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The importance of body composition assessment in the rehabilitation process

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Abstract

Introduction. This personal study provides several aspects of the importance of body composition assessment in rehabilitation process in order to manage fat mass (FM), fat-free mas imbalances (FFM), pre-sarcopenia status, sarcopenia and risks association and to improve global functionality. Health outcomes and risk estimations regarding fat mass and skeletal muscle mass (SMM) plays a major role and should be integrated into the rehabilitation process routine in order to avoid functional impairment and physical disability by applying specific kinetic programs. **Material and method.** A number of 14 subjects classified as outpatients who have received physical therapy at home- kinesiotherapy for post-fracture / dislocation status of the lower limbs in accordance with the medical recommendations and legislation in force. At the end of the rehabilitation phase, the body composition was measured using bio impedance in order to adjust the next step of the active rehabilitation. The measurements were obtained with a completely bioelectrical impedance analyzer (BIA). Single frequency BIA (SF-BIA) was used. For each subject major body compartments determined as FFM (including bone mineral tissue, total body water-TBW and visceral protein), SMM and FM were measured as a tissue-system by means of linear empirical equations stored in the system memory together with personal physical data. IBM SPSS software version 25 was used for statistical analysis. **Results and discussions.** Four age groups determined as follows: 21.43% for 18-39 years, 50-69 years, >70 years each and 35.71% for 40-49 years, based on the rate of muscle loss, because its integrity is essential for rehabilitation program. From the 14 subjects there are 57.14 % men and 42.86% women, from urban environment 78.57% and rural 21.43%. Mean Age is 48.79 years ± 18.792 Std. Deviation. Fat mass from BIA recorded 21.43% cases low and normal each, and high/very high 57.14% of total cases. Consequently, of BMI (body mass index) association, 57.14% are at normal weight, 35.71% overweight and with obesity and 7.14% underweight. One Sample Chi-Square test applied to BMI Type Associate with FM reveals the statistical significance, < .05(.014). Fat-free mass index (FFMI), fat mass index (FMI), skeletal mass index (SMI) were computed by adjusted with height square. FMI somatotype components results are 64.3% adipose cases, 21.4% intermediate and 14.3% lean. One Sample Chi-Square test applied to FMI Types reveals the statistical significance < .05(.046). Regression equation of standard BMI and FMI with scatter plots for 77.8% of cases was computed in the present study. FFMI somatotype components recorded 57.1% intermediate cases, 21.4% slender and solid each. Regression equation of standard BMI and FFMI with scatter plots for 57.4% of cases was computed. Three patients exceeded 15 seconds at the chair stand test so probable sarcopenia was identified. From BIA were extracted the value for the skeletal mass and SMI was calculated by height adjusted: 13 (92.86%) cases have normal values and one (7.14%) case have optimal value. Regression equation of standard BMI and SMI with scatter plots for 66.4% of cases was computed. Pearson correlation (CI =99%) denotes strong statistical relationship between BMI and FMI (r=0.882), FFMI (r=0.815), Age (r=0.659), Water (r=-0.693). FMI also correlates strongly with Age (r= 0.707), Water (r=-0.925) and Proteins values (r=-0.819). FFMI also correlates strongly with SMI (r=0.984). Water correlates with Protein (r=0.848, CI = 99%). Beta regression analysis strongly correlates SMI prediction with FFMI (ß=0.731), Water (ß=0.138) and Protein (ß=-0.370) for p<0.05. Anova significance of .000 (CI=99%) with applicability of 99.8% of the cases (R2 =0.998) proved that constant predictors: Water (%), FFMI, Proteins (%), FMI, BMI interact to influence SMM variability. 64.25% of subjects recorded an insufficient water level and 71.43% of subjects recorded an insufficient proteins level. Body composition evaluation should be integrated into routine clinical practice for the initial assessment and sequential follow-up and the strongest point of BIA is the possibility to replace invasive laboratory analysis with a quick, noninvasive test that can be carried out in a medical office. Body composition evaluation should be performed at the different stages of the disease, during the course of treatments and the rehabilitation phase. **Conclusions.** For each patient specific kinetic program will be developed. FMI increase (64.3% adipose cases) denotes the risk of metabolic syndrome and insulin resistance. Consequently, resistive and concentric exercises will be applied. For FFMI loss (57.1% intermediate cases, 21.4% slender) and SMI increasing (92.86% cases have normal values but not optimal ones, 21.43% pre-sarcopenia detected by positive chair test) resistance, eccentric/concentric exercises should be applied. All kinetic programs will be preceded by warm-up and followed by stretching taking into account cardiac reserve for each patient. Maximal/sub-maximal force exercises will be used age-related. Additional water (64.25% of subjects recorded an insufficient water level) and proteins levels (71.43% of subjects recorded an insufficient proteins level) must be balanced by nutritional support in accordance with rehabilitation consult and current physician approval in the interdisciplinary team. BIA may be an important supporting tool for health professionals in order to customize the rehabilitation programs for each patient.

Keywords: *body composition, rehabilitation, bioelectrical impedance, fat-free mass index, fat mass index, skeletal muscle index,*

1. Introduction This personal current study proposes that the body composition evaluation should be integrated into the rehabilitation process routine in order to reduce the clinical and functional consequences of diseases in the setting of a cost effective medico-economic approach.

1.1 Body composition models and measurement methods. Body composition comprises five level components defined as atomic, molecular, cellular, tissue system and whole body being described as a two, three or four compartment model, which can be used combined for a better understanding. A two-compartment model example is body weight (BW) = fat mass (FM) + fat-free body mass (FFM); a three-compartment model in which BW = fat + water (TBW- total body water) + residual (glycogen+ minerals + protein) and BW = fat (FM)+ bone mineral + lean soft tissue (FFM equivalent); and a four compartment model in which BW = fat (FM)+ water (TBW)+ minerals + residual (glycogen + protein).(1, 2)
Measurement technologies currently available for body composition levels are specified in Table 1.

Table 1 Body composition components and measurement method (1, 3, 4)

Level	Items	Recent methods	Other
Atomic	Hydrogen, Carbon, Oxygen (95%)	Neutron activation analysis	Whole-body 40 potassium counting
Molecular	Lipid + Water+ Proteins+ Glycogen + Minerals	**Bio impedance analysis** Dual energy X-ray absorptiometry Multicompartment models	
Cellular	Cells + Extracellular Fluid and Solids		Tracer dilution
Tissue system	Adipose Tissue+ Skeletal Muscle+ Skeleton+ Visceral Organs and Residual	Computerized axial tomography Magnetic resonance imaging	Ultrasound 24-h urinary creatinine and 3-methyl histidine excretion
Whole body			Anthropometry

1.2. Health outcomes and risk estimation regarding FM/FFM and SMM

The most common way to evaluate body composition is at molecular level according to Fat-free mass (FFM) referred as lean body mass and fat mass (FM). FFM can be divided into various items: bone mineral, extracellular water (ECW), intracellular water (ICW) and visceral protein. Total body water (TBW) represents the sum of ECW and ICW, in a normal hydration state = 73.2% (5, 6, 7, 14). These estimations are important health outcomes in relation to the management of sarcopenia (low muscle mass and functional impairment, physical disability, gait speed and mortality) and in the process of identifying the risk of excess fat. (1, 2). Sarcopenia defined as an age-related loss of skeletal muscle mass (SMM), muscle strength (dynapenia), and physical function integrity are important facts in the etiology of disability. (8, 9, 10, 11).
Direct (cadaver dissection) and indirect methods were developed to estimate FM and FFM, bone minerals and skeletal muscle mass (SSM) – Table 2.

Table 2 Indices and predictive techniques after (12, 13, 14, 15)

Simple measurements or indices (3)	**Features**	**Method type**
Skinfold thickness measurements	Assessment of subcutaneous fat depots; can be converted into standard deviation score (SDS) format for longitudinal evaluations	Indirect
Body mass index (BMI, calculated as weight/ height^2)	Index of relative weight, often expressed as SDS to take into account gender and sex. BMI is predictive of clinical outcomes such as type 2 diabetes, metabolic syndrome	Indirect
Waist circumference (WC)	Predictive of adverse outcomes such as lipid profile or insulin resistance	Indirect
Predictive techniques	**Features**	**Method type**
Bioelectric impedance analysis (BIA)	Measures impedance of the body to a small electric current. Conventional BIA analysis measures properties of the FFM only, indicating whether changes in lean mass are in the same direction as body weight, but should not be used to estimate change in fat mass.	Double Indirect
Dual energy x ray absorptiometry (DXA)	(DXA) measures bone mineral mass, which is calculated from the differential absorption of x rays of two different energies. Values of FM and FFM are calculated for whole body using instrument specific algorithms. Ionising radiation dose equivalents of contemporary instrumentation are below background levels.	Indirect
Densitometry	FM and FFM, requires measurement of total body density (body mass/body volume). Body volume was measured by hydro-densitometry or plethysmography. Densitometry monitors changes over time in overweight or obese individuals, and its accuracy is less likely to be confounded by longitudinal changes in fatness than DXA	Indirect
Isotope dilution (hydrometry)	Deuterium dilution can be used to measure TBW, allowing estimation of FFM. A dose of water labelled with deuterium is given and, following equilibration, enrichment of the body water pool measured using samples of either saliva, urine, or blood. Samples are generally analysed by isotope ratio mass spectrometry	Indirect
Magnetic resonance imaging	MRI is an imaging technique that estimates the volume rather than the mass of adipose tissue. By analysing the absorption and emission of energy in the radio frequency range of the electromagnetic spectrum, the technique produces images based on spatial variations in the phase and frequency of the energy absorbed and emitted.	Double Indirect
Other techniques	Total body electrical conductivity (TOBEC) a whole body potassium scanning (TBK)	Indirect
Multi-component models	Gold standard for in vivo measurement. The three-component model divides body weight into fat, water, and remaining fat-free dry tissue, and requires measurements of body weight, body water by hydrometry, and body volume by densitometry. The four component model divides fat-free dry tissue into protein and mineral, and requires the same data plus measurement of bone mineral by DXA	Indirect or double indirect

Application of the combination of these methods may reduce the misdiagnosis FFM variability. Multicomponent models are considered accurate to act as reference or criterion methods for the molecular approach to measuring body composition (fat and fat-free masses).

Material and method

Material 14 subjects classified as outpatients who have received physical therapy-kinesiotherapy at home for post-fracture / dislocation status of the lower limbs in accordance with the medical recommendations and legislation in force. (Period March-October 2021).

Method At the end of the rehabilitation phase, the body composition was measured using bio impedance in order to adjust the next step of the active rehabilitation.

The measurements of bioelectric impedance were obtained with a whole bioelectrical impedance analyzer (Amazfit Smart Scale - Body Composition Analyzer, Declaration of Conformity with directives 2014/53/EU and 2014/65/EU) from the own endowment of the practice cabinet. It was used a single frequency BIA (SF-BIA) of 50 kHz for body impedance components resistive and reactive ones. The method is based on the conduction of a painless low-intensity, imperceptible electrical current (500 to 800 μA) at a fixed (≈ 50 kHz). Measurement of body composition using bioelectric impedance is based on prediction equations. For each subject major body compartments determined as FFM (including bone mineral tissue, total body water and visceral protein), SMM and FM were measured as a tissue-system. TBW, SMM and FFM using SF-BIA were automatically estimated by means of linear empirical equations stored in the system memory together with personal physical data (age, weight, height).

Exclusion criteria: pregnant women, people wearing a pacemaker, subjects with skin lesions and altered fluid balance

Inclusion criteria: before the test: no alcohol for at least 8 h, no food and no drinking water for at least 4 h;

Procedure: the subjects were positioned vertically with arms and feet spread apart and shoes and socks removed and the conducting surfaces enter in contact with one of the body extremities, foot-foot in this case. The vertical model is easy to apply due to the fact that requires the subject to stand up barefoot on the electrodes platform (foot-foot touch). The system is a portable scale of facile use.

Results interpretation referred to Body Composition Zepp Analyser used, revised European consensus on definition and diagnosis of sarcopenia (16), fat-free mass index cut-off (FFMI =FFM/height2) and fat mass index cutoffs (FMI = FM/height2) (16, 17,18), BMI cutoffs and its association with percent body Fat (%) (18, 19). Age groups were established based on the rate of muscle loss (16, 20). IBM SPSS software version 25 was used for statistical analysis.

Results

Demographic variables.

There are four age groups as follows: 21.43% for 18-39 years, 50-69 years, >70 years each and 35.71% for 40-49 years based on the rate of muscle loss, because its integrity is essential for rehabilitation program, according to Fig. 1 - Age Groups based on the rate of muscle loss. Reason for age group distribution was the variability of muscle mass with aging.

Variation of muscle mass and strength decreases with aging so up to 40 years are maximal levels and between 40 and 50 years and over, loss of leg muscle mass is 1–2% per year and loss of strength levels 1.5–5% per year. As a result, 25 % of people under the age of 70 years and 40 % of those over the age of 80 years are sarcopenic. (16, 20, 21, 22, 23, 24)

From the 14 subjects there are 57.14 % men and 42.86% women, from urban environment 78.57% and rural 21.43%, according to Fig. 2 - Gender Distribution Pyramid, Fig. 3 - Environment Distribution.

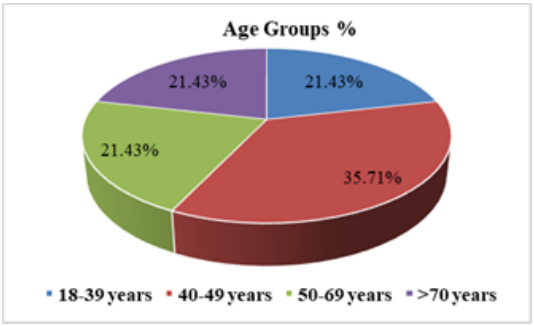


Fig. 1 Age Groups based on the rate of muscle loss

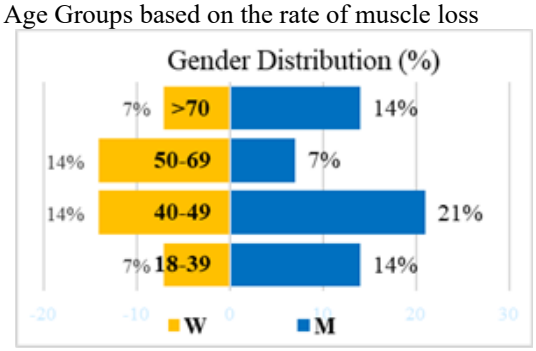


Fig. 2 Gender Distribution Pyramid

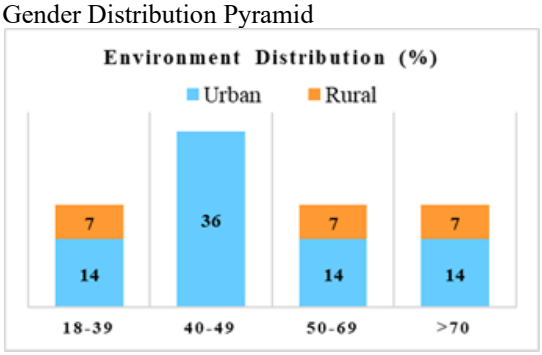


Fig. 3 Environment Distribution

Mean Age is 48.79 years ± 18.792 Std. Deviation, Weight 74.41 kg ± 17.99 Std. Deviation, Height (m) 1.70 m ± 0.081 Std. Deviation as specified in Table 3 - Mean, median, standard deviation on the studied sample. Frequency of Age Groups, Weight and Height including percentiles presented in Fig.4, Fig. 5 and Fig. 6.

Table 3 Mean median, standard deviation on the studied sample

Statistics		Age	Weight (Kg)	Height (m)
N	Valid	14	14	14
	Missing	0	0	0
Mean		48.79	74.4107	1.7057
Median		44.50	73.1250	1.7000
Std. Deviation		18.762	17.99798	.08055
Minimum		18	48.50	1.58
Maximum		78	104.10	1.84
Percentiles	25	39.75	57.6125	1.6300
	50	44.50	73.1250	1.7000
	75	67.75	89.0125	1.7675

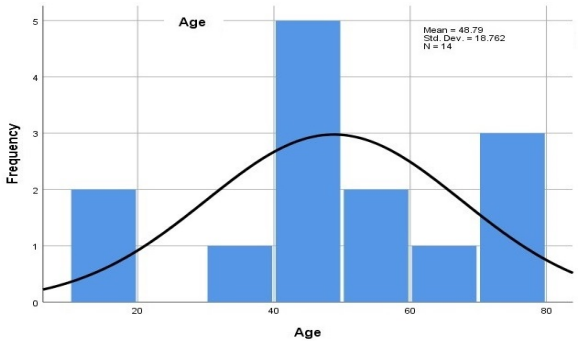


Fig. 4 Frequency of Age Groups including percentiles

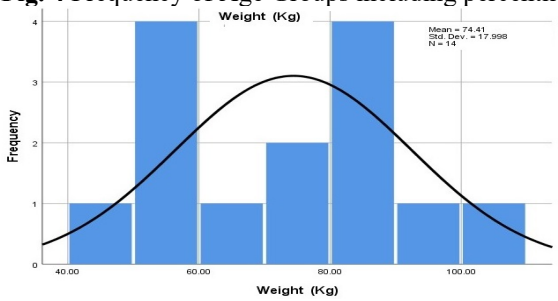


Fig. 5 Frequency of Weight including percentiles

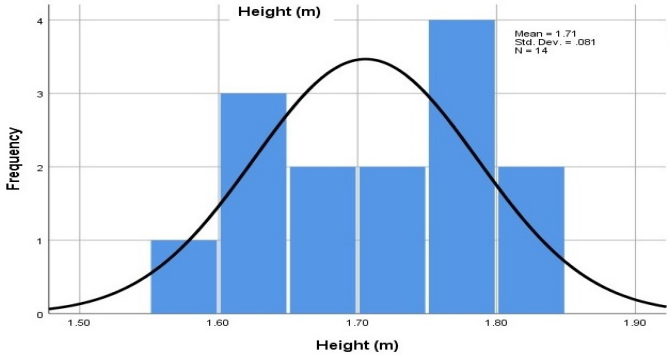


Fig. 6 Frequency of Height including percentiles

Health outputs

Standard BMI interpretation denotes 7.14% of cases underweight, 50% of normal weight and 42.86% overweight and obese. Fat mass from BIA recorded 21.43% cases low and normal each, and high/very high 57.14% of total cases. Association with Corporal Fat (%) from BIA was proceed according to Weight Classification (18, 19)

Table 4 Weight Classification

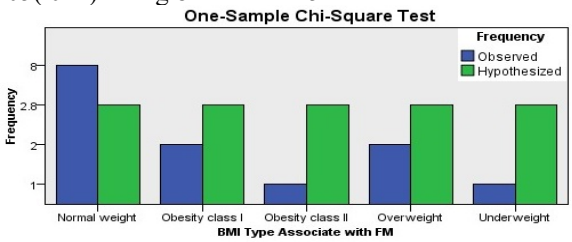
BMI kg/m2	Weight Classification (18,19)	Males FM(*)	Female FM(*)
18.5-24.9	Normal weight	<=26.0	<=34.0
18.5-24.9	Overweight	>26	>34
25.0-29.9	Normal weight	<=31.0	<=39.5
25.0-29.9	Overweight	>31	>39.5
30.0-34.9	Obesity class I	>=35	>=43
>=35	Obesity class II	>=39	>=50

As a result, 57.14% are at normal weight, 35.71% overweight and with obesity and 7.14% underweight as Table 5 shows.

Table 5 BMI Type Associate with FM

BMI Type Associate with FM					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal weight	8	57.1	57.1	57.1
	Obesity class I	2	14.3	14.3	71.4
	Obesity class II	1	7.1	7.1	78.6
	Overweight	2	14.3	14.3	92.9
	Underweight	1	7.1	7.1	100.0
	Total	14	100.0	100.0	

One Sample Chi-Square test applied to BMI Type Associate with FM reveals the statistical significance by rejecting the null hypothesis of equal distribution. The significance level is < .05(.014) as Fig 8 and Table 5 shows.



Total N	14
Test Statistic	12.429
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.014

1. There are 5 cells (100%) with expected values less than 5. The minimum expected value is 2.800.

Fig. 8 Chi-Square test BMI Type/FM

Table 5 Hypothesis Test Summary BMI Type/FM

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The categories of BMI Type Associate with FM occur with equal probabilities.	One-Sample Chi-Square Test	0.014	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Fat mass (FM) was deducted from corporal fat percentage adjusted by weight. The results body composition is based on the same principle as BMI calculation, towards the systematic normalization for body height of (FMI) (kg)/height^2 (m) = FM index. FMI types lean, intermediate and adipose used to evaluate general relationships between the body composition indices and somatotype components.

Table 6 FMI Types somatotype components

FMI Types (17)	Lean	Intermediate	Adipose
Males	<1.7	1.7–4.4	>4.4
Females	<3.4	3.4–6.4	>6.4

Applying to FMI Types somatotype components to the present sample results 64.3% adipose cases, 21.4% intermediate and 14.3% lean as Table 7 and Fig 9 of frequency. Age group distribution of 64.3% adipose cases comprises: 1 subject of 18-39 years, 4 cases of 40-49 years, 2 cases of 50-69 years and 2 cases of >70 years.

Table 7 FMI Types

FMI Types					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adipose	9	64.3	64.3	64.3
	Intermediate	3	21.4	21.4	85.7
	Lean	2	14.3	14.3	100.0
	Total	14	100.0	100.0	

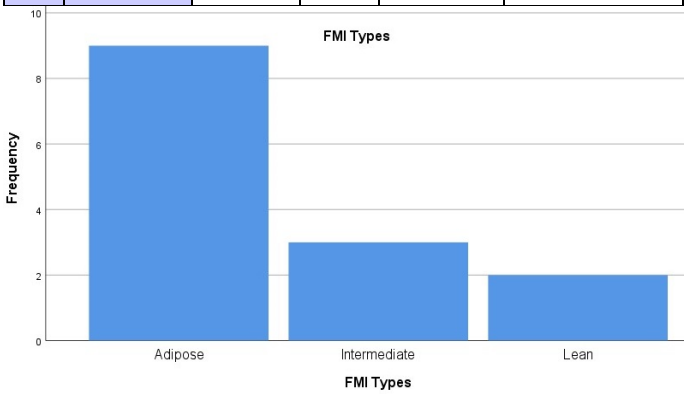
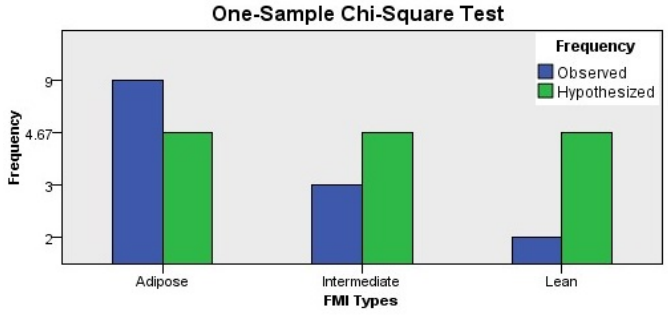


Fig. 9 Frequency of FMI Types

One Sample Chi-Square test applied to FMI Types reveals the statistical significance by rejecting the null hypothesis of equal distribution. The significance level is < .05(.046) as Fig 10 and Table 8 shows.



Total N	14
Test Statistic	6.143
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.046

1. There are 3 cells (100%) with expected values less than 5. The minimum expected value is 4.667.

Fig. 10 Chi-Square test for FMI Type

Table 8 Hypothesis Test Summary for FMI Type

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The categories of FMI Types occur with equal probabilities.	One-Sample Chi-Square Test	0.046	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Regression equation (**1**) was computed in the present study by taking into consideration standard BMI (x) and FMI (y) with scatter plots for 77.8% of cases, strong relation between the two variables as Fig 11 shows – personal contribution

$$y=8.31+0.63*x \quad (1)$$

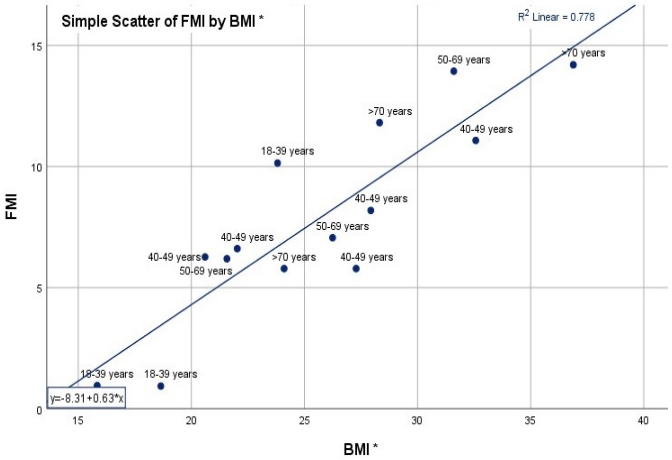


Fig. 11 Scatter plots/ regression equation of standard BMI (x) and FMI (y)

Fat-free mass (FFM) was determined by summing the amounts adjusted by weight of various components: bone mineral (%); water seen as total body water (%) and visceral protein (%). A fat-free mass index (FFMI = FFM/ height^2) may also eliminate the influence of stature in comparing FFM by FFM index calculation.

Table 9 FFMI Types somatotype components

FFMI Types (17)	Slender	Intermediate	Solid
Males	<16.5	16.5–19.9	>19.9
Females	<14.4	14.4–17.1	>17.1

Applying to FFMI Types somatotype components to the present sample results 57.1% intermediate cases, 21.4% slender and solid each as shown in Table 10 and Fig 12 of frequency. Age group distribution of 21.4% slender and solid each cases comprises: 2 subjects of 18-39 years, 1 case of 40-49 years for slender and 2 cases of 40-49 years and 1 case of >70 years for solid.

Table 10 FFMI Types

FFMI Types					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Intermediate	8	57.1	57.1	57.1
	Slender	3	21.4	21.4	78.6
	Solid	3	21.4	21.4	100.0
	Total	14	100.0	100.0	

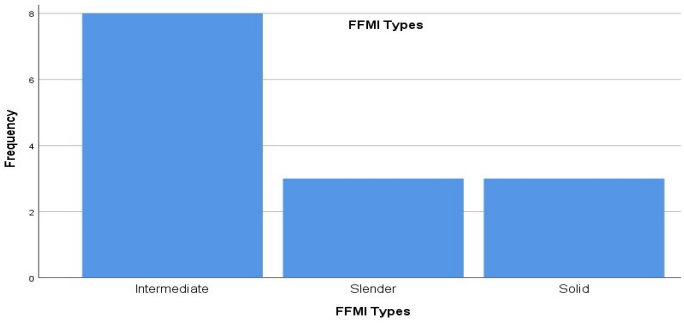
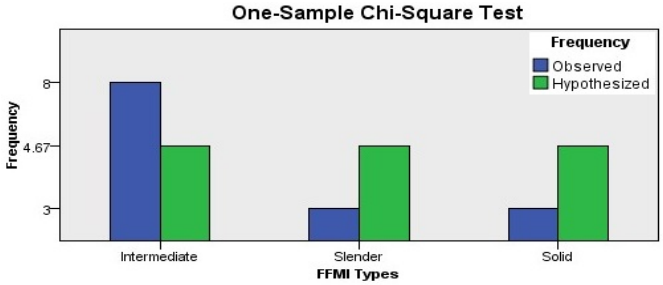


Fig. 12 Frequency of FFMI Types

One Sample Chi-Square test applied to FFMI Types reveals no statistical significance by retaining the null hypothesis of equal distribution. The significance level is > .05(.168) as Fig 13 and Table 11 shows.



Total N	14
Test Statistic	3.571
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.168

1. There are 3 cells (100%) with expected values less than 5. The minimum expected value is 4.667.

Fig. 13 Chi-Square test for FFMI Type

Table 10 Hypothesis Test Summary for FFMI Type

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The categories of FFMI Types occur with equal probabilities.	One-Sample Chi-Square Test	0.168	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.				

Regression equation (**2**) was computed in the present study by taking into consideration standard BMI (x) and FFMI (y) with scatter plots for 57.4% of cases, strong relation between the two variables as Fig 14 shows – personal contribution.

y=7.26+0.37*x	(**2**)

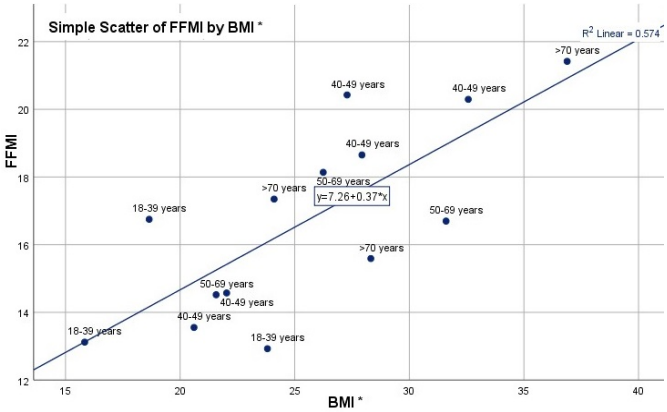


Fig. 14 Scatter plots/ regression equation of standard BMI (x) and FFMI (y)

European consensus on definition and diagnosis of sarcopenia specified the factors that cause sarcopenia. Factors usually interact. Categorised as primary age-associated muscle loss and secondary based on physical inactivity determined by inflammatory conditions, sedentary behaviour, limited mobility or bed rest, under-nutrition or malabsorption over-nutrition or obesity. (16) All 14 subjects have a sedentary behaviour and physical inactivity due to the specific condition post-fracture / dislocation status of the lower limbs so at the end of rehabilitation. SMM and strength were evaluated according to EWGSOP2 practical algorithm. The chair stand test (also called chair rise test) was used for strength of leg muscles. The chair stand test measures the time needed for a patient to rise five times from a seated position without using arms. Since the chair stand test requires both strength and endurance, this test is a qualified but convenient measure of strength. It is used to identify low muscle strength. If time exceed 15 seconds for five rises, the test is positive. Three patients exceeded 15 seconds at the chair stand test so probable sarcopenia was identified: 2 woman and one man, one woman underweight, lean (FMI Type), slender (FFMI Type), age group 18-39 years, one woman adipose (FMI Type), intermediate (FFMI Type) and one man normal weight, intermediate (FM/FFM Type), both group age > 70 years. From BIA were extracted the value for the skeletal mass and SMI was calculated by height adjusted: 13 (92.86%) cases have normal values and one (7.14%) case have optimal value. EWGSOP2 sarcopenia cut-off points for low muscle quantity was used <7.0 kg/m2 form men and <5.5 kg/m2 for women. (16, 25).

Regression equation (**3**) was computed in the present study by taking into consideration standard BMI (x) and SMI (y) with scatter plots for 66.4% of cases, strong relation between the two variables as Fig 15 shows – personal contribution.

y=3.15+0.24*x	(**3**)

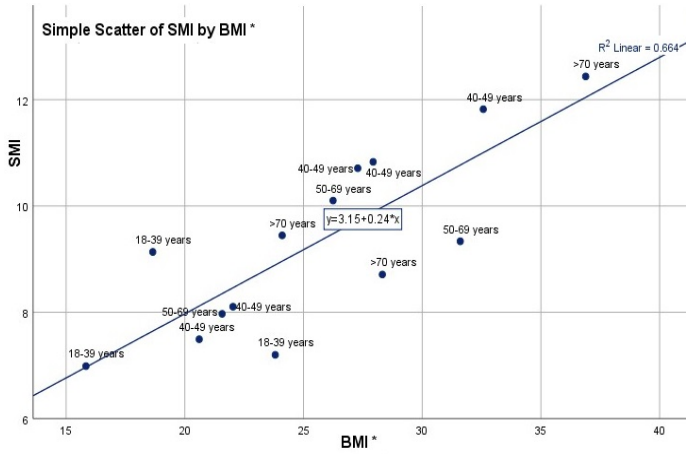


Fig. 15 Scatter plots/ regression equation of standard BMI (x) and SMI (y)

Pearson correlation were computed for BMI, FMI, FFMI, Age, Water (%), Protein (%) according to Table 11 and Fig 16. Strong statistical relationship were found between BMI and FMI (r=0.882, CI =99%), FFMI (r=0.815, CI =99%), Age (r=0.659, CI =99%), Water (r=-0.693, CI = 99%). FMI also correlates strongly with Age (r= 0.707, CI = 99%), Water (r=-0.925, CI =99%) and Protein values (r=-0.819, CI = 99%). FFMI also correlates strongly with SMI (r=0.984, CI = 99%). Water correlates with Protein (r=0.848, CI = 99%). Negative values descending trend of one independent variable influenced by the ascending trend of the dependent variable.

Table 11 Pearson Correlation

Pearson Correlations (r)								
		BMI *	FMI	FFMI	SMI	Age	Water (%)	Protein (%)
BMI *	r	1	.882**	.758**	.815**	.659*	-.693**	-0.494
	p		0.000	0.002	0.000	0.010	0.006	0.073
FMI	r	.882**	1	0.363	0.454	.707**	-.925**	-.819**
	p	0.000		0.202	0.103	0.005	0.000	0.000
FFMI	r	.758**	0.363	1	.984**	0.340	-0.098	0.153
	p	0.002	0.202		0.000	0.234	0.738	0.601
SMI	r	.815**	0.454	.984**	1	0.369	-0.170	0.014
	p	0.000	0.103	0.000		0.194	0.560	0.963
Age	r	.659*	.707**	0.340	0.369	1	-.670**	-0.516
	p	0.010	0.005	0.234	0.194		0.009	0.059
Water (%)	r	-.693**	-.925**	-0.098	-0.170	-.670**	1	.847**
	p	0.006	0.000	0.738	0.560	0.009		0.000
Protein (%)	r	-0.494	-.819**	0.153	0.014	-0.516	.847**	1
	p	0.073	0.000	0.601	0.963	0.059	0.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Matrix correlation representation with regression equation based on points cloud dispersion based on group age are according to Fig. 16

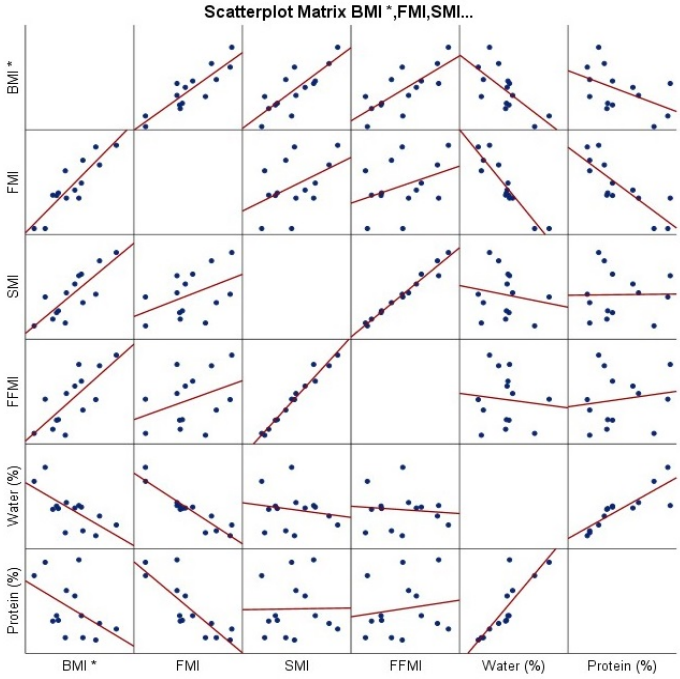


Fig. 16 Matrix correlation representation

Beta regression analyse was applied to index predictors for skeletal mass variation in order to identify interdependency of action. SMI was considered depended variable and constant predictors established were Water, FFMI, Protein, FMI and BMI. Anova significance of .000 (CI=99%) with applicability of 99.8% of the cases (R^2 =0.998) proved that constant predictors: Water (%), FFMI, Protein (%), FMI, BMI interact to influence SMM variability according to Table 12 R Square, Table 13 ANOVA and Table 14 Variables Entered/Removed

Table 12 R Square

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999[a]	0.998	0.996	0.10240
a. Predictors: (Constant), Water (%), FFMI, Protein (%), FMI, BMI*				

Table 13 ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.690	5	7.538	718.894	.000[b]
	Residual	0.084	8	0.010		
	Total	37.774	13			
a. Dependent Variable: SMI						
b. Predictors: (Constant), Water (%), FFMI, Protein (%), FMI, BMI *						

Table 14 Variables Entered/Removed[a]

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	Water (%), FFMI, Protein (%), FMI, BMI *[b]		Enter
a. Dependent Variable: SMI			
b. All requested variables entered.			

Beta regression analyse strongly correlates SMI prediction with FFMI (ß=0.731), Water (ß=0.138) and Protein (ß=-0.370) for $p<0.05$. Pearson correlation denotes the action of each variable independent but beta regression analyse emphasizes interdependency between different predictors.

According to Zepp analyser 64.25% of subjects recorded an insufficient water level, age group distribution being as follows one case at 18-39 years, 3 cases at 40-49 years, 2 cases at 50-69 years and 3 cases over 70 years.

According to Zepp analyser 71.43% of subjects recorded an insufficient proteins level, age group distribution being as follows one case at 18-39 years, 4 cases at 40-49 years, 3 cases at 50-69 years and 2 cases over 70 years.

Discussions

Bioelectrical impedance analysis (BIA) is widely used as a quick, non-invasive and low-cost technique to estimate human body composition. The human body can be divided into different compartments. Body composition evaluation allows measurement of the major body compartments: FFM (including bone mineral tissue), FM, and total body water. Fat-free mass (FFM) or lean body mass includes all body parts that are not fat mass (FM). (26)

Fat mass determination is important for the onset and progression of obesity. Adipose tissue is a key factor in modulating lipid and glucose homeostasis. Given the role of fat and lean tissue in lipid metabolism and insulin resistance, assessing the body's tissue composition is an important part of the management of the diabetic patient. (27)

Changes in body compartments are detected with the techniques of body composition evaluation. The relation between FFM loss and mortality has been extensively shown with BIA, which is the most used method in clinical situation as nursing home residence, chronic heart failure, chronic obstructive pulmonary disease, dialysis, cancer, liver transplantation, amyotrophic lateral sclerosis, Alzheimer's disease. (28-41)

BIA measures the phase angle and a low phase angle is related to survival in geriatrics, oncology, HIV infection/ AIDS, amyotrophic lateral sclerosis, peritoneal dialysis, and cirrhosis. The phase angle is associated with reduced survival. The relation of phase angle with prognosis and disease severity reinforces the interest in using BIA for the clinical management of patients with chronic diseases at high risk of undernutrition and FFM loss. FFM loss or a low phase angle is related to mortality in patients with chronic diseases, cancer (including obesity cancer patients), and elderly patients in long-stay facilities. A low FFM and an increased FM are associated with an increased period in adult hospitalized patients. The relation between FFM loss and clinical outcome is shown in patients with sarcopenic obesity. (28, 42-46). The increased prevalence of obesity together with chronic illnesses associated with fat-free mass (FFM) loss leads to an increased prevalence of sarcopenic obesity. FFM loss is related to increasing mortality, and impaired quality of life. The magnitude of the changes in this group of healthy men with few medical problems suggests that stronger exercise recommendations are needed to prevent sarcopenia and the early onset of disability. (47)

Consensus paper on sarcopenia by EWGSOP2 focuses on low muscle strength, detection of low muscle quantity and quality to confirm the sarcopenia diagnosis, updates the clinical algorithm that can be used for sarcopenia and provides clear cut-off points for measurements of variables that identify and characterise sarcopenia. Sarcopenia increases risk of falls and fractures, impairs ability to perform activities of daily living, mobility disorders and contributes to lowered quality of life. Sarcopenia is a progressive and generalised skeletal muscle disorder that is associated with increased adverse outcomes including fractures, falls, physical disability and mortality. Sarcopenia is probable when low muscle strength is detected. A sarcopenia diagnosis is confirmed by the presence of low muscle quantity or quality. When low muscle strength, low muscle quantity/quality and low physical performance are all detected, sarcopenia is considered severe. (16, 48-58)

Bioelectrical impedance analysis (BIA) has been explored for estimation of total or skeletal mass. BIA equipment does not measure muscle mass directly, but instead derives an estimate of muscle mass based on whole-body electrical conductivity. BIA equipment is affordable, widely available and portable, especially single-frequency instruments. Since estimates of muscle mass differ when different instrument brands and reference populations are used, cross-validated Sergi equation for standardisation are needed. (59, 60).

Body composition evaluation should be integrated into routine clinical practice for the initial assessment and sequential follow-up. (28). The strongest point of BIA is the possibility to replace invasive laboratory analysis with a quick, noninvasive test that can be carried out in a medical office. Body composition evaluation should be performed at the different stages of the disease, during the course of treatments and the rehabilitation phase.

Conclusion

There are four age groups as follows: 21.43% for 18-39 years, 50-69 years, >70 years each and 35.71% for 40-49 years based on the rate of muscle loss, because its integrity is essential for rehabilitation program. From the 14 subjects there are 57.14 % men and 42.86% women, from urban environment 78.57% and rural 21.43%. Mean Age is 48.79 years ± 18.792 Std. Deviation, Weight 74.41 kg ± 17.99 Std. Deviation, Height (m) 1.70 m ± 0.081 Std. Deviation. Standard BMI interpretation denotes 7.14% of cases underweight, 50% of normal weight and 42.86% overweight and obese. Fat mass from BIA recorded 21.43% cases low and normal each, and high/very high 57.14% of total cases. Consequently, of BMI association, 57.14% are at normal weight, 35.71% overweight and with obesity and 7.14% underweight. One Sample Chi-Square test applied to BMI Type Associate with FM reveals the statistical significance, the significance level is < .05(.014). Applying to FMI Types somatotype components to the present sample results 64.3% adipose cases, 21.4% intermediate and 14.3% lean. Age group distribution of 64.3% adipose cases comprises: 1 subject of 18-39 years, 4 cases of 40-49 years, 2 cases of 50-69 years and 2 cases of >70 years. One Sample Chi-Square test applied to FMI Types reveals the statistical significance, the significance level is < .05(.046). Regression equation (**1**) was computed in the present study by taking into consideration standard BMI (x) and FMI (y) with scatter plots for 77.8% of cases, strong relation between the two variables.

$y=8.31+0.63*x$	(**1**)

Applying to FFMI Types somatotype components to the present sample results 57.1% intermediate cases, 21.4% slender and solid each. Age group distribution of 21.4% slender and solid each cases comprises: 2 subjects of 18-39 years, 1 case of 40-49 years for slender and 2 cases of 40-49 years and 1 case of >70 years for solid. Regression equation (**2**) was computed in the present study by taking

into consideration standard BMI (x) and FFMI (y) with scatter plots for 57.4% of cases, strong relation between the two variables.

y=7.26+0.37*x	(**2**)

All 14 subjects have a sedentary behaviour and physical inactivity due to the specific condition; SMM and strength were evaluated according to EWGSOP2 practical algorithm. Three patients exceeded 15 seconds at the chair stand test so probable sarcopenia was identified: 2 woman and one man, one woman underweight, lean (FMI Type), slender (FFMI Type), age group 18-39 years, one woman adipose (FMI Type), intermediate (FFMI Type) and one man normal weight, intermediate (FM/FFM Type), both group age > 70 years. From BIA were extracted the value for the skeletal mass and SMI was calculated by height adjusted: 13 (92.86%) cases have normal values and one (7.14%) case have optimal value.

Regression equation (**3**) was computed in the present study by taking into consideration standard BMI (x) and SMI (y) with scatter plots for 66.4% of cases, strong relation between the two variables.

y=3.15+0.24*x	(**3**)

Pearson correlation were computed for BMI, FMI, FFMI, Age, Water (%), Protein (%). Strong statistical relationship were found between BMI and FMI (r=0.882, CI =99%), FFMI (r=0.815, CI =99%), Age (r=0.659, CI =99%), Water (r=-0.693, CI = 99%). FMI also correlates strongly with Age (r= 0.707, CI = 99%), Water (r=-0.925, CI =99%) and Protein values (r=-0.819, CI = 99%). FFMI also correlates strongly with SMI (r=0.984, CI = 99%). Water correlates with Protein (r=0.848, CI = 99%). (Fig 17-23)

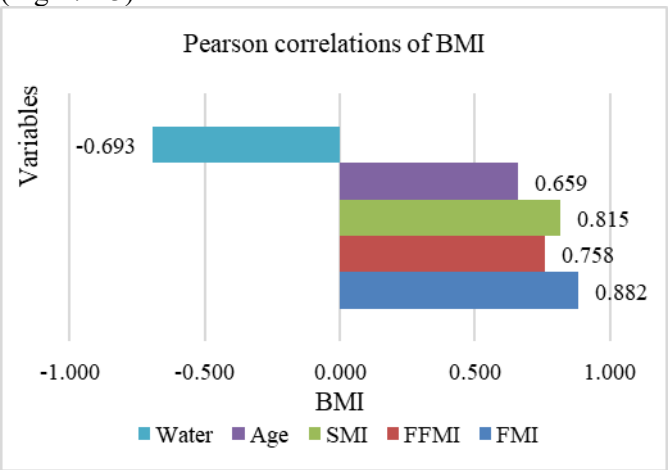


Fig. 17 Pearson Correlation of BMI

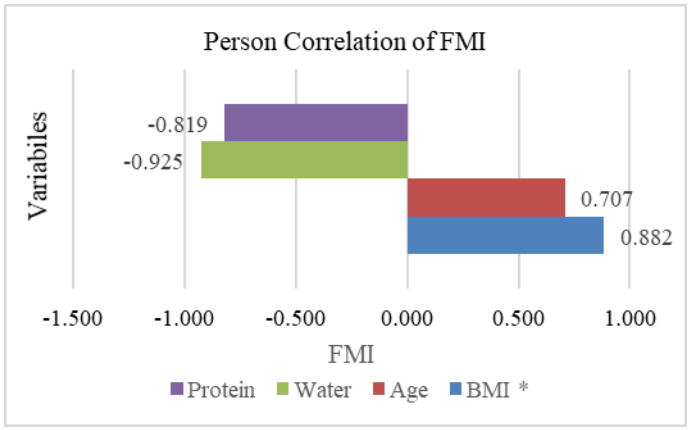


Fig. 18 Pearson Correlation of FMI

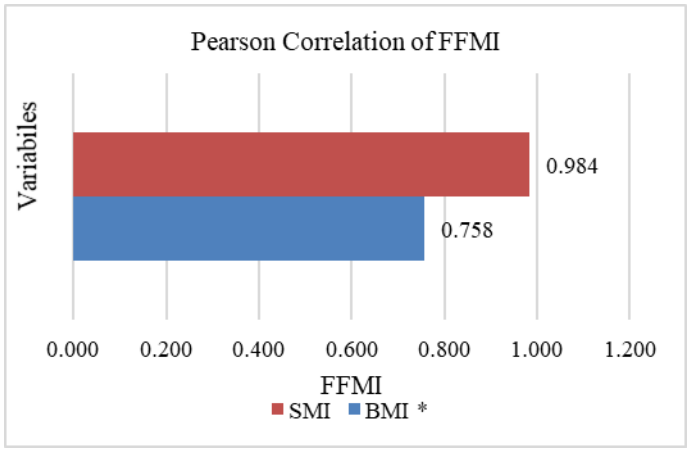


Fig. 19 Pearson Correlation of FFMI

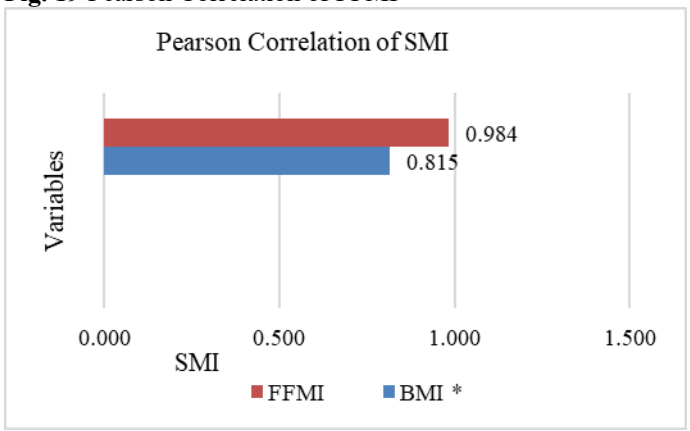


Fig. 20 Pearson Correlation of SMI

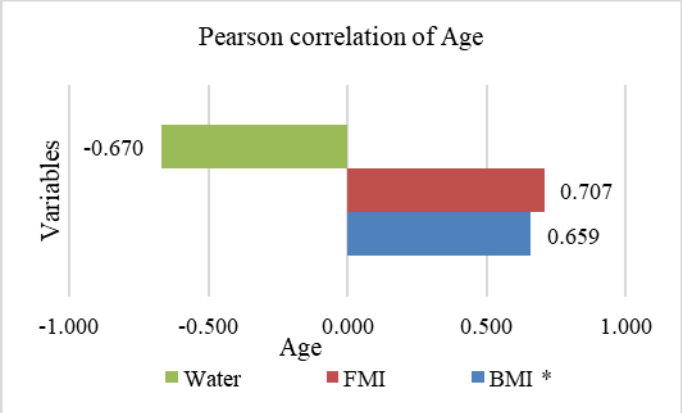


Fig. 21 Pearson Correlation of Age

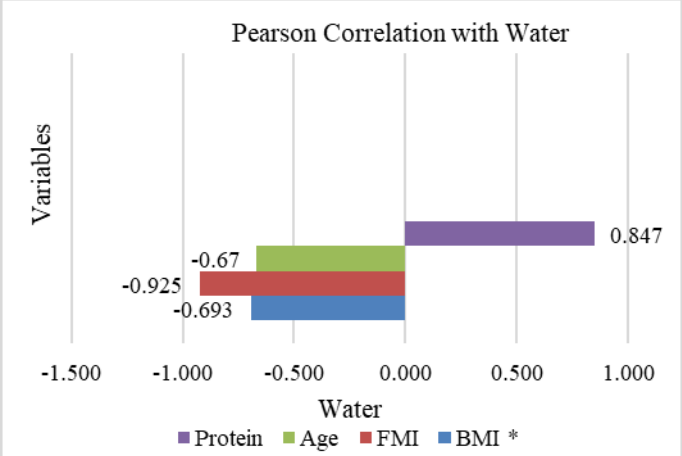


Fig. 22 Pearson Correlation of Water

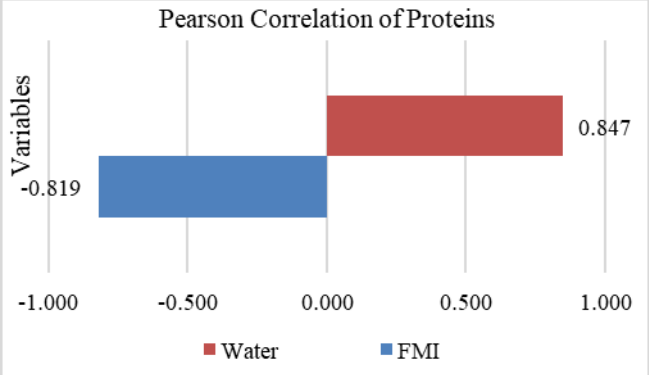


Fig. 23 Pearson Correlation of Proteins

Beta regression analyse strongly correlates SMI prediction with FFMI (ß=0.731), Water (ß=0.138) and Protein (ß=-0.370) for $p<0.05$. Pearson correlation denotes the action of each variable independent but beta regression analyse emphasizes interdependency between different predictors. Anova significance of .000 (CI=99%) with applicability of 99.8% of the cases (R^2 =0.998) proved that constant predictors: Water (%), FFMI, Protein (%), FMI, BMI interact to influence SMM variability.

According to Zepp analyser, 64.25% of subjects recorded an insufficient water level. For this issue age group distribution is as follows: one case at 18-39 years, 3 cases at 40-49 years, 2 cases at 50-69 years and 3 cases over 70 years. The amount of 71.43% of subjects recorded an insufficient proteins level. For this issue age group distribution is as follows: one case at 18-39 years, 4 cases at 40-49 years, 3 cases at 50-69 years and 2 cases over 70 years.

Conclusions regarding all 14 subjects can be summarized in ascending order as in Fig 24.

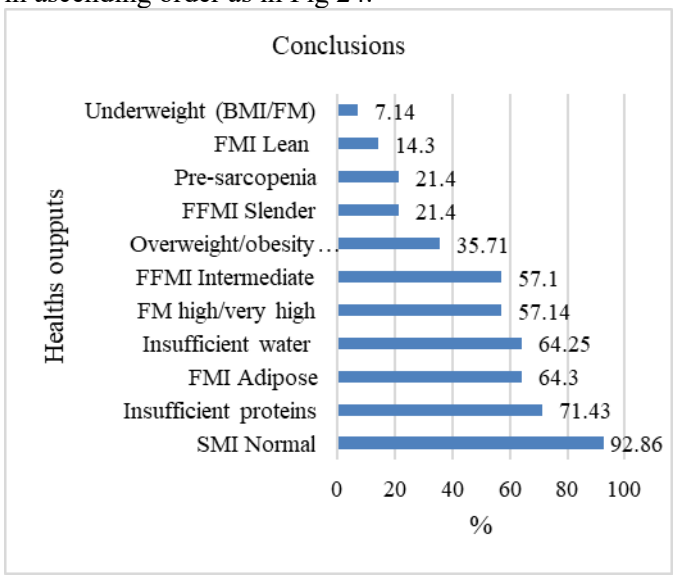


Fig 24 Conclusions regarding all 14 subjects

Finaly conclusion: for each patient specific kinetic program should be developed. Rehabilitation programs is essential, but it is very important that the programs to be customized for each patient.

FMI increase (64.3% adipose cases) denotes the risk of metabolic syndrome and insulin resistance. Consequently, resistive and concentric exercises will be apllied preceded by warm-up and followed by stretching. For FFMI loss (57.1% intermediate cases, 21.4% slender) and SMI increasing (92.86% cases have normal values but not optimal ones, 21.43% pre-sarcopenia detected by positive chair test) resistance, eccentric/concentric exercises should be applied taking into account cardiac reserve for each patient, preceded by warm-up and followed by stretching. Maximal/sub-maximal force exercises will be used age-related. Additional water (64.25% of subjects recorded an insufficient water level) and proteins levels (71.43% of subjects recorded an insufficient proteins level) must be balanced by nutritional support in accordance with rehabilitation consult and current physician approval in the interdisciplinary team as Fig. 24 - Flow diagram of specific intervention shows. Advantages of this approach are effort capacity increasing, cardiovascular factors

improvement (decrease in lipid fractions, normalizing glycemic status and blood pressure normalizing, weight loss and reducing the depression risk), preventing, delaying, treating, even reversing sarcopenia by effective interventions and reducing associated risks.

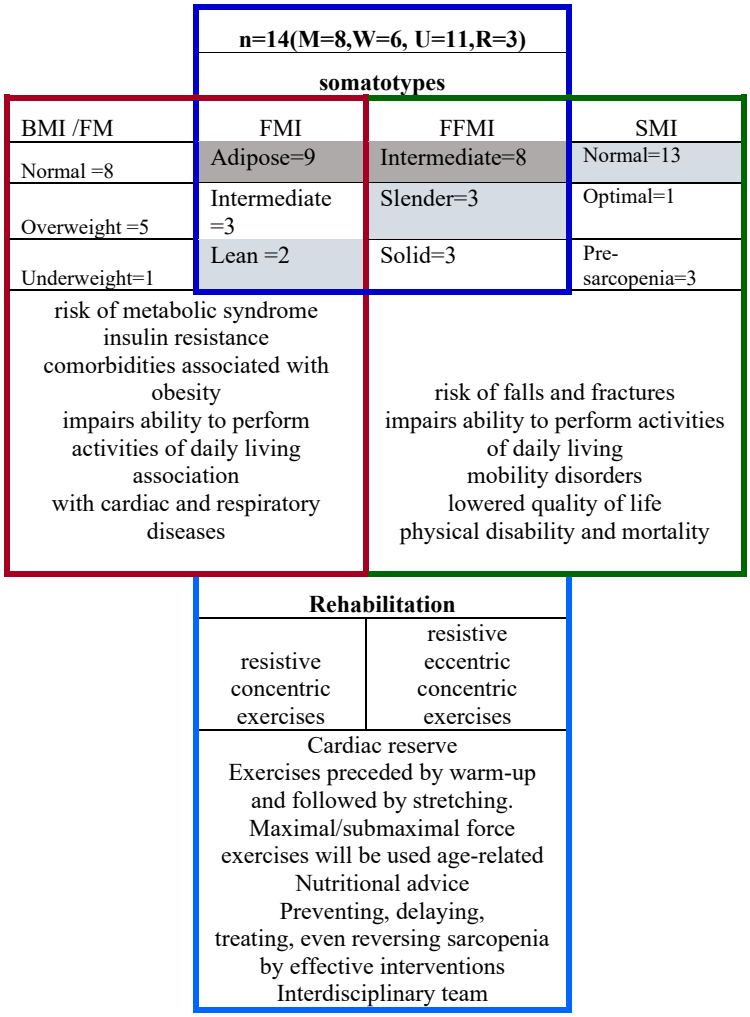


Fig. 25 Flow diagram of specific intervention (M=men, W=women, U=urban, R=rural)

Limits of the present study are the number of patients, SF BIA and for more accuracy multi-frequency BIA cam be used and the combination of other methods may reduce the misdiagnosis FFM variability.

Because of its simplicity, low cost, quickness of use at bedside, and good reproducibility, BIA appears to be the technique of for the systematic and repeated evaluation of FFM/SMM/FM, identifying masked obesity. With additional calculation as FMI, FFMI, SMI allows assessing and monitoring individuals suffering from consequences and comorbidities associated with obesity. Optimal care for people with pre-sarcopenia /sarcopenia is essential because the condition has high personal, social and economic burdens when untreated. BIA may be an important supporting tool for health professionals.

Declaration of conflict of interests

There is no conflict of interest for the author regarding this paper.

Informed consent

The investigated subjects were informed about the purpose and methodology of the study presented here, expressing their agreement to the processing and publication of the results, in compliance with the rules on personal data protection.

The present study was performed in accordance with the ethical standards. All patients included in the present study gave their informed consent.

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