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The sensitivity and specificity of mid-upper arm circumference compared to body mass index in screening malnutrition of adult HIV patients taking ART; evidence from selected facilities of Addis Ababa, Ethiopia

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Abstract: Introduction: For nutritional assessment of HIV-positive adults and adolescents, it is recommended to take Weight, Height and MUAC (for pregnant and lactating women and/or adults who cannot stand straight) in every contact, such measurements increase the waiting time and inconvenience(1). So that a simple and yet useful anthropometric measurement is needed to screen malnutrition for an immediate nutrition support in developing countries. Objective: To assess the sensitivity (SN) and specificity (SP) of mid-upper arm circumference (MUAC) in detecting under nutrition of adult people with HIV who have a follow up at ART clinic. Methods: A cross-sectional study was conducted from January to July 2013 among adults with HIV (PLHIV), who have follow-up in three selected Governmental Hospitals of Addis Ababa city administration. A total of 594 study subjects were selected using a multi stage cluster sampling technique. MUAC, Height and weight were measured for all subjects and BMI was calculated as Wt/Ht^2. Receivers operating characteristic curve analyses were undertaken to discover the most suitable cut-off values of MUAC for both Men and Women. Results: The prevalence of chronic energy deficiency (CED) based on BMI (BMI <18.5) was 39.4% for males and 24.21% for females, while based on MUAC <230 mm for male was 48.4% and < 220 mm for female was 35.7%. The sensitivity and specificity of MUAC for Female with optimal criteria of ≤224 for females were 92.86 and 87.07, whereas for Males MUAC with optimal criteria of ≤234 were 94.85 and 68.46, respectively. The area under curve (AUC) was 0.93 (p<0.001). A MUAC value of ≤239mm was identified as the best cut off-points to identify CED (BMI <18.5) with SN and SP of 96.43% and 72.62%, respectively. The PPV was 56.6(95%CI=89.9 to 99.3) with the highest NPV 98.2 (95%CI=66.8 to 77.9), thus having the highest Youden Index of 0.21. A MUAC value of ≤242mm was identified as the best cut off point to identify CED (BMI <18.5) with SN and SP of 96.91% and 58.39%, respectively. The PPV was 46.3(95%CI=91.2 to 99.4) with the highest NPV 98.1 (95%CI=50.0 to 66.4), thus having the highest Youden Index of 0.32. Conclusion: a MUAC value of close to 242 mm for male and 239mm for female seemed to be appropriate as a simple and efficient cut-off point for the determination of under nutrition in adult PLHIV.

Keywords: Sensitivity, Specificity, BMI, CED, Mid-Upper Arm Circumference, Nutritional Status, ROC Curve

1. Introduction

Inadequate nutrition in patients living with HIV (PLHIV) can put them at high risk of chronic diseases particularly if combined with other adverse lifestyle behaviors, received recognition of policy makers and launched national nutritional programs to combat the threat of malnutrition(2).

For individual assessment of body composition and size, anthropometry is being replaced by more accurate but also more complicated methods. Calculation of individual BMI from weight and height still remains a standard and valid tool for the assessment of nutritional status(3),though the complexity of calculations for health workers without mathematical backgrounds or access to calculation software

is an issue and its use in clinical practice may mask important weight changes and result in a failure to alert healthcare staff to a nutritional problem(4). Furthermore, charts and tables may not be available for those working in traditional health/nutrition services which are often poorly equipped(5).

Currently the national Guidelines for HIV/AIDS and Nutrition in Ethiopia recommends weight, height and MUAC (for pregnant and lactating women and/or adults who cannot stand straight) measurements to be taken in every contact(6) and this entails to increase the waiting time and inconvenience for the patients underlines the need for an alternative anthropometric measurements like Mid-upper arm circumference (MUAC). MUAC measurement is a reliable and a feasible method of assessment of nutritional status of adults and can be used for screening. An important advantage of using MUAC compared with BMI is that it can be easily obtained in older persons using a simple measuring tape. It has been used for many years as an alternative index of nutritional status in situations like famines and refugee crises, where the height and weight measurements are difficult (7, 8). In addition to reliability and simplicity, MUAC demonstrated superior sensitivity to risk of death (9, 10), and can offer considerable cost advantages because it only requires measuring tapes which are less expensive than height boards. MUAC measurement is easier to perform on severely malnourished adults than BMI assessment(11)) but no studies have identified the use of MUAC for patient with PLHIV. It is a potentially useful indicator requiring only a cheap, widely available and durable measuring tape that requires no calibration, and having the advantage that it can be measured in patients who have difficulty in standing. Therefore; identification of simple practical ways to assess nutritional status and related outcomes in patients with HIV/AIDS before and during treatment with particular reference to resource-limited settings is mandatory to provide appropriate interventions (12). The purpose of this study was to determine a tool that will be easier and more appropriate for screening of malnutrition among PLHIV and assess the sensitivity and specificity of MUAC in correctly identifying the patient qualifying for supplementary feeding and examine whether BMI can be substituted by MUAC in assessing the nutritional status.

2. Methodology

2.1. Study Design and Settings

An institution based cross-sectional quantitative study design was employed to assess the sensitivity and specificity of MUAC in Addis Ababa, the capital and largest city of Ethiopia as well as the country's commercial, manufacturing, and cultural center. Its projected population of 2013 is estimated to be 3,038,096 million that resides in 10 sub-cities and 116 Woreda. In the city, there were 36 private and 6 governmental hospitals, 52 health centers (of which 45 are public and 7 are NGO health centres), 136 health stations, 700 private clinics. The numbers of health facilities providing ART services were 66 in number and patients currently on ART were 54,667. The number of ART clients registered in each government hospitals namely *Tikur Anbesa* specialized (1,302), Saint Paul (987), *Zewditu* Memorial (1,018), *Yekatit* 12 (3,065), Ghandi Memorial (987) and *Ras Desta Damtew* Memorial hospital (1,011) at the time of the study; of these, only three accessible hospitals with large number of clients were purposively selected.

2.2. Sample Size

The Sample Size was estimated using single population proportion formula assuming 50% prevalence of wasting (since there is no information), 5% degree of precision and 95% confidence level of certainty and 5% non response rate with a design effect of (1.5), a total of 594 subjects were estimated and allocated proportionately across the three hospital namely *Zeweditu* memorial (n=345); *Yekatit 12* (n=135); *Ras Desta Damtew* memorial Hospital (n=114). The required subjects in each facility were recruited and enrolled consecutively until the required sample size was reached.

2.3. Data Collection

Data were collected by trained health workers under the supervision of the PI using anonymous pretested questionnaire containing information on socio-demographic, environmental, anthropometry, dietary. Each completed questioner was checked immediately by the PI to ascertain all the questions have been answered consistently. The information entered was rechecked in 5% of randomly selected respondents.

Middle upper arm circumference was measured in centimeter with a non-stretched measuring tape with the right arm hanging relaxed. The measurement was taken midway between the tip of the acromion and olecranon process. The tape was placed gently but firmly round the arm to avoid compression of soft tissue. Measurement was taken nearest to 0.1 cm; and subjects were categorized as undernourished when MUAC was ≤230 mm for male and ≤220 mm for females(13).

Weight was measured in kilogram without shoes using a digital bath scale with good precision. Checks on the scale were made routinely before recording the weight of each subject.

Height was taken barefooted in centimeter using stadiometre. A vertical tape fixed perpendicular to the ground on the wall was used as the scale. During the anthropometric measurements the scale was repeatedly checked for accuracy against a known weight. Height was recorded to the nearest 1 cm.

Body mass index (BMI) was calculated as weight in kg/height in m^2 , and values below or equal to 18.5 kg/m^2 was considered undernourished or CED(14)

2.4. Data Analysis

After sorting the data and performed quality control for completeness and consistency, the data were then coded and entered into computers and validated for consistency using EPI version 7.1 and analysis was done using SPSS version 16 for windows. The anthropometric variables were described as mean (SD) and range values. The frequencies of CED were expressed as percentages. Chi-square was utilized to test the significance differences in frequencies of CED among the MUAC categories and BMI and a p-value <0.05 was considered statistically significant.

Receiver operating characteristic curve (ROC) analysis was done using Medcalc software version 12.1 to locate the optimal cut-off values of MUAC corresponding to the BMI cut-off in identifying CED cases. Youden index (YI) was calculated as: 'sensitivity + specificity – 1'. Among the different MUAC values, YIs were compared to discern the optimal cut-off points for CED.

2.5. Ethical Issues

Ethical approval was obtained from the School of Public Health Research Ethics Review Committee of Addis Ababa University, College of Health Sciences; as well as Addis Ababa Health bureau research ethics committee. Officials of each facility were also contacted, and permission was granted to conduct the study. Informed written consent was obtained from each subject for their participation and the right to withdraw from the study at any time was also communicated to all of them.

3. Result

Of the total of 594 respondents, 593 participated making the response rate 99.8%. Over half (58.5%) were females. The mean age of study participant was 34. About one-third (32.8%) were single and over half (51.0%) were Orthodox. The proportion of respondents who had tertiary level of schooling was 34.7%, and private employees constituted 45.3% and less than half (41.7%) earned less than or equal to 500 Birr, Ethiopian currency, (Table 1).

Table 1. socio-demographic characters of the respondents, Addis Ababa, 2014

Characters	Number(N=593)	Percents
Sex		
Male	246	41.5
Female	347	58.5
Age(years)		
≤ 20	16	2.7
21 – 26	53	8.9
27 – 32	136	22.9
33 – 37	187	31.6
38 – 43	118	19.9
44+	83	14.0
Mean (SD)	34(7.2)	
Marital status		
Single	195	32.8
Married	231	39.0

Characters	Number(N=593)	Percents
Divorced	78	13.2
Widowed	89	15.0
Religion		
Orthodox	304	51.3
Protestant	112	18.9
Muslim	82	13.8
Catholic	64	10.8
Educational status		
No schooling	35	5.9
Grade 1-6	119	20.0
Grade 7-12	233	39.4
Tertiary schooling	206	34.7
Occupation		
NGO	62	10.5
Government	139	23.4
Student	30	5.1
Housewife	81	13.7
Private/ Merchant	269	45.3
Daily laborer	12	2
Monthly HH Income		
≤ 500 (Birr)	247	41.7
501 – 1,000	157	26.5
1,001+	189	31.8

20 Birr=1USD

3.1. Anthropometric Data

Table 2 shows the anthropometric measurement of the respondents. The mean (SD) MUAC, weight (SD, height (SD) and BMI (SD) were 161.7 (±8) mm, 56.2 (±9.3) kg, 242(±31.5) mm, and 21.5±3.4 kg/m^2 , respectively.

Table 2. Anthropometric result of the respondents in selected health facilities of Addis Ababa, May 2013.

Variable	Mean	(±SD)	Minimum	Maximum
Height(cm)	161.7	8.1	130.0	182.0
Weight(kg)	56.2	9.3	31.0	94.0
BMI(kg/m^2)	21.5	3.4	16.0	32.0
MUAC(mm)	242.0	33.5	150.0	350.0

SD=standard deviation

Table 3. Association of MUAC and BMI of the respondents in selected health facilities of Addis Ababa, May 2013

	CED BMI (≤18.5kg/m2)	Well nourished BMI (>18.5kg/m2)	Total
Female MUAC			
<220mm CED	92	32	124
Well nourished	9	214	223
Total	124	223	347
Male MUAC			
<230mm CED	76	43	119
Well nourished	4	123	127
Total	80	166	246

3.2. Sensitivity and Specificity of MUAC and BMI

Receiver operating characteristic curve analysis of sensitivity and specificity of MUAC using the cutoff point of 240mm and 220mm for male and female is computed respectively using Medcalc version 12 Software. The

sensitivity and specificity of MUAC for Female with optimal criteria of ≤220mm were 91.9% and 86.9%, respectively whereas for Males MUAC with optimal criteria of ≤230mm were 95% and 74% respectively.

Receiver operating characteristic curve analysis of sensitivity and specificity of MUAC for Female with optimal criteria of ≤226mm were 94.9% and 85.9% respectively whereas for Males MUAC with optimal criteria of ≤234 were 94.8% and 68.5% respectively.

The results of ROC curve analyses for Female MUAC with optimal criteria of (≤226mm) shows sensitivity (SN) 94.9%, specificity (SP) 85.9%, positive predictive value (PPV) 71.2% and negative predictive value (NPV) 97.5% for each MUAC value to identify CED are presented in (Table 4).

The results of ROC curve analyses of Male MUAC are presented in (Table 6) with optimal criteria of (≤230 mm), with the sensitivity (SN) , specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) for each MUAC value to identify CED.

The use of MUAC for female correctly diagnosed 74.2% of cases of CED and 96% with normal nutritional status and the use of MUAC for male correctly diagnosed 96.9% of cases of CED and 63.9% with normal nutritional status. Similar study done on MUAC correctly diagnosed 82.35% of cases of CED and 81.82% of women with normal nutritional status.

Table 4. *Receiver operating characteristic curve of MUAC with sensitivity and specificity of female respondents in selected health facilities of Addis Ababa, May 2013.*

Criterion	Sensitivity	95% CI	Specificity	95% CI	PPV	NPV	YI
≤226mm	94.05	86.7 - 98.0	85.93	81.1 - 89.9	71.2	97.5	0.135
≤230mm	95.24	88.3 - 98.7	78.33	72.9 - 83.2	61.9	97.8	0.184
≤231mm	96.43	89.9 - 99.3	77.57	72.0 - 82.5	61.4	98.3	0.183
≤239mm	96.43	89.9 - 99.3	72.62	66.8 - 77.9	56.6	98.2	0.219
≤240mm	97.62	91.7 - 99.7	63.88	57.8 - 69.7	50	98.6	0.277
≤240.5mm	98.81	93.5 - 100.0	63.88	57.8 - 69.7	50.3	99.3	0.27

Table 5. *Estimated specificity at fixed sensitivity of Female respondents in selected health facilities of Addis Ababa, May 2013.*

Estimated specificity at fixed sensitivity			
Sensitivity	Specificity	95% CI	Criterion
80	89.56	85.42 to 93.46	≤221.7467
90	87.83	81.90 to 92.02	≤223.43
95	79.85	58.92 to 89.35	≤229.2
97.5	64.75	18.77 to 82.56	≤239.9
80	94.98	88.78 to 98.79	≤229.12
90	77.92	61.77 to 95.34	≤221.63
95	64.83	36.60 to 78.47	≤219.23
97.5	31.17	18.93 to 55.94	≤209.7964

Table 6. *Results of receiver operating characteristic curve analyses of mid-upper arm circumference with sensitivity and specificity of Male respondents in selected health facilities of Addis Ababa, May 2013.*

Criterion	Sensitivity	95% CI	Specificity	95% CI	PPV	NPV	YI
≤234mm	94.85	88.4 - 98.3	68.46	60.3 - 75.8	52.7	97.3	0.258
≤239mm	94.85	88.4 - 98.3	66.44	58.3 - 74.0	51.1	97.2	0.273
≤240mm	96.91	91.2 - 99.4	59.06	50.7 - 67.0	46.7	98.1	0.316
≤242mm	96.91	91.2 - 99.4	58.39	50.0 - 66.4	46.3	98.1	0.32
≤244mm	97.94	92.7 - 99.7	58.39	50.0 - 66.4	46.5	98.7	0.315

Table 7. *Estimated specificity at fixed sensitivity of Male respondents in selected health facilities of Addis Ababa, May 2013.*

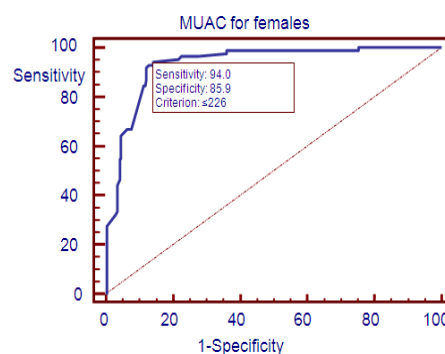| Estimated specificity at fixed sensitivity			
Sensitivity	Specificity	95% CI	Criterion
80	69.13	59.65 to 79.87	≤230.32
90	69.13	61.07 to 76.36	≤232.55
95	65.89	27.52 to 75.17	≤239.075
97.5	58.39	4.70 to 73.15	≤243.15
80	75.4	60.63 to 85.57	≤228.0941
90	24.74	13.22 to 60.82	≤212.45
95	18.07	1.78 to 28.04	≤209.3062
97.5	2.53	0.00 to 22.99	≤187.525

Figure 1. *Receiver operating characteristic curve of Female respondents MUAC in selected health facilities of Addis Ababa, May 2013.*
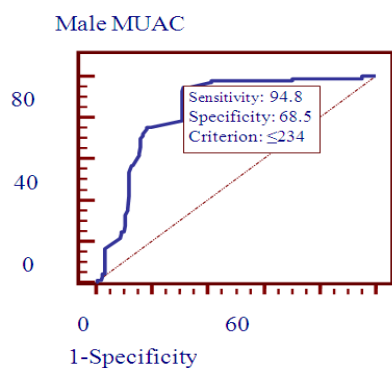
Figure 2. Receiver operating characteristic curve analysis of MUAC of Male respondents in selected health facilities of Addis Ababa, May 2013.

4. Discussion

The present study found that thirty five percent of women based on MUAC (≤220mm) and twenty-nine percent based on BMI (less than 18.5 kg/m^2) were Undernourished whereas forty-eight percent of men based on MUAC (≤230mm) and thirty–two percent based on BMI were undernourished. Since the study was aimed at assessing the sensitivity and specificity of MUAC in detecting under nutrition of PLWH. The determination of an adult population's Nutritional Status is recognized as of prime importance when assessing for population health and wellbeing. There are different modalities for this, BMI is most often used and MUAC is also recognized as a useful and simpler tool for screening adult individuals for poor nutritional status(15) and has been shown to accurately reflect adult nutritional status as defined by BMI(16).

The prevalence of CED (BMI ≤18.5) was 32.5% and 29.1% for male and female, were as the prevalence of under nutrition based on (MUAC ≤230 mm&, ≤220mm) were 48.4% and 35.7% in male and female respectively. The sensitivity and specificity of MUAC for Female and Male with optimal criteria of ≤220mm and ≤230mm were 91.9% and 95% respectively whereas for Males MUAC with optimal criteria of ≤234mm were 94.8% and 68.4% respectively. The sensitivity and specificity of MUAC for Female and male with optimal criteria of ≤224mm were 92.8% and 87.0%, respectively whereas for Males MUAC with optimal criteria of ≤234mm were 94.8% and 68.4% respectively.

There was a significant positive association between MUAC and BMI, regression analysis demonstrated that MUAC had a significant positive relation with BMI; the percentage of the variation in BMI explained by MUAC was 71%. The binary Logistic regression analysis demonstrated that overall, 82.2% of cases of CED were correctly classified by using MUAC. The use of MUAC for female correctly diagnosed 74.2% of cases of CED and 96% with normal nutritional status and the use of MUAC for male correctly diagnosed 96.9% of cases of CED and 63.9% with normal nutritional status this finding is similar with other studies done on MUAC which correctly diagnosed 82.4% of cases of CED and 81.82% of women

with normal nutritional status.

The present study demonstrated a significant positive correlation between MUAC and BMI(r=.71, p<0.01). MUAC value of 239 mm was found to be most appropriate in identification of female subjects with CED, and a value of 242 mm was most useful in identifying men with CED. Both of these values are higher than the internationally recommended men's MUAC cut-off value of 230 mm and females 220mm.

It is also recognized as an effective means of screening for poor NS in adults(17)-(15). However, the recommended MUAC cut-off value of 230 mm to define in men(3) may not be the most appropriate for all ethnic groups. A study from Nigeria(18) reported that a MUAC cut-off point of 230 mm was optimal for the north of the country, while a 240 mm Cut-off point was more appropriate for the south. Thus, there is a need to establish ethno-specific MUAC cut-off points. Similarly, a cut-off point of 240 mm was reported to be suitable in a recent study from the south of India(19); however, a recent study(20) of non-tribal adult slum dwellers of Bengalee ethnicity in West Bengal, India, reported a MUAC value of 240 mm to be the most appropriate cut-off point for identifying CED (BMI<18.5). A possible reason for cut-off points being higher than that suggested by James et al(3) is that persons of South Asian origin (eg the Oraon) have higher levels of regional adiposity (irrespective of BMI) compared with other ethnic groups(21)-(22).

Under nutrition is more prevalent in males than females this might be due to the peripheral adiposity of females, Individuals with a MUAC less than 240 mm were approximately twice as likely to report recent illness compared with those with a MUAC equal to or above 240 mm(20). Again in this study, MUAC close to 240 mm was appropriately sensitive to reported illness. However, this study combined with the similar findings discussed, suggests an urgent need to revisit BMI and MUAC cut-off values as the measures of CED and under-nutrition.

The area under curve (AUC) was 0.93 (p<0.001) (Table 9). A MUAC value of ≤ 239mm for female was identified as the best cut off to identify CED (BMI <18.5kg/m^2) with SN and SP of 96.43% and 72.62%, respectively. The PPV was 56.6(CI 89.9-99.3) with the highest NPV 98.2 (CI 66.8-77.9), thus having the highest YI of 0.21.

Another result of ROC curve analyses for Male MUAC are presented, with the sensitivity (SN), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) for each MUAC value to identify CED. The area under the curve (AUC) was 0.83 (p<0.0001) (Table 11). A MUAC value of <= 242mm for males was identified as the best cut off to identify CED (BMI <18.5) with SN and SP of 96.91% and 58.39%, respectively. The PPV was 46.3(CI 91.2-99.4) with the highest NPV 98.1 (CI 50.0-66.4), thus having the highest Youden Index of 0.32.

The mean BMI in this study for age group15-49 is 21.85 kg/m2 and 21.02 kg/m2 for women and men respectively. Forty-two percent of women have a normal BMI (between

18.5 and 24.9 kg/m2), while 29 percent of women are thin or undernourished (BMI less than 18.5 kg/m2) and 7 percent are overweight or obese (BMI 25 kg/m2 or above) this finding is supported by other studies except undernourished27% (23). Thirty –two percent of men have normal BMI (between 18.5 and 24.9 kg/m2), while 39.4 percent of men are thin or undernourished (BMI less than 18.5 kg/m2) and 4.5 percent are overweight or obese (BMI 25 kg/m2 or above).

Acknowledgement

Reference

[1]   Ferro-Luzzi A SS, Franklin M, James WPT. A simplified approach to assessing adult chronic energy deficiency. *European Journal of Clinical Nutrition* 1992;46:173-86.

[2]   WHO. *Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee.* World Health Organ Technical Report Series. 1995.

[3]   James WP M-TG, Norgan NG, Bistrian BR, Shetty PS, Ferro-Luzzi A. The value of arm circumference measurements in assessing chronic energy deficiency in Third World adults. *European Journal of Clinical Nutrition* 1994;48:883-94.

[4]   Bisai S BK. Undernutrition in the Kora Mudi tribal population, West Bengal, India: a comparison of body mass index and mid-upper-arm circumference. Food Nutr Bull2009;30(1):63-7.

[5]   Gustafson VFG, C>S> Vieira, B. Samb, A. Naucler,. Predictors for Death in HIV-positive and HIV-negative Tuberculosis Patients in Guinea-Bissau. 2007;35(2):69-80.

[6]   EFMOH. National Guidelines for HIV/AIDS and Nutrition in Ethiopia. 2000.

[7]   Jelliffe DB JE. The arm circumference as a public health index of protein-calorie malnutrition in early childhood. Journal of tropical pediatrics. 1996;15(177-260.).

[8]   Velzeboer Mea. Evaluation of arm circumference as a public health index of protein-calorie malnutrition in early childhood. Joumal of tropical pediatrics1983;29(135-44).

[9]   Briend A DC, Graven K, Mazumder RN, Wojtyniak B. Usefulness of nutritional indices and classifications in predicting   death   of   malnourished   children. BMJ1986;923:373=5.

[10]   Vella V TA, Ndiku J, Marshal T, Cortinovis I Anthropometry as a predictor for mortality among Ugandan children, allowing for socio-economic variables. Eur J Clin Nutr 1994;48:189-97.

[11]   Steve Collins M, BS. Using Middle Upper Arm Circumference to Assess Severe Adult Malnutrition During Famine *JAMA*1996;276(5):391-5.

[12]   WHO. Executive Summary of a scientific review. Consultation on Nutrition and HIV/AIDS in Africa.(Evidence, lessons and recommendations for action. Durban, South Africa); 2005.

[13]   BAPEN. Malnutrition universal screening tool (MUST); British Dietetic Association, 2011.

[14]   Z. Cook SK SLaSS. Use of BMI in the assessment of undernutrition in older subjects: reflecting on practice. 2005;64:313.

[15]   T.Khadivzadeh. Mid-upper arm and calf circumferences as indicators of nutritional status in women of reproductive age. *Eastern and Mediterranean Health Journal* 2002; 8:612-8.

[16]   Collins.S. Using middle upper arm circumference to assess severe adult malnutrition during famine. *JAMA* 1996;276:391-5.

[17]   Bose K GS, Mamtaz H, Mukhopadhyay A, Bhadra M. High prevalence of undernutrition among adult Kora Mudi tribals of Bankura District, West Bengal, India. *Anthropological Sciences 2006*;114:65-8.

[18]   AAO. Identification of underweight women by measurement of the arm circumference. International *Journal of Gynecology and Obstetrics* 1990;31:231-5.

[19]   Rodrigues VC RR, Lena A. . Utility of arm circumference as a screening instrument to identify women at nutritional risk. *Tropical Doctor*1994;24:164-6.

[20]   India Go. *Census of India.* (Online) 2001. http:/wwwcensusindiagovin 2010.

[21]   K. B. Generalised obesity and regional adiposity in adult White and migrant Muslim males from Pakistan in Peterborough. *Journal of Royal Society of Health* 1996;116:161-7.

[22]   Deurenberg P YM, van Staveren WA. Body mass index and percent body fat: a meta- analysis among different ethnic groups. *International Journal of Obesity Related Metabolic Disorder* 1998;22(12):1164.

[23]   Calverton M, USA, Central Statistical Agency Ethiopia Ethiopia Demographic and Health Survey 2011. Central Statistical Agency and ICF International2012:152-88.