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ESTIMATING NUTRITIONAL STATUS IN A SMALL COHORT OF ELDERLY CARE HOME RESIDENTS USING MUST, MNA AND BIOELECTRICAL IMPEDANCE PHASE ANGLE AND VECTOR ANALYSIS

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Abstract: *Objectives:* This study aimed to perform a non-invasive nutritional assessment in a group of elderly care home residents over a two-month period to estimate nutritional status using the malnutrition universal screening tool (MUST), the mini-nutritional assessment (MNA)-short form (-SF) and full version (-FULL), and bioelectrical impedance assessment (BIA). *Design:* An observational study performed over a 2 month period. *Setting:* A residential nursing care home in Lincolnshire, United Kingdom. *Participants:* 14 elderly Caucasian participants with presence of significant comorbidity were recruited (8 females and 6 males), mean age 85.6 ±6.2 (77-96). *Measurements:* Anthropometric measurements (height, weight, mid-upper arm and calf circumferences), calculation of body mass index (BMI), MUST and MNA scoring, and BIA at 50 kHz were completed at weeks 0, 4 and 8. BIA phase angle (PA) and BIA vector analysis (BIVA) at 50 kHz was investigated. *Results:* Group BMI indicated that the residents were a mixed group of body sizes and on average generally well nourished (e.g. week 0: 26.4kg/m2±6.5 (18.3-35.9). The MUST tool categorised residents predominantly within the low risk/normal range (62-67%); whereas MNA-SF placed the majority within medium/at risk category (57-77%); and MNA-FULL within medium/at risk (64-92%). PA (group at 0: 4.1±1.2 (2.2-6.7)) and BIVA indicated group data was similar to reference data for comorbid elderly populations with a lower nutritional and functional status. *Conclusion:* Study results indicate a potential data trend whereby there may be a mismatch in the assessment of nutritional status using MUST compared to the MNA. BIA PA and BIVA data supported the MNA results and were found to be consistent with reference population groups. Further studies in larger cohort groups will be necessary to confirm or refute this finding.

Key words: Malnutrition in the elderly, MUST, MNA, bioelectrical impedance, phase angle.

Introduction

Malnutrition in the elderly is believed to be a significant problem globally and within the United Kingdom (UK), although it's true prevalence is unknown (1-3). It is understood that during ageing there are characteristic alterations in body composition, energy expenditure and food intake which impact upon nutritional status. These include; a relative increase in fat mass (FM) and simultaneous reductions in fat free mass (FFM), skeletal muscle mass (SMM), resting metabolic rate (RMR) and total energy expenditure (TEE) (4-7). Weight loss is common in those over 70 years of age and there is thought to be a reduction in food intake and appetite coined "the anorexia of ageing" by J Morley, 1997 (8, 9). Further, comorbidity and frailty has an impact upon nutritional status with weight loss, sarcopenic and cachectic-type states being common (10-12). Studies have further indicated that poor food intake, loss of weight, FFM and low body mass index (BMI) are strong predictors of risk of morbidity and mortality in the elderly (13-19).

A range of nutritional screening tools have been developed with the aim of highlighting those at risk of malnutrition (20-22). This includes the malnutrition universal screening tool (MUST) advocated by BAPEN in the UK (2, 3) which formulates a risk of malnutrition score based upon current BMI, weight loss and the presence of acute disease. BMI is classified as normal at >20 kg/m2 (score-0), 18.5-20 (1) and <18.5 (2). The mini nutritional assessment (MNA) has been developed specifically for the elderly by Vellas et al and has been well utilised and researched (23, 24). It exists in both a short form composed of 6 questions and a full version of 18 questions; requiring additional information to the MUST including questions on neuropsychological status, physical mobility and food intake (23, 24). Scoring works

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in the opposite direction to MUST with a lower score indicating increased risk of malnutrition. BMI is classified as <19 (score-0), 19-21 (1), 21-23 (2) and >23 (3).

Bioelectrical impedance assessment (BIA) is a non-invasive portable tool for assessing body composition, FM and FFM. BIA has potential usage in the assessment of nutritional status although there is concern that in the co-morbid elderly population BIA predictive equations may lead to significant errors and lack accuracy (25, 26). Piccoli and Pastori, developed the BIA vector analysis (BIVA) concept and software using raw impedance resistance (R) and capacitance (xC) data at 50 kHz, normalising for height and plotting data onto a vectorgraph; and comparing data groups to healthy reference populations (25, 27). Norman et al, 2007 showed BIVA to be useful in assessing elderly patients with malnutrition (26). In addition, the BIA phase angle (PA) component which reflects the contributions between R and xC (calculated using the equation: PA (degrees) = arctan (Xc/R) x (180/π)) has been found to have prognostic potential in a range of clinical states and in the elderly (28).

The aims of this study were to estimate nutritional status and possible presence of malnutrition in a small group of elderly care home residents over a 2 month period comparing the MUST to MNA tools; and investigating the use of BIA PA and BIVA.

Methods

Participants and study design

Participants were recruited from an elderly nursing care home (LACE Housing Association, Lincoln) in Lincolnshire, United Kingdom in September 2011. Participants were elderly Caucasian residents, 14 in total (8 females and 6 males), with a mean age of 85.6 ±6.2 standard deviation (SD) (age range: 77-96). Participants had a high prevalence of co/poly-morbidity, disability and frailty, and treated with poly-medication.

Study protocol was submitted to the School of Life Sciences, University of Lincoln Ethics committee in June 2011. Full written consent from LACE Housing Association and written informed consent from individual participants was gained before study commencement. Exclusion criteria included inability to provide written informed consent and comorbidity which may significantly impair ability to perform measurements. Participants were un-identified and designated codes female, 'F' 1-8 and male, 'M' 1-6.

A full nutritional assessment was performed at three time points over a 2 month period, at week - '0'-initial screening/assessment, and at second and third time points, week '4' and '8' weeks. All measurements were taken in the presence of and with assistance from local known carers and nursing staff.

Nutritional assessment

MUST tool and MNA® screening

MUST and MNA® screening was undertaken at time points 0, 4 and 8. The MUST (bapen.org.uk) and MNA® tools (mna-elderly.com) were completed according to instructions and completed with assistance of local care staff. Both the MNA®-short form (MNA-SF) and full version (MNA-FULL) were completed and scores recorded. Scores were converted into categories for nutritional status using MUST and MNA® scoring criteria either 'low risk'/'normal'(0 points-MUST, 12-14 MNA-SF and 24-30 MNA-FULL), 'medium risk/at risk' (1 point-MUST, 8-11 MNA-SF and 17-23.5 MNA-FULL) 'high risk/malnourished' (≥2 points-MUST, 0-7 MNA-SF and < 17 MNA-FULL).

Anthropometric measurements

Height (m) and weight (kg) measurements were completed by local site carers. In some cases these had to be estimated, e.g. height from demi-span. BMI was then calculated in kg/m^2. In addition, calf, CC and mid-upper arm circumferences, MUAC (cm) were taken as components of the MNA tool.

Bioelectrical impedance measurements

BIA measurements were taken using a dual-frequency (5 kHz & 50 kHz) Bodystat ®1500 MDD bioelectrical impedance analyzer (Bodystat Ltd., Isle of Man). Measurements were taken using a hand-to-foot tetra-polar technique with participants in the supine position, in accordance with the manufacturer's guidelines. Raw impedance measurements of R and xC in ohms and PA were recorded at 50 kHz frequency. R and xC data was used for subsequent BIVA analysis according to Piccoli and Pastori, 2002 (25). Participants R and xC were normalised for height, H and group mean data +/- SD were calculated. Data for the group at week 0 was inputted into BIVA software and compared to reference healthy adult population using confidence ellipses as described by Piccoli and Pastori, 2002. In addition, median study group data points at weeks 0, 4 and 8 (without confidence ellipses) were plotted on a separate vectograph and relative positioning compared against adult reference data (27, 29) and data published by Norman et al, 2007 for comorbid elderly subjects grouped by MNA score I-III (26).

Table 1
Participant characteristics at week 0, mean values presented ± SD and range (minimum-maximum) for the entire group, females and males

	Group	Females	Males
Number of participants, n	14	8	6
Age, years	85.6±6.2 (77-96)	83.8±7.2 (77-96)	88±4.1 (82-94) *
Height, m	1.61±0.05 (1.52-1.68)	1.59±0.04 (1.52-1.66)	1.64±0.04 (1.56-1.68)
Weight, kg	68.8±17 (44.5-90.6)	67.9±20 (44.5-90.6)	70±13.6 (57.2-84.9)
Body mass index, kg/m²	26.4±6.5 (18.3-35.9)	26.8±7.8 (18.3-35.9)	25.9±4.8 (19.5-31.2)
Resistance at 50 kHz, ohms	544.3±104.1 (373.0-733.0)	550.1±101.6 (373.0-667.0)	536.5±116.7 (421.0-733.0)
Resistance at 50 kHz/Height, ohms/m	338.3±69.1 (236.0-470.0)	345.5±63.3 (236.0-401.8)	328.8±81.3 (255.2-470.0)
Reactance at 50 kHz, ohms	38.7±10.9 (29.6-73.5)	42.6±13.1 (32.5-73.5)	33.5±3.2 (29.6-37.3) *
Reactance at 50 kHz/Height, ohms/m	24.1±7.2 (17.8-47.1)	26.8±8.6 (20.3-47.1)	20.6±2.3 (17.8-24.0) *
Phase angle at 50 kHz, degrees	4.1±1.2 (2.9-6.7)	4.5±1.4 (3.3-6.7)	3.7±0.6 (2.9-4.2)
Mid-upper arm circumference, cm	29.5±5.8 (21.0-40.0)	29.9±6.6 (22-40)	28.9±4.9 (21-35)
Calf circumference, cm	31.1±4.9 (22.5-41.0)	30.8±4.4 (23.5-36.5)	31.5±6.0 (22.5-41.0)

*significantly different compared to female group ($P < 0.05$);

Data analysis

Data is presented as mean average measurements ± SD with a range (minimum-maximum). Medians are stated for specific BIVA and BIA PA measurements as they are compared to reference data of a similar elderly population (26). Data has been grouped into whole participant group, females and males, and where relevant at all time points weeks 0, 4 and 8. Statistical analysis has been performed using IBM SPSS Statistics, version 19, New York, USA and PAST, version 1.97, Hammer and Harper, 2010. T-tests were used for normally distributed data and Mann-Whitney-U test for nonparametric data. Correlations between variables were performed with r and P values presented. A P value of < 0.05 was considered statistically significant.

The comparison of categorical variables including the MUST versus MNA data was conducted using descriptive statistics only as sample size was limited.

Results

Of the 14 participants, 1 female resident (F4) left the care-home to return home after the initial screening period at week 0, and 1 male resident (M5) was taken ill on the final set of measurements in week 8. Participant characteristics at week 0 can be seen in Table1.

Males were significantly older than the female group ($P < 0.05$). xC measurements at 50 kHz (xC and xC/H) were higher in females than males ($P < 0.05$).

Body weight, BMI and anthropometric measurements

Body weight (kg), weight changes (weight loss) and BMI (kg/m^2) are main components of both the MUST and MNA and play key roles in generating a malnutrition screening score. Group, female and male weight and BMI at week 0 can be seen in Table 1. Group weight and BMI for all weeks can be seen in Table 2.

Table 2
Weight (kg) and BMI (kg/m2) for the participant group at weeks 0, 4 and 8. Results displayed as mean ±SD and range (minimum-maximum)

	Week 0 (n = 14)	Week 4 (n = 13)	Week 8 (n = 12)
Weight, kg	68.8±17.0 (44.5-90.6)	70.5±17.5 (42.6-92.0)	69.1±17.0 (46.1-90.9)
Body mass index, kg/m²	26.4±6.5 (18.3-35.9)	26.7±6.9 (17.5-36.0)	26.5±6.8 (19.0-35.5)

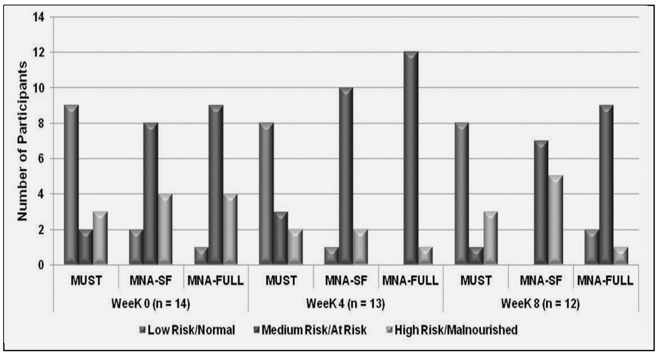
MUAC and CC were measured as a component of the MNA-full (Table 1). MUAC correlated with BMI ($r = 0.77$, $P = 0.001$) and CC with BMI ($r = 0.73$, $P = 0.003$).

Malnutrition screening using the MUST compared to MNA

Presence of malnutrition was assessed using the MUST tool, MNA-short form (MNA-SF) and MNA-FULL version at weeks 0, 4 and 8 (as described within methods). These can be seen in Figure 1.

The MUST tool categorised residents predominantly within the low risk/normal range, 9/14 (64%) for week 0, 8/13 (62%) for week 4, and 8/12 (67%) for week 8. The MNA-SF placed the majority of residents within the medium/at risk category; i.e. 8/14 (57%) for week 0, 10/13 (77%) for week 4 and 7/12 (58%) for week 8. The MNA-FULL also placed the majority of residents within the medium/at risk category; i.e. 9/14 (64%) for week 0, 12/13 (92%) for week 4 and 9/12 (75%) for week 8.

Figure 1
Graph to show the number of residents who scored either in the 'low risk/normal' range, 'medium risk/at risk' or 'high risk/malnourished' using the MUST tool, MNA-short form (-SF) and MNA-FULL, for weeks 0, 4 and 8



Bioelectrical impedance phase angle and vector analysis

BIA measurements were taken for all resident participants at weeks 0, 4 and 8 with the exceptions of resident F4 at 4 and 8, and M5 at 8. As shown in Table 1, R, xC and PA at 50 kHz were recorded. In addition, R and xC values were normalised for H (m). PA, R/H and xC/H for weeks 0, 4 and 8 are shown in Table 3.

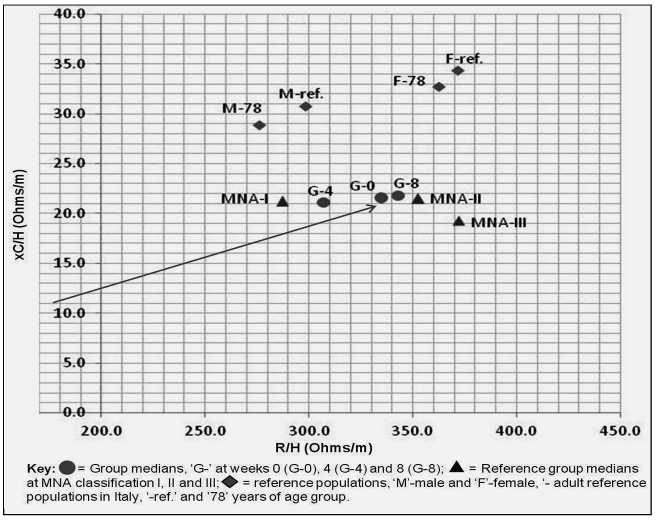
Table 3
Table to show group measurements for R/H and xC/H (in ohms/m) and PA (in degrees) for weeks 0, 4 and 8. Mean ±SD is presented followed by median and range (minimum and maximum)

	Week 0 (n = 14)	Week 4 (n = 13)	Week 8 (n = 12)
R/H, ohms Ω/m	338.3±69.1	328.4±63.2	353.1±82.4
	334.7 (236-470)	307 (236-404)	343 (224-470)
xC/H, ohms Ω/m	23.7±7.5	23.4±7.7	22.4±2.9
	21.6 (17.4-47.1)	21.1 (17.9-48.6)	21.8 (17.5-26.7)
PA, degrees °	4.1±1.2	4.1±1.1	3.7±0.6
	3.9 (2.2-6.7)	4 (3.1-7.3)	3.9 (2.9-4.5)

Bioelectrical impedance vector analysis

BIA R/H and xC/H mean group results at week 0 were inputted into the BIVA software (25) and compared to the reference healthy population (27) using principles of BIVA software and confidence ellipses (data not shown), indicating a distinct vector migration from normal ranges. Secondly, group data points for this study were then plotted on to a separate vectograph with the reference group data points (26, 27) and another 78-year old reference population (29) to indicate relative positioning of vectors (see Figure 2.).

Figure 2
Vectograph of R and xC (ohms) normalised for H (m) as R/H and xC/H (ohms/m) to show relative positioning (not including tolerance ellipses) for group median data points at weeks 0, 4 and 8 of study (mean vector arrow direction towards the groups, 0, 4 and 8 is shown). Relative positioning is compared to reference adult Caucasian male and female populations from the literature (27), at 78 years of age (29), and reference group median data points from (26) - classification of elderly comorbid patients based upon MNA scoring I-III. MNA I (normal) (n=22), median R/H = 287.1 (265.5-329.8), xC/H = 21.2 (18.8-23.0) and PA = 4.0 (3.8-4.7). MNA II (at risk) (n=80), median R/H = 352.5 (299.8-385.4), xC/H = 21.5 (18.1-26.3) and PA = 3.7 (3.3-4.3). MNA III (malnourished) (n=10), median R/H = 372.0 (337.0-455.4), xC/H = 19.3 (17.8-22.6) and PA = 2.9 (2.6-3.5)



Discussion

This case study aimed to investigate the simultaneous use of a range of rapid and non-invasive screening and assessment methods of determining nutritional status and potential presence of malnutrition in a small group of elderly people within a nursing care home. Group mean BMI at weeks 0, 4 and 8 indicate that the residents were a mixed group of body sizes but generally well nourished on average (e.g. at 0: 26.4kg/m2±6.5 (18.3-35.9)). Presence of malnutrition using the MUST tool categorised residents predominantly within the low risk/normal range (62-67% at week 0, 4 and 8); whereas the MNA-SF placed the majority of residents within the medium/at risk category (57-77% at week 0, 4 and 8); and MNA-FULL also within the medium/at risk category (64-92% at week 0, 4 and 8)-see Figure 1. This discrepancy between the MUST and MNA scores within this group is interesting considering the presence of comorbidity and in particular related to scoring on sections (C) mobility, (D) psychological stress or acute disease and (E) neuropsychological problems on the MNA-SF. Handgrip dynamometry (data not shown here in ref. 30) further supported lowered physical functional status. The low number of participants at high risk of malnutrition fluctuated over the weeks as a small number of residents had either been suffering from illness (or recovering) and with low BMI and weight changes (loss). Note also that MUAC and CC which are components of the MNA-full correlated significantly (P = 0.001 and P = 0.003, respectively) with BMI indicating that these are good indicators of BMI status in this group.

An issue of concern to address in future studies is whether the current BMI scale utilised in the MUST is adequate for this specific elderly population group. Beck and Ovesen as far back as 1998 suggested the cut-off point that should be used in the elderly to indicate an increased risk of malnutrition should be <24 kg/m2 (31). The MNA has a 'graded score' for BMI which is perhaps more appropriate compared to the MUST and <23 kg/m2 is the beginning of 'at risk' scaling (23, 24). This perhaps is sensible as body composition alterations in ageing (and physical inactivity) are consistent with a reduction in FFM and SMM and an increase in FM (4, 5, 10). This may have a potential 'masking' effect on weight loss from FFM and as explained by Beck and Ovesen at a BMI of 18.5-20 the elderly person may already have become malnourished (31). Other BIA data from this study using predictive equations further support reduced FFM and SMM in residents (30). This issue with BMI in the elderly as described in the introduction is a problem that should be addressed, and research indicates evidence of an "obesity paradox" in older aged people, with a higher BMI being associated with reduced mortality (14-16).

BIA PA results (see Table 2) are similar to data obtained in elderly hospital patients (n = 1071) by Wirth et al, (PA = 4.2±1.1°) (28). Wirth describes their results as being consistent with multimorbid elderly and lower than reference age/sex-specific measures previously reported. In addition, reference values from a large scale study by Bosy-Westphal et al report an average PA for >70 year old women at 5.07-5.27 and males to be 5.03-5.50 (range dependent on BMI) (32). Further, Wirth et al indicates that at a PA of <3.0-3.4 and >6.4 there is a significant increase in mortality rate (28). The PA data here is also similar to that obtained by Norman et al, in particular to the MNA class II group (26).

BIVA (see Figure 2) indicated a distinct vector shift from the normal reference population and similar to a comorbid elderly population (26). The downward shift in xC characteristically indicating a loss of tissue mass and structure as described by Piccoli and others (25, 33), potentially indicating a loss of tissue and FFM with age and disease and may signify the presence of other conditions such as malnutrition, sarcopenia and cachexia (21).

Hydration status may have been a study limitation as this has an impact on BIA (33, 34). The limited sample size of the participant group is unfortunately a major shortcoming of the study but should be placed in context that this is an exploratory case study in the UK in a particularly frail elderly group.

In summary, routine screening for malnutrition in the elderly in the UK is principally based upon utilisation of the MUST and BMI. In this small cohort the average BMI and MUST scores at weeks 0, 4 and 8 indicated that the residents were generally well nourished and had a normal/low risk of malnutrition. However, in contrast the MNA tool classified residents predominantly within the medium/at risk range, although this was not statistically significant due to low participant numbers. The BIA PA and BIVA data corresponded with the MNA trend and other data from reference population groups. Further research will be necessary in larger study groups in comparing these tools to fully evaluate these trends as they may ultimately impact upon nutritional screening outcomes in the elderly.

Conflict of interest statement: There is no disclosure of conflict of interest regarding this article.

Contributions: Dr Adrian Slee designed and carried out the study; analysed the data and wrote the manuscript.

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