* gender and nutrition status

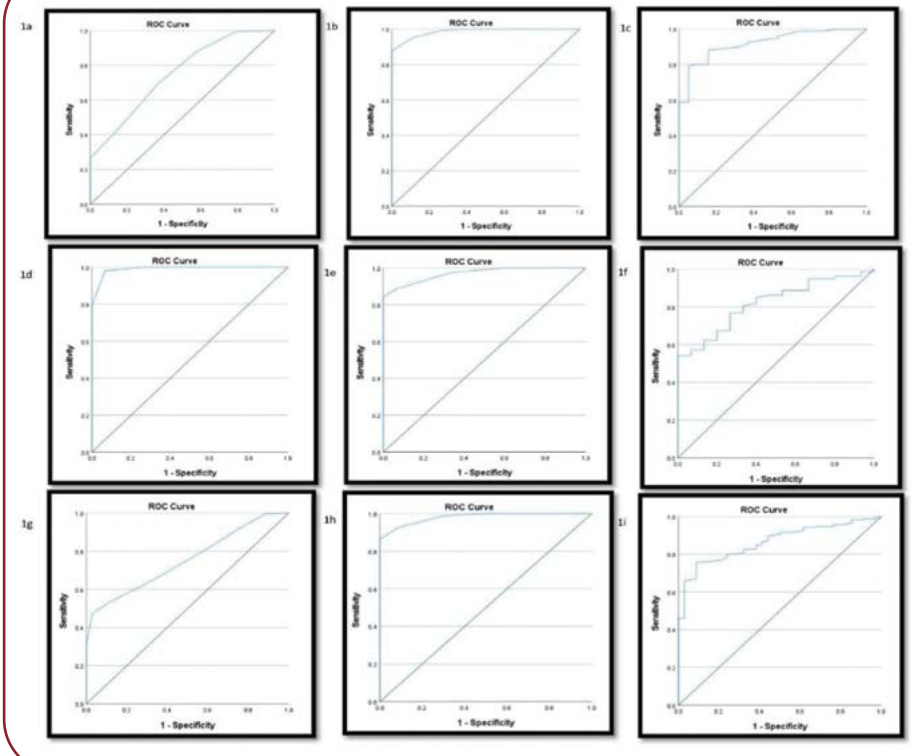

Fig 1. ROC curve to screen the malnourished elderly
1a. for TST in males
1b. for NC in males
1c. for AMC in males
1d. for TST in females
1e. for NC in females
1f. for AMC in females
1g. for TST in both males & females
1h. for NC in both males & females
1i. for AMC both males & females

FIGURE 1. ROC curve for identification of malnourishment amongst the elderly

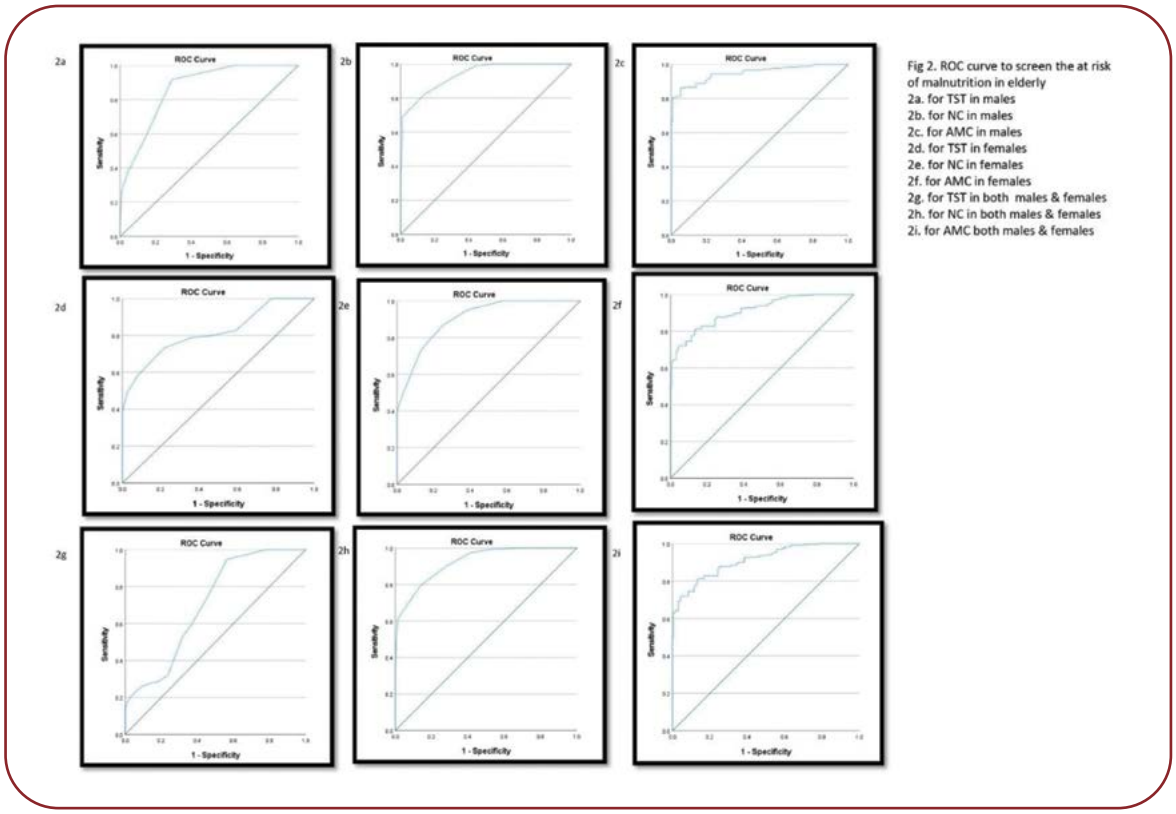

FIGURE 2. ROC curve for identification of malnutrition risk amongst the elderly

31.5 cm had the highest sensitivity (87.6%) and specificity (100%) to detect malnutrition and for female participants, triceps skinfold thickness (TST) with a cut-off value of 13.5 cm had 98.1% sensitivity and 93.3% specificity for detecting malnutrition. Table 3 and Figure 2 showed that AMC with cut-off values of 21.5 cm and 18.3 cm for males and females, respectively, had the highest sensitivity and specificity for detecting the risk of malnutrition. Overall, NC was found to be most suitable measurement, with cut-off values of 32.5 cm and 35.5 cm for detecting malnutrition and the risk of malnutrition, respectively, as it possessed the highest Youden index and AUC (Table 3, Figures 1 and 2).

TABLE 4. Distribution of cut-off values of anthropometric measurements as *per* gender and nutrition status

		BMI	CC	MAC	TST	NC	AMC
BMI	r		0.448	0.587	0.298	0.507	0.478
	p-value		0.0001	0.0001	0.0001	0.0001	0.0001
CC	r	0.448		0.355	0.075	0.347	0.327
	p-value	0.0001		0.0001	0.105	0.0001	0.0001
MAC	r	0.587	0.355		0.190	0.655	0.932
	p-value	0.0001	0.0001		0.0001	0.0001	0.0001
TST	r	0.298	0.075	0.190		0.170	-0.180
	p-value	0.0001	.105	0.0001		0.0001	0.0001
NC	r	.507	.347	.655	.170		.593
	p-value	0.0001	0.0001	0.0001	0.0001		0.0001
AMC	r	.478	.327	.932	-.180	.593	
	p-value	0.0001	0.0001	0.0001	0.0001	0.0001	

Table 4 and Figure 3 showed the correlation between various anthropometric measurements. Neck circumference had a highly significant positive correlation with MAC (r=0.655, p-value-0.0001), AMC (r=0.593, p-value -0.0001), BMI (r=0.507, p-value -0.0001), TST (r=0.170, p-value -0.0001), and CC (r=0.347, p-value -0.0001). The BMI had strong positive correlation with other anthropometric measurements (r>0.45, p-value <0.001). All anthropometric measurements were internally correlated with each other but triceps skinfold thickness (TST) revealed a negligible association with AMC (r= -0.180) and CC (0.075). ❑

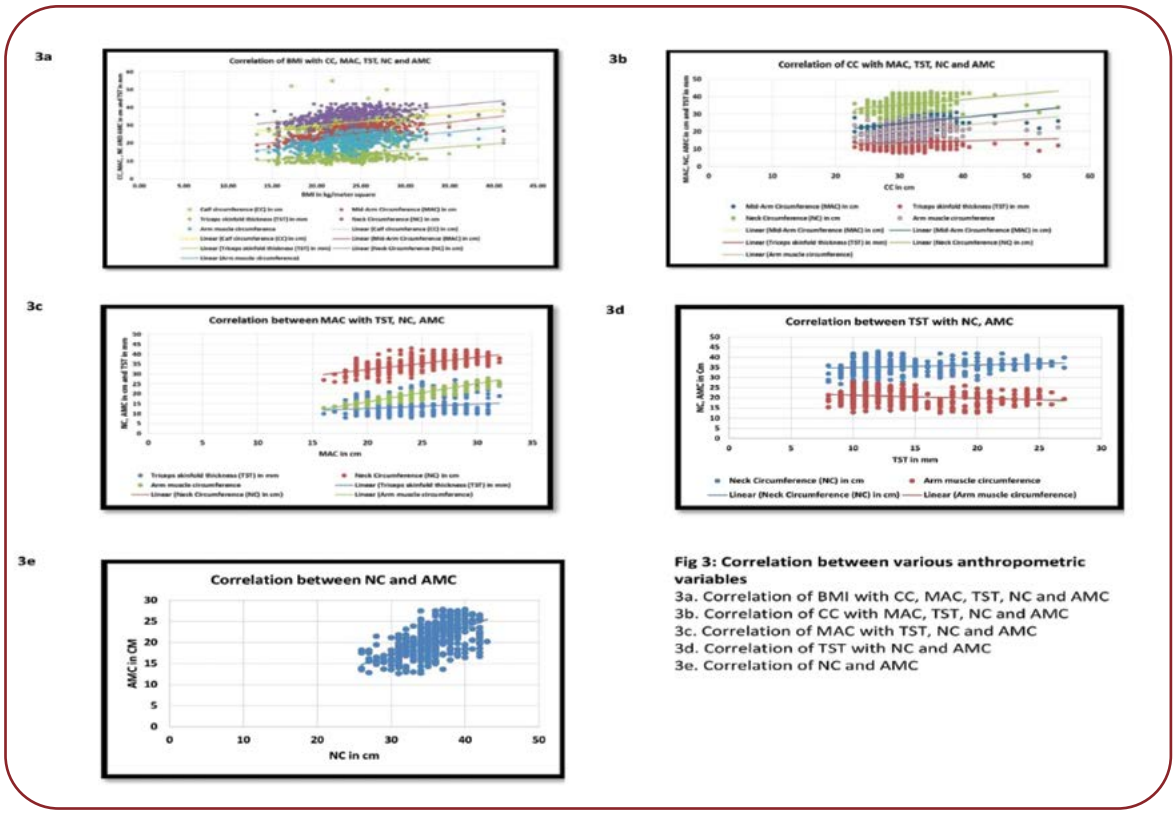

Fig 3: Correlation between various anthropometric variables
3a. Correlation of BMI with CC, MAC, TST, NC and AMC
3b. Correlation of CC with MAC, TST, NC and AMC
3c. Correlation of MAC with TST, NC and AMC
3d. Correlation of TST with NC and AMC
3e. Correlation of NC and AMC

FIGURE 3. Scatter plot showing correlation between various anthropometric measurements

DISCUSSION

The nutritional status of the elderly population is an important public health issue in India as the country is currently going through a demographic and nutritional transition phase (16). In the present study we explored the nutritional status of 468 elderly participants who visited the geriatric clinic of a tertiary health care institute of Telangana, India, using the MNA scale. We attempted to determine the cut-off points of various anthropometric measurements, including NC, BMI, CC, AMC, MAC and TST, using ROC analysis and Youden index for detecting malnutrition and the risk of malnutrition among elderly population. This study was the first of its kind to provide cut-off points of various anthropometric measurements in addition to prevalence of malnutrition among elderly population from a tribal community dominant area.

In our study, the majority of participants were males (62.8%) belonging to the 60–69-year age group (68.2%) and had a mean age (±SD) of 66.9 years (±6.7). Most participants lived in the rural area (89.7%), which matched the Yadadri district profile (84%) as *per* the 2011 census report (2), were illiterate (62%) and had a monthly income below 10,000 rupees (72.2%), which was lower than the national average monthly income of 13,912 rupees (44). Similar sociodemographic findings were reported by studies conducted in Puducherry (17), Uttarakhand (18), Delhi (19) and Coimbatore (20), except female dominance in the above-mentioned studies. In the present study, out of the total number of 468 elderly participants, one third (33.3%) had malnutrition risk and 34 (7.3%) malnutrition. Our findings were supported by the studies conducted by Vaish K *et al* (21), in Delhi, and Sebastian IR *et al* (22), in Kerala, whereas various studies done in different parts of the world and India reported a higher proportion of people at risk of malnutrition and malnourishment among the elderly (12, 17, 18, 20, 23-30). This difference in prevalence may be explained by the fact that the majority of participants in the present study were young elderly (60-70 years) and males. We found that the prevalence of malnutrition and malnutrition risk was significantly higher in the >70-year age group compared to the 60-69-year age group (p-value <0.001). We observed that elderly participants who were not working had a significantly poorer nutritional sta-

tus than those who were working (p-value < 0.05). By income, participants with a monthly income below 10,000 rupees had a higher malnourishment level than those with >10,000 rupees (p-value < 0.05). We reported that subjects who were married (6.3%) had a significantly lower prevalence of malnutrition than single/widowed/widower/divorced ones (18.9%) (p-value < 0.05). Similar associations were reported by various studies done among the elderly population in different research settings (4, 8, 19, 21, 25, 29-33).

We tried to find out the cut-off values of anthropometric measurements for screening malnutrition among elderly population as early diagnosis of malnutrition is essential. In this study, we obtained cut-off values of various anthropometric measurements in the elderly considering the 18-item validated MNA scale with high predictive values (34) as gold standard. On ROC analysis, we found that NC with a cut-off value of 32.5 cm had 85.4% sensitivity and 100% specificity (AUC 0.980) for detecting malnutrition. By gender, TST a with cut-off point of 13.5 cm had a good predicting power with 98.1% sensitivity and 93.3% specificity (AUC 0.991) for detecting malnutrition among female participants, followed by NC (84.3% sensitivity, 100% specificity). For detecting the risk of malnutrition among the elderly, NC with a cut-off value of 35.5 cm had 97.1% sensitivity and 86% specificity as well as a high Youden index, whereas AMC with a cut-off point of 21.5 cm and NC with a cut- off value of 34.5 cm had a good predictive power for detecting the risk of malnutrition among male and female elderly, respectively. Similarly, studies done by B Lardies-Sanchez *et al* (12) on elderly subjects, Das K *et al* (35) on adult popuation and Patil CR *et al* (36) on children reported that NC had the highest predictive value for detecting malnutrition. Our study showed that NC could be considered a simple anthropometric measurement for screening the malnutrition status among the elderly population. Most of the time, elderly people have multimorbidity, bent over posture and bed-ridden when they come to hospital, and in such a situation, NC can be used as for a rapid assessment of malnutrition because it is a direct, non-invasive, rapid and easy measurement method, with a high predictive value compared to other anthropometric measurements. The measurement of NC can be used for screening the malnutrition status in various study settings such as hospitalized patients, outpatient departments, old-age homes and community/field surveys. Various studies had validated NC as a screening tool for nutrition assessment in children but to our knowledge, no previous study supported similar findings in elderly population other than present study (37-40).

We found that all anthropometric measurements had a significant positive correlation with each other (r >0.5, p-value <0.001). Our study showed that NC had a strong positive correlation with other anthropometric measurements and fulfilled most of the current criteria for screening and diagnostic test (41). Various studies on adult subjects indicated that NC had a good inter- and intra-rater reliability and a strong correlation with other anthropometric measurements, so it can be considered as a screening tool for malnutrition (26, 42, 43).

The key strength of our study is that it provides cut-off values of anthropometric measurements in male and female subjects for detecting the risk of malnutrition among the elderly population. We decided upon the cut-off values through comparison to the MNA scale, a validated and highly predictive tool for the detection of malnutrition among the elderly. Data was collected by a single trained local language speaking nursing officer in order to avoid measurement bias as much as possible. Standard statistical tests such as ROC and correlation analysis were used to decide the cut-off values. Our study had also limitations, as it was a hospital-based study among elderly people coming to geriatric clinic for routine check-up. There was chance of recall bias as the actual nutrient intake was not measured. ❑

CONCLUSIONS AND RECOMMENDATIONS

The present study found a low prevalence of malnourishment and malnutrition risk among elderly people visiting a geriatric clinic of AIIMS, Bibinagar, India. Several factors such as age, educational level, monthly income, marital status and occupation were associated with the subjects' nutritional status. In addition, we provided the cut-off values of anthropometric measurements along with levels of specificity and sensitivity for both genders of participants. Neck circumference was found to be a valid anthropometric measurement for the rapid and easy assessment of malnutrition risk among the elderly;

thus, NC can be used for the screening of the malnutrition status among elderly people in primary health care setting and geriatric clinics under the National Programme for Health Care of the Elderly (NPHCE). ❑

Conflicts of interest: none declared.

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References

1. **Rudnicka E, Napierała P, Podfigurna A, et al.** The World Health Organization (WHO) approach to healthy ageing. *Maturitas* [Internet]. 2020 Sep [cited 2022 Mar 1];139:6–11. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7250103/
2. Census of India Website: Office of the Registrar General & Census Commissioner, India [Internet]. [cited 2022 Feb 26]. Available from: https://censusindia.gov.in/2011-common/census_data_2001.html
3. **Operational Guidelines.** :53. **Please, complete this reference (year, etc)**
4. **Fávaro-Moreira NC, Krausch-Hofmann S, Matthys C, et al.** Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data123. *Adv Nutr* [Internet]. 2016 May 9 [cited 2022 Feb 21];7(3):507–22. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4863272/
5. **Shahar S, Wong S, Wan C.** A Prospective Study on Malnutrition and Duration of Hospitalisation among Hospitalised Geriatric Patients Admitted to Surgical and Medical Wards of Hospital UniversitiKebangsaan Malaysia. *Malays J Nutr* 2002;8:55-62.
6. **Camina-Martín MA, de Mateo-Silleras B, Malafarina V, et al.** Nutritional status assessment in geriatrics: Consensus declaration by the Spanish Society of Geriatrics and Gerontology Nutrition Work Group. *Maturitas* 2015;81:414-419.
7. **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;87:177-186.
8. **Shatenstein B, Kergoat MJ, Nadon S.** Anthropometric changes over 5 years in elderly Canadians by age, gender, and cognitive status. *J GerontolA Biol Sci Med Sci* 2001;56:M483-M488.
9. **de Onis M, Habicht JP.** Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. *Am J Clin Nutr* 1996;64:650-658.
10. Yadadri Bhuvanagiri District, Govt of Telangana | Welcome to YadadriBhuvanagiri | India [Internet]. [cited 2022 Mar 1]. Available from: https://yadadri.telangana.gov.in/
11. **Barthel Index** [Internet]. *Physiopedia.* [cited 2022 Feb 21]. Available from: https://www.physiopedia.com/Barthel_Index
12. **Lardiés-Sánchez B, Arbones-Mainar JM, Perez-Nogueras J, et al.** Neck circumference is associated with nutritional status in elderly nursing home residents. *Nutrition* [Internet]. 2019 Jun [cited 2022 Feb 21];62:153–7. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0899900718310864
13. **Chumlea WC, Roche AF, Steinbaugh ML.** Estimating stature from knee height for persons 60 to 90 years of age. *J Am Geriatr Soc* 1985;33:116-120.
14. **LaBerge RC, Vaccani JP, Gow RM, et al.** Inter- and intra-rater reliability of neck circumference measurements in children. *Pediatr Pulmonol* 2009;44:64-69.
15. **Cohendy R, Rubenstein LZ, Eledjam JJ.** The Mini Nutritional Assessment-Short Form for preoperative nutritional evaluation of elderly patients. *Aging Milan Italy* 2001;13:293-297.
16. **Chatterjee C, Chandra Nayak N, Mahakud J.** Magnitude and determinants of inpatient health expenditure among the elderly in India. *Int J Health Plann Manage* 2021;37:1402-1420.
17. **Krishnamoorthy Y, Vijayageetha M, Kumar SG, et al.** Prevalence of malnutrition and its associated factors among elderly population in rural Puducherry using mini-nutritional assessment questionnaire. *J Fam Med Prim Care* [Internet]. 2018 [cited 2022 Feb 25];7(6):1429–33. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6293907/
18. **Gupta A, Khandelwal R, Kapil U.** Interrelationship between dental health status and nutritional status among elderly subjects in India. *J Fam Med Prim Care* [Internet]. 2019 Feb [cited 2022 Feb 25];8(2):477–81. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6436255/
19. **Goswami A, Nongkynrih B, Kalaivani M, et al.** Double burden of malnutrition among elderly population of Delhi. *Indian J Community Health* 2016;28:324-330.
20. **Mathew AC, Das D, Sampath S, et al.** Prevalence and correlates of malnutrition among elderly in an urban area in Coimbatore. *Indian J Public Health* [Internet]. 2016 Apr 1 [cited 2022 Feb 25];60(2):112. Available from: https://www.ijph.in/article.asp?issn=0019-557X;year=2016;volume=60;issue=2;spage=112;epage=117;aulast=Mathew;type=0
21. **Vaish K, Patra S, Chhabra P.** Nutritional status among elderly: A community-based cross-sectional study. *Indian J Public Health* [Internet]. 2020 Jul 1 [cited 2022 Feb 25];64(3):266. Available from: https://www.ijph.in/article.asp?issn=0019-557X;year=2020;volume=64;issue=3;spage=266;epage=270;aulast=Vaish;type=0
22. **Sebastian IR, Venkitaraman S, Syamala S, et al.** Nutritional Status and COVID-19 among Older Persons in Kerala, India. *Inq J Med Care Organ ProvisFinanc* [Internet]. 2021 Dec 6 [cited 2022 Feb 25];58:00469580211059738. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8842181/
23. **Ziebolz D, Werner C, Schmalz G, et al.** Oral Health and nutritional status in nursing home residents—results of an explorative cross-sectional pilot study. *BMC Geriatr* [Internet]. 2017 Jan 31 [cited 2022 Feb 25];17:39. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5282867/
24. **Ghasemi NS, Dazi M, Nikrad B, et al.** Nutritional Status and the Affecting Factors in the Elderly InGonbadKavus, Iran. *J Res Dev Nurs Midwifery* 2021;18:53-57.
25. **Patil D, Shindhe M.** Effect of socio-economic, demographic and environmental factors on nutritional status of elderly: a cross sectional study. *Int J Community Med Public Health*

2019;6:3483.
26. **Selvaraj K, Ramakrishnan J, Yousuf A, et al.** Can mid-upper arm circumference and calf circumference be the proxy measures to detect undernutrition among elderly? Findings of a community-based survey in rural Puducherry, India. *J Fam Med Prim Care* 2017;6:356-359.
27. **Setiati S, Istanti R, Andayani R, et al.** Cut-off of Anthropometry Measurement and Nutritional Status Among Elderly Outpatient in Indonesia: Multi-centre Study. *Acta Med Indones* 2010;42:7.
28. **Naik R, Dudeja P, Thamban N, et al.** Nutrition assessment of elderly residing in urban areas and urban slum: A comparative study. *Indian J Community Health* 2018;30:390-394.
29. **Kritika, Shikha D, Semwal J, et al.** Nutritional status and associated comorbidities among the elderly in Doiwala block, Dehradun. *Indian J Community Health* 2015;26:197-203.
30. **Kanin MNB, Tatree B, Thanakamon L, et al.** Nutritional status and associated factors among elderly people in primary care center. *GSC Adv Res Rev* [Internet]. 2020 [cited 2022 Feb 28];2(3):018–35. Available from: https://gsconlinepress.com/journals/gscarr/content/nutritional-status-and-associated-factors-among-elderly-people-primary-care-center
31. **Nykanen I, Lönnroos E, Kautiainen H, et al.** Nutritional screening in a population-based cohort of community-dwelling older people. *Eur J Public Health* 2013;23:405-409.
32. **Hweidi IM, Carpenter CL, Al-Obeisat SM, et al.** Nutritional status and its determinants among community-dwelling older adults in Jordan. *Nurs Forum* (Auckl) [Internet]. 2021 [cited 2022 Feb 28];56(3):529–38. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/nuf.12576
33. **Agarwalla R, Saikia AM, Baruah R.** Assessment of the nutritional status of the elderly and its correlates. *J Fam Community Med* [Internet]. 2015 [cited 2022 Feb 28];22(1):39–43. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4317993/
34. mna-mini-english.pdf [Internet]. [cited 2022 Feb 26]. Available from: https://www.mna-elderly.com/sites/default/files/2021-10/mna-mini-english.pdf
35. **Das K, Bagchi S, Pal S, et al.** Neck circumference and undernutrition. *Adult Sabar males of West Bengal* 2019;8:316-329.
36. **Patil CR, Dagdiya KR, Petkar PB, Kherde A.** Neck circumference as a marker of malnutrition among children attending the under five clinic of a tertiary care hospital in Nagpur, Maharashtra. *Indian J Community Fam Med* [Internet]. 2018 Jan 3 [cited 2022 Feb 28];4(2):27. Available from: https://www.ijcfm.org/article.asp?issn=2395-2113;year=2018;volume=4;issue=2;spage=27;epage=30;aulast=Patil;type=0
37. **Kelishadi R, Djalalinia S, Motlagh ME, et al.** Association of neck circumference with general and abdominal obesity in children and adolescents: the weight disorders survey of the CASPIAN-IV study. *BMJ Open* [Internet]. 2016 Sep 1 [cited 2022 Mar 1];6(9):e011794. Available from: https://europepmc.org/articles/PMC5051415
38. **Hatipoglu N, Mazicioglu MM, Kurtoglu S, Kendirci M.** Neck circumference: an additional tool of screening overweight and obesity in childhood. *Eur J Pediatr* 2010;169:733-739.
39. **Kim Y, Lee J-M, Lee J-M, et al.** Accuracy of Neck Circumference in Classifying Overweight and Obese US Children. *ISRN Obes* [Internet]. 2014 Jan 1 [cited 2022 Mar 1];2014:781841. Available from: https://europepmc.org/articles/PMC3929509
40. **Yashoda HT, Swetha B, Goutham AS.** Neck circumference measurement as a screening tool for obesity in children. *Int J Contemp Pediatr* [Internet]. 2017 Feb 22 [cited 2022 Mar 1];4(2):426. Available from: http://www.ijpediatrics.com/index.php/ijcp/article/view/560
41. **van Asselt DZB, van Bokhorst-de van der Schueren MAE, van der Cammen TJM, et al.** Assessment and treatment of malnutrition in Dutch geriatric practice: consensus through a modified Delphi study. *Age Ageing* 2012;41:399-404.
42. **Freedman DS, Rimm AA.** The relation of body fat distribution, as assessed by six girth measurements, to diabetes mellitus in women. *Am J Public Health* [Internet]. 1989 Jun 1 [cited 2022 Mar 1];79(6):715–20. Available from: https://doi.org/10.2105/ajph.79.6.715
43. **Kamrul-Hasan ABM, Aalpona FTZ.** Neck Circumference as a Predictor of Obesity and Metabolic Syndrome in Bangladeshi Women with Polycystic Ovary Syndrome. *Indian J Endocrinol Metab* [Internet]. 2021 [cited 2022 Mar 1];25(3):226–31. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8547400/
44. **National Statistics Office.** *Periodic labor force survey (PLFS)* 2019-2020. Ministry of Statistics and Programme Implementation, New Delhi. 2021.