Body Mass Index in elderly people - do the reference ranges matter?

Babiarczyk B., Turbiarz A.*

Faculty of Health Sciences, University of Bielsko-Biala, Poland

ABSTRACT

Introduction: Changes in body composition have important implications for the health status and functional efficiency of the elderly. There are many different methods used to diagnose malnutrition, with BMI being used most frequently.
Purpose: The objective of this research was to analyse the nutritional status of over 65 year olds using different BMI ranges and verify if the BMI cut-off values for the elderly are justified.
Materials and methods*:* The study population consisted of people aged 65 years and over, hospitalized in selected medical and care institutions located within the Bielsko county. Information was compiled by a questionnaire and the research was conducted by a direct interview. Anthropometric measurements (weight, height, BMI) were taken and clinical data were obtained from review of the participants' medical charts.
Results*:* In total, 202 people took part in the study. The majority of the study population were women (73.76%). The average age of participants was 77.59 ± 7.35 years. The average length of stay was 3.16 ± 2.48 days (hospitalized patients) and 66.17 ± 55.64 months (residents of care institutions). The majority of participants (86.63%) suffered from multiple diseases. The average BMI of the surveyed was 27.76±5.34 kg/m^2. According to WHO recommendations, 24.75% of participants were classified as having a "desirable" BMI, whereas 71.29% of them exceeded the "desirable" BMI range. BMI analysis in accordance with criteria proposed by the Committee on Diet and Health classified 38.61% of participants as having a "desirable" BMI, 39.11% as overweight or obese and 22.28% as being underweight.
Conclusions: Our study showed that BMI range for elderly were more effective in detecting of under nutrition in study population. However, more researches are needed to define specific BMI cut-off points for elderly and, once defined, these standards should be applied as international standards.
Key words: ageing, BMI thresholds, elderly, obesity, undernutrition

***Corresponding author:**
Faculty of Health Sciences, 6 Konopnickiej str.
43-300 Bielsko-Biala, Poland
Tel: +48 33 827 91 97
E-mail: aturbiarz@ath.bielsko.pl (Turbiarz Agnieszka)

Received: 13.03.2012
Accepted: 19.05.2012
Progress in Health Sciences
Vol. 1(2) ·2011 ·pp 58-67.

INTRODUCTION

Among numerous factors influencing both Polish and the global health situation, the process of demographic and epidemiological transition of society, understood as an ageing of society, remains one of the most significant. Demographic predictions indicate that by 2025 approximately 21% of the Polish population and 29% of the total European population will be over 65 years old [1, 2].

Evidence suggests that the risk of finding oneself at the extremes of the body mass index (either underweight or obese), increases along with age [3]. Changes in weight and body composition that occur as we are getting older, have important implications for the health status and functional efficiency of the elderly population [4-6].

The most obvious changes associated with ageing concern body composition [4]. Ageing is typically associated with a reduction in total and lean body mass. It is generally known that weight increases until approximately 60 years of age and decreases progressively thereafter. Muscle mass declines with age and is gradually replaced by a fat mass. Furthermore, fat location changes over time, with fat mass tending to increase around the abdomen as we age, which can often lead to serious metabolic consequences [3, 5-8].

Loss of height is also integrally connected with the ageing process. It is caused by a thinning of the vertebrae, compression of the vertebral discs, development of kyphosis or the effects of osteoporosis. Loss of height occurs in both men and women, although it may develop more rapidly in elderly women due to osteoporosis. It is estimated that loss of height begins at around 30 years of age, leading to a loss of approximately 1cm per decade until the age of 70, with a loss of 0.5cm per year thereafter [9].

The changes in body composition associated with ageing may result in BMI increase of 1.5-2.5 kg/m^2 in both men and women, even when body weight remains constant [3, 10, 11].

All changes in body composition should draw our attention to the nutritional status of elderly people, especially that they are often affected by co-morbidities.

Many different methods have been used to diagnose malnutrition in the elderly, but BMI (Body Mass Index) is the most frequently used method, both in Poland and globally. Moreover, BMI calculations are included in such screening tools as the MNA® (Mini Nutritional Assessment), the MUST (Malnutrition Universal Screening Tool) and the NRS 2002 (Nutritional Risk Screening 2002) and is generally accepted as an indicator of an optimal weight [12, 13]. BMI has been also shown to be a longitudinal predictor of quality of life in the elderly with chronic diseases like hypertension and diabetes [14].

BMI, sometimes also referred to the Quetelet index, is a weight-for-height index. It is calculated by dividing the subject's weight (kg) by the square of their height (m). Currently, the BMI criteria proposed by WHO are the most widely used (Table 1.).

However, there is an ongoing debate about whether use of the BMI index is appropriate for monitoring the nutritional status of older subjects [15]. Some experts claims that current BMI thresholds for overweight/obesity may be overly restrictive for elderly people, believing that BMI is of limited usefulness in the elderly population as this method does not allow us to distinguish between a lean body mass and a fat mass [16-18]. Instead, experts have proposed using age-related BMI criteria developed in 1989 by the Committee on Diet and Health in the USA (Table 1). The age-related BMI criteria has been used by several international researchers [19, 20].

The objective of the study was to analyse the nutritional status of over 65 year olds using different BMI cut-offs and verify if the BMI cut-off values for the elderly are justified.

MATERIALS AND METHODS

The research was conducted between November 2008 and July 2010. Studied institutions were comprised of one hospital and five care institutions located within the Bielsko, county in the south of Poland. The research proposal was accepted by the Ethical Committee of the Regional Medical Chamber in Bielsko-Biała (research approved 25th January 2008).

All patients, aged 65 and above, were hospitalised in the selected institutions and were eligible for inclusion in the study. A total of 308 elderly patients were tested. Participation was voluntary and all subjects were informed that they could leave the study at any stage of research. The following exclusion criteria were implemented:

- patients less than 65 years of age;
- patients with severe cognitive impairment;
- lack of informed consent;
- active phase of neoplastic disease on course of chemo- or radiotherapy treatment;
- physical condition hindering anthropometric examination (such as immobile patients, contraindication to lifting or amputation of both lower extremities).

Fig.1 shows a flow chart for patients considered for inclusion selection.

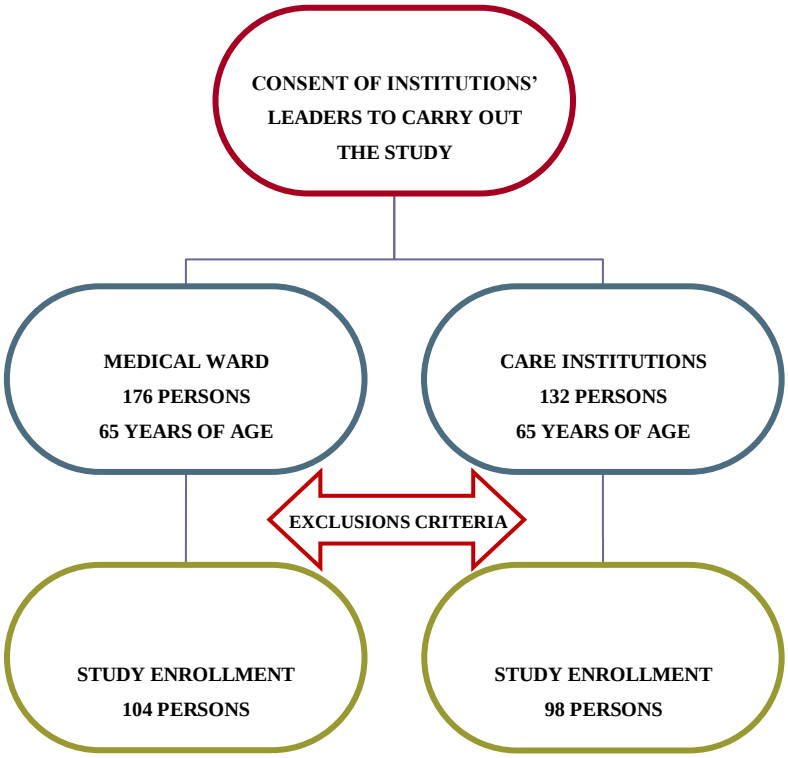

Fig.1. Flow chart for the selection of patients considered for inclusion.

The study employed a questionnaire method and was conducted by means of direct interview. During the interview categorising notes were taken. Clinical data were obtained from careful review of the participants' medical charts. All anthropometric measurements were recorded by a single individual. The body weight was obtained by weighing all patients in a state of fasting; using the same calibrated electronic wheelchair scale (SECA-EC, type approval D 05-09-024). In patients with amputated limbs (upper or lower), weight was calculated by adding the weight of the missing limbs to the current body weight, in accordance with the Nestlé Nutrition Institute guidelines (Table 2) [13].

The participants' heights were calculated using the patients age and knee height (KH) (measured in centimeters), in accordance with Chumlea's formula:

For men:

Height (cm) = 64.2 - 0.04 x age + 1.83 x KH

For women:

Height (cm) = 84.9 - 0.24 x age + 1.83 x KH

KH is a surrogate measurement used to estimate the height of elderly and non-ambulatory patients [21-23].

KH was measured using a knee caliper with the knee bent at a 90 degree angle to the ankle. BMI was calculated using the formula: Wt (kg)/Ht(m^2)

The participants' nutritional status was assessed using a criteria proposed by the WHO and the Committee on Diet and Health (Table 1).

The results were recorded on Excel Microsoft Office 2007 database prepared for the needs of this study and statistical analysis was conducted by the Statistica PL 9.0 program; license granted to the University of Bielsko-Biała. The study population was described using numbers and percentages of subjects. Quantitative features were presented with the arithmetic mean and standard deviation. In the assessment of differences between the groups, the Mann-Whitney non-parametric U test was used for independent variables.

RESULTS

The majority of studied population were women (73.76%), and the average age of participants was 77.59 ± 7.35 years (65-100 years of age). Almost half of the participants had completed only primary level education (47.52%), 4.95% of participants received no formal education.

The majority of the study population were professionally active prior to reaching retirement age, and of those study participants previously working 62.38% had performed manual work, 22.77% clerical work and 6.43% had worked in

agriculture. Hospital patients were admitted for an average of 3.16±2.48 days (1-8 days) and people staying in care institutions were resident for an average of 66.17±55.64 months (0.5-216 months). Due to different units of time being (hospital stays were measured in days, whereas care institution stays were measured in months) the average length of stay for the total population had not been specified.

Table 1. Selected BMI criteria.

Source	Age	Criteria	Classification
Committee on Diet and Health (1989)	19-24y	19-24 kg/m^2	Desirable BMI
	25-34 y	20-25 kg/m^2	
	35-44 y	21-26 kg/m^2	
	45-54 y	22-27 kg/m^2	
	55-65 y	23-28 kg/m^2	
	>65 y	24-29 kg/m^2	
Ferro-Luzzi (1992)	unspecified	<16 kg/m^2	Chronic energy deficiency-class 3
		16-16.9 kg/m^2	Chronic energy deficiency-class 2
		17-18.4 kg/m^2	Chronic energy deficiency-class 1
		18.5-24.9 kg/m^2	Normal weight
		25-29.9 kg/m^2	Obese-class 1
		30-39.9 kg/m^2	Obese-class 2
		>40 kg/m2	Obese-class 3
WHO (1997)	unspecified	<16 kg/m^2	Undernutrition-class 3
		16-16.9 kg/m^2	Undernutrition-class 2
		17-18.4 kg/m^2	Undernutrition-class 1
		18.5-24.9 kg/m^2	Normal weight
		25-29.9 kg/m^2	Preobese/overweight
		30-34.9 kg/m^2	Obese-class 1
		35-39.9 kg/m^2	Obese-class 2
		>40 kg/m^2	Obese-class 3
MNA®	unspecified	<19 kg/m^2	Undernutrition
		19-24.9 kg/m^2	Normal weight
		25-29.9 kg/m^2	Overweight
		>30 kg/m^2	Obese

Table 2. Percent of body weight contributed by specific body parts [13]

BODY PART	PERCENTAGE
Trunk w/o limbs	50
Hand	0.7
Forearm with hand	2.3
Forearm without hand	1.6
Upper arm	2.7
Entire arm	5.0
Foot	1.5
Lower leg with foot	5.9
Lower leg without foot	4.4
Thigh	10.1
Entire leg	16.0

Table 3. Demographics of study participants.

Variable	**Total sample** n=202	**Medical ward (MW)** n=104	**Care institutions (CI)** n=98
Gender			
Female	149 (73.76)	78 (75)	71 (72.45)
Male	53 (26.24)	26 (25)	27 (27.55)
Age (Mean±SD)	77.59±7.35	75.83±6.03	79.47±8.15
Education			
None	10 (4.95)	2 (1.92)	8 (8.16)
Primary school	96 (47.52)	53 (50.96)	43 (43.88)
Vocational school	21 (10.40)	11 (10.58)	10 (10.20)
College	56 (27.72)	30 (28.85)	26 (26.53)
High school	19 (9.41)	8 (7.69)	11 (11.23)
Former professional activity			
Manual work	126 (62.38)	68 (65.38)	58 (59.19)
Clerical work	46 (22.77)	18 (17.31)	28 (28.57)
Farmer	13 (6.43)	6 (5.77)	7 (7.14)
Non-working	17 (8.42)	12 (11.54)	5 (5.10)
Length of the stay in institutions* (Mean±SD)	-	3.16±2.48	66.17±55.64
Number of chronic diseases (Mean ± SD)	3.24±1.57	3.46±1.58	3.01±1.54

*MW in days; CI in months; MW-CI: p=non significant

Table 4. Comparison of study participants‘ BMI in accordance with different BMI criteria.

BMI range	**WHO criteria**	**Committee on Diet and Health criteria[a]**
Above the norm		
Total sample	144 (71.29)	78 (38.61)
MW	80 (76.92)	53 (50.96)
CI	64 (65.31)	25 (25.51)
Normal		
Total sample	50 (24.75)	79 (39.11)
MW	19 (18.27)	34 (32.69)
CI	31 (31.63)	45 (45.92)
Below the norm		
Total sample	8 (3.96)	45 (22.28)
MW	5 (4.81)	17 (16.35)
CI	3 (3.06)	28 (28.57)

MW: medical ward, n=104; **CI**: care institutions, n=98; **Below the norm**: WHO <18.5 kg/m2, Committee on Diet and Health <24 kg/m^2; **Normal**: WHO 18.5-24.9 kg/m^2, Committee on Diet and Health 24-29 kg/m^2; **Above the norm**: WHO >25 kg/m^2, Committee on Diet and Health >29 kg/m^2; [a] Mann-Whitney test; MW-CI: p=0.007

Table 5. Number of participants with chronic diseases in accordance with different BMI criteria.

Diseases	BMI range by WHO		
	Above the norm (N=144)	**Normal (**N=50)	**Below the norm (**N=8)
	n(%)	n(%)	n(%)
Number of chronic diseases	3.29 ± 1.61	3.20±1.43	2.63±1.69
cardiovascular	116 (80.56)	41 (82.00)	5 (62.50)
respiratory	27 (18.75)	7 (14.00)	2 (25.00)
gastrointestinal	42 (29.17)	10 (20.00)	3 (37.50)
renal & urinary	16 (11.11)	2 (4.00)	0
metabolic & endocrine	45 (31.25)	17 (34.00)	2 (25.00)
musculoskeletal	45 (31.25)	20 (40.00)	1 (12.50)
sensorineural	30 (20.83)	13(26.00)	1 (12.50)
hematology	7 (4.86)	3 (6.00)	2 (25.00)
cancer	5 (3.47)	4 (8.00)	1 (12.50)
Diseases	**BMI range by Committee on Diet and Health**		
	Above the norm (N=78)	**Normal** (N=79)	**Below the norm** (N=45)
	n(%)	n(%)	n(%)
Number of chronic diseases	3.29±1.51	3.24±1.71	3.16±1.43
cardiovascular	64 (82.05)	60 (75.95)	38 (84.44)
respiratory	15 (19.23)	14 (17.73)	7 (15.56)
gastrointestinal	21 (26.92)	23 (29.11)	11 (24.44)
renal & urinary	8 (10.26)	8 (10.13)	2 (4.44)
metabolic & endocrine [a]	35 (44.87)	14 (17.72)	15 (33,33)
musculoskeletal	27 (34.62)	24 (30.38)	15 (33.33)
sensorineural	15 (19.23)	17 (21.52)	12 (26.67)
hematology	1 (1.28)	8 (10.13)	3 (6.67)
cancer	4 (5.13)	1 (1.27)	5 (11.11)

Below the norm: WHO <18.5 kg/m2, Committee on Diet and Health <24 kg/m^2; **Normal**: WHO 18.5-24.9 kg/m^2, Committee on Diet and Health 24-29 kg/m^2; **Above the norm**: WHO >25 kg/m^2, Committee on Diet and Health >29 kg/m^2; **[a]** Mann-Whitney test; p=0.0490

A significant majority of studied population suffered from multiple diseases (86.63% of subjects were diagnosed with 2-8 concurrent diseases) and the average number of chronic diseases was 3.24±1.57 (0-8). The two study subgroups had similar compositions in terms of the gender, age and educational status of the subjects, former professional activity and number of chronic diseases (p-value >0.05). Table 3 shows demographics of study participants.

The average BMI value of the subjects was 27.76±5.34kg/m^2 (15-48kg/m^2). Comparison of study participants' BMI in accordance with different BMI criteria is shown in Table 4. Having analysed the BMI results in accordance with the criteria proposed by the WHO, it was found that only a quarter of the studied group fell within the "normal" BMI range, whereas a significant majority (71.29%) exceeded this range to varying degrees: 36.14% of subjects were found to be overweight; I° obesity was confirmed in 25.74% of the population, II° obesity in 8.42% of subjects and III° obesity was confirmed in 2 subjects (0.99%). Only a small percentage of participants were found to have below average BMIs (3.96%). The place of residence at the time of examination did not significantly influence the results.

Analysis of BMI results in accordance with the criteria for elderly people proposed by the Committee on Diet and Health revealed 38.61% of participants to have a desirable BMI. Almost exactly the same percentage (39.11%) were found to be overweight or obese, whilst as many as 22.28% of the study participants were found to have BMI results below the norm for elderly people. Using these criteria, the place of residence significantly influenced results (p=0.007). Almost twice as many residents of care institutions were diagnosed as undernourished compared with hospitalised patients, whereas patients on medical wards were twice as likely as care institution residents to exceed the desirable BMI thresholds for elderly people.

By far the most frequent diseases diagnosed in the subjects were those related to the cardiovascular system, regardless of which BMI category the study participants were found to belong to. The single-most common disease among the study population was hypertension. The second most common type of diseases were those of the metabolic & endocrine systems, of which the most frequently diabetes was diagnosed. Using the BMI criteria for elderly people, diseases of the metabolic and endocrine system were significantly more common in participants with higher or lower than average BMIs (p=0.490).

Musculoskeletal disease was the third most commonly diagnosed type of disease in all groups, except for those study participants, who were classified, according to the WHO criteria, as being undernourished; these participants were found to be more likely to suffer from gastrointestinal disease (Table 5).

DISCUSSION

From a population health perspective, malnutrition in the elderly is an important health issue, which requires attention. Undernutrition and overweight/obesity are both global problems that have serious negative health consequences [21-23].

Despite the widespread use of BMI, there is evidence that practitioners lack confidence in its efficacy. Cook at al. state that among dieticians working with older subjects who participated in the study, only 26% are totally happy with its use, while 69% continue to use BMI with elderly patients but feel that the reference ranges are not applicable for this demographic. Indeed, 5% continue to use this method because there is "nothing better" or because it is required by departmental policy [24].

Studies regarding the nutritional status of elderly people are confounded by numerous methodological problems. Significant amongst these problems is the fact that most data regarding desirable BMI thresholds originates from studies on children and young adults [3]. The BMI thresholds identified by the WHO as defining obesity were chosen because of increased all-cause mortality rates in subjects with a BMI greater than 25 kg/m^2 [5]. However, in the elderly the relationship between BMI and mortality is not the same.

It is clear, that the risk of being overweight or obese increases with advancing age. Obesity often leads to functional disability, depression and poor quality of life [25-27]. According to Polish epidemiological studies, all of which followed the BMI criteria recommended by the WHO, 27.9% of the Polish population were estimated to be overweight, with a further 17.4% estimated to be obese [28-31]. In their study of the rural population of eastern Poland, Panasiuk et al diagnosed underweight in 2.8%, overweight in 37.6% and obesity in 33.8% of participants aged 60 and above [29]. All studies conducted in Poland in years 1983-2005 reviewed by Jarosz and Rychlik used WHO criteria as well [32]. They estimated the level of overweight as between 41-45.5% of elderly men and 28.7-35.5% of elderly women, while the level of obesity was recorded as between 20.8-37.2% of elderly study participants. In the present study, only 24.75% of study participants fell within the "normal" BMI range according to WHO standards, and excess body weight seemed to be a significant problem in the study population. The findings were different when the BMI criteria for elderly people were used. Following these guidelines, about 40%

of the studied population proved to be well-nourished, but the percentage of undernourished people rose significantly to 22.28%.

Obesity in over 65 year olds has different effects on morbidity and mortality compared with the effects on younger subjects [33]. Review of the international literature with regards to the relationship between BMI and mortality in the elderly suggests that the BMI range with the lowest risk for mortality is between 23.5-27kg/m^2 [10, 14, 34, 35]. These findings may suggest that overweight in elderly people is not associated with a higher all-cause mortality risk, the opposite of which is true when it comes to obesity.

On the other hand, underweight, not only obesity, can also be responsible for frailty and higher mortality in the elderly [36, 37]. Kimyagarov et al. observed that low BMI was associated with a 45% increase in the mortality rates of elderly people, while high BMI was associated with a 11% decrease in mortality compared with the normal BMI group [38]. In Poland, Jóźwiak et al. analyzed the relationship between BMI and mortality in a study of 1219 older hospitalized subjects and reported that increased BMI reduced the risk of mortality by 22% for each decimal of BMI [39]. Jóźwiak et al. found, in common with previous studies, that the highest mortality rate was amongst the subjects with a BMI of less than 25 kg/m^2, whilst the lowest was among those who were overweight or moderately obese. As tolerance of undernutrition is much poorer in old age and the range of homeostasis is scarce, weight loss should be considered as an alarm signal rather than weight gain. These findings also suggest that the recommended BMI range for the elderly should be adjusted, favoring higher values in order to detect inadequate nutritional status earlier.

With regards to morbidity, the incidence of chronic disease in the present study population tended to rise with increasing BMI value, regardless of the criteria used. The most frequently diagnosed diseases in the subjects were those related to obesity, such as diseases of the cardiovascular, metabolic & endocrine systems. The incidence of cardiovascular disease was, in fact, higher amongst those subjects with a below average BMI (classified according to the Committee on Diet and Health criteria) than it was amongst the subjects with an above average BMI. This phenomenon is quite difficult to understand but it could be explained by several factors that were not investigated in this study, such as smoking habits, functional condition or cognitive status. Beck and Damkjær stated in their study that participants with a BMI of greater than 29 kg/m^2 had a higher quality of life, despite increased incidence of obesity-related diseases [40]. Thus, perhaps the quality of life of the elderly population is of greater importance than a single measurement such as body mass index.

This study has several limitations. Firstly, obtained data are limited to elderly people hospitalized in selected medical and care institutions. The inclusion of community-dwelling seniors could strengthen the research. Secondly, there is relatively little data regarding studies which used BMI criteria specific for elderly. The widely access to the international data could make the findings more meaningful for clinical practice.

CONCLUSIONS

In spite of the fact that BMI is not an ideal method for assessing nutritional status in the elderly and that there is still much controversy regarding the correct parameters to use, this method is far more effective than any alternative. Our study showed that BMI range proposed by the Committee on Diet and Health were more effective in detecting of undernutrition in elderly people. Since the BMI of less than 25 kg/m^2 can be responsible for frailty and higher mortality in the elderly, using of specific criteria for this population can be recommended. However, more studies in this research area are needed. In the interest of being as thorough as possible, future research into the nutritional status of the elderly should always take into account the subjects' age, weight change history, history of chronic diseases, anthropometric measurements and test results, rather than just BMI measurement alone.

Conflicts of interest

We declare that we have no conflicts of interest.

REFERENCES

1. The Polish Central Statistical Office. Prognoza ludności Polski na lata 2008-2035. [Internet]. Available from: http://www.stat.gov. pl/cps/rde /xbcr/gus/ PUBL_L_ prognoza_ ludnosci_na_ lata 2008_2035.pdf [cited 2012 Feb 29].
2. Wojtyniak B, Goryński P: Sytuacja zdrowotna ludności polski. Narodowy Instytut Zdrowia Publicznego – Państwowy Zakład Higieny [Internet]. Warszawa 2008. Available from: http://www.pzh.gov.pl/page/fileadmin/user_upload/PZH_Raport_2008.pdf. [cited 2012 Feb 26]. (Polish)
3. Goulart AC, Rexrode KM. Health consequences of obesity in the elderly: a review. Curr Cardiovasc Risk Rep. 2007 Sept; 1: 340-7.
4. Stanga Z. Basics in clinical nutrition: Nutrition in the elderly. e-SPEN, the European e-J Clin Nutr Metab. 2009 Dec; 4: e289-e99.

5. Ritz P. Obesity in the elderly: should we be using new diagnostic criteria? J Nutr Health Ageing. 2009 Mar; 13(3): 168-9.
6. Chernoff R. Normal ageing, nutrition assessment and clinical practice. Nutr Clin Pract. 2003 Feb; 18: 12-20.
7. Ahmed T, Haboubi N. Assessment and management of nutrition in older people and its importance to health. Clin Interv Ageing. 2010 Aug; 5: 207-16.
8. Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, the Obesity Society. Am J Clin Nutr. 2005 Nov; 82: 923-34.
9. Zamboni M, Mazzali G, Zoico E, Harris TB, Meigs JB, Francesco V, Fantin F, Bissoli L, Bosello O. Health consequences of obesity in the elderly: a review of four unresolved questions. Int J Obes (Lond). 2005 Sep; 29(9): 1011-29.
10. Donini LM, Savina C, Cannela C. Eating habits and appetite control in the elderly: the anorexia of ageing. Int Psychogeriatr. 2003 Mar; 15(1): 73-87.
11. Lechleitner M. Obesity and the metabolic syndrome in the elderly - a mini-review. Gerontol, 2008 Oct; 54: 253-9.
12. Barendregt K, Soeters PB, Allison SP, Kondrup J, Skowrońska U. Rozpoznawanie niedożywienia - badania przesiewowe i ocena pogłębiona. [In:] Sobotka L (Eds.). Podstawy żywienia klinicznego. PZWL, Warszawa 2004, pp. 11-19. (Polish)
13. Vellas B, Villars H, Abellan G, Soto ME, Rolland Y, Guigoz Y, Morley JE, Chumlea W, Salva A, Rubenstein LZ, Garry P. Overview of the MNA - its history and challenges. J Nutr Health Ageing, 2006 Nov-Dec, 10(6): 456-63.
14. Maatouk I, Wild B, Herzog W, Wesche D, Schellberg D, Schöttker B, Müller H, Rothenbacher D, Stegmaier C, Brenner H. Longitudinal predictors of health-related quality of life in middle-aged and older adults with hypertension: results of a population-based study. J Hypertens. 2012 Apr. [in press].
15. Bahat G, Tufan F, Saka B, Akin S, Ozkaya H, Yucel H, Erten N, Karan MA. Which body mass index (BMI) is better in the elderly for functional status? Arch Gerontol Geriatr. 2012 Jan-Feb; 54(1): 78-81.
16. Janssen I. Morbidity and mortality risk associated with an overweight BMI in older men and women. (Silver Spring). 2007 Jul; 15(7): 1827-40.
17. Heiat A, Vaccarino V, Krumholz HM. An evidence-based assessment of federal guidelines for overweight and obesity as they apply to elderly persons. Arch Intern Med. 2001 May; 161(9): 1194-203.
18. Nygaard HA. Measuring body mass index (BMI) in nursing home residents: the usefulness of measurement of arm span. Scan J Prim Health. 2008 Jan; 26(1): 46-9.
19. Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: background and recommendations for the United States. Am J Clin Nutr. 2000 Nov; 72(5): 1074-81.
20. Committee on Diet and Health [Internet]. Diet and health: implications for reducing chronic disease risk. Washington, DC: National Academy Press 1989. Available from: http://www.nap.edu/openbook.php?isbn=0309039940 [cited 2012 Feb 29].
21. Chumlea WC, Guo S. Equations for predicting stature in white and black elderly individuals. J Gerontol. 1992 Nov; 47(6): M197-203.
22. Schenker S. Undernutrition in the UK. British Nutrition Foundation Bulletin. 2003 Mar; 28: 87-120.
23. Pepersack T. Nutritional problems in the elderly. Acta Clin Belg. 2009 Mar-Apr; 64(2): 85-91.
24. Cook Z, Kirk S, Lawrenson S, Sandford S. Use of BMI in the assessment of undernutrition in older subjects; reflecting on practice. Proceed Nutr Soc, 2005 Aug; 64(3): 313-7.
25. Bogus K, Borowiak E, Kostka T. Otyłość i niska aktywność ruchowa jako ważne czynniki determinujące jakość życia osób starszych. Geriatr. 2008 Apr; 2: 116-20. (Polish)
26. Kaleta D, Ruszkowska-Majzel J, Kwaśniewska M, Drygas W. Nadwaga i otyłość jako czynnik ryzyka wybranych chorób przewlekłych - charakterystyka zjawiska oraz elementy zaleceń profilaktycznych. Kardiodiabetol. 2007; 2: 19-23. (Polish)
27. Makara-Studzińska M, Buczyjan A, Morylowska J. Jedzenie - przyjaciel i wróg. Korelaty psychologiczne otyłości. Przegląd piśmiennictwa. Zdr Publ. 2007; 117: 392-396. (Polish)
28. Biela U, Pająk A, Kaczmarczyk-Hałas K, Głuszek J, Tendera M, Waśkiewicz A, Kuriata P, Wyrzykowski B. Częstość występowania nadwagi i otyłości u kobiet i mężczyzn wieku 20-74 lat. Wyniki programu WOBASZ. Kardiol Pol. 2005; 63, Supl. 4: 632-5. (Polish)
29. Panasiuk L, Wdowiak L, Paprzycki P, Lukas W. Occurrence of overweight and obesity among rural population in eastern Poland. Relationship between obesity and selected socio-economic factors. Ann Agr Environ Med. 2008 Jun; 15(1): 149-52.

30. Wyrzykowski B, Zdrojewski T, Sygnowska E, Biela U, Drygas W, Tykarski A, Kozakiewicz K, Broda G. Epidemiologia zespołu metabolicznego w Polsce. Wyniki programu WOBASZ. Kardiol Pol. 2005; 63, Supl.4: 639-44. (Polish)
31. Szymocha M, Bryła M, Maniecka-Bryła I. Epidemia otyłości w XXI wieku. Zdr Publ. 2009; 119: 207-12. (Polish)
32. Jarosz M, Rychlik E. Overweight and obesity among adults in Poland, 1983-2005. Adv Med Sci. 2008; 53(2): 158-66.
33. Elia M. Obesity in the elderly. Obes Res. 2001 Nov; 9, Suppl.4: 244S-8S.
34. Dey DK, Rothenberg E, Sundh V, Bosaeus I, Steen B. Body mass index, weight change and mortality in the elderly. A 15 y longitudinal populations study of 70 y olds. Eur J Clin Nutr. 2001 Jun; 55(6): 482-92.
35. Weiss A, Beloosesky Y, Boaz M, Yalov A, Kornowski R, Grossman E. Body Mass Index is inversely related to mortality in elderly subjects. J Gen Intern Med. 2008 Jan; 23(1): 19-24.
36. Dorner TE, Rieder A. Obesity paradox in elderly patients with cardiovascular diseases. International Journal of Cardiology, 2011. Article in press. Available from: http://www.adipositasaustria.org/pdf/news/1105_Obesity_paradox_Int_J_Cardiol_2011.df [cited 2012 Feb 29].
37. de Hollander EL, Van Zutphen M, Bogers RP, Bemelmans WJE, De Groot LCPGM. The impact of Body Mass Index in old age on cause-specific mortality. J Nutr Health Ageing. 2012 Jan; 16(1): 100-6.
38. Kimyagarov S, Klid R, Levenkrohn S, Fleissig Y, Kopel B, Arad M, Adunsky A. Body mass index (BMI), body composition and mortality of nursing home elderly residents. Arch Gerontol Geriatr. 2010 Sep-Oct; 51(2): 227-30.
39. Jóźwiak A, Guzik P, Wieczorkowska-Tobis K. Wskaźnik masy ciała jako czynnik rokowniczy umieralności wewnątrzszpitalnej wśród pacjentów oddziału geriatrycznego. Gerontolol Pol. 2005; 13: 266-70. (Polish)
40. Beck AM, Damkjær K. Optimal body mass index in a nursing home population. J Nutr Health Ageing. 2008 Nov; 12(9): 675-7.