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NUTRITIONAL STATUS IN THE HEALTHY LONGEVAL POPULATION FROM SARDINIA (ITALY)

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Abstract: *Objectives:* The aim of this study was to evaluate sex- and age-related variations of the nutritional status in the aged population of central Sardinia, a geographical area with a high frequency of long-lived people, particularly men. *Design:* The sample consisted of 200 subjects over 70 years of age (men: N= 100, age= 81.0±7.0 years; women: N= 100, age= 81.5±7.3 years). *Setting:* Orroli (central Sardinia, Italy). *Measurements:* Mini nutritional assessment (MNA) and bioelectrical impedance vector analysis (BIVA) were used to evaluate nutritional status and body composition. *Results:* The indicators revealed a generally good nutritional status. The MNA results (men: 24.6±2.2; women: 23.4±2.5) showed that 64.1% of the subjects had a normal nutritional status and only a small proportion (1.2%) could be classified as malnourished. BIVA showed that most subjects (74.2%) were normal, while the prevalence of low body cell mass was 10.7% and that of dehydration 11.2%. According to the MNA, the nutritional status was significantly better in the men. Almost three-quarters of the men (73.1%) were well nourished vs. half of the women (50.6%). A worsening of the nutritional status with age was observed. The proportion of malnourished individuals, as assessed by MNA, increased from 0% to 9.1% from 70-79 to >90 years. *Conclusions:* With respect to their contemporaries from other regions, the elderly of Orroli presented a better nutritional status, a similar worsening with age and generally higher sexual dimorphism.

Key words: Mini nutritional assessment, anthropometry, bioelectrical impedance vector analysis, aging, sex differences.

Introduction

Life expectancy is increasing worldwide and the maintenance of health status in the elderly is a fundamental socio-political goal. As recognized by the Research Agenda on Ageing for the 21st Century (1), "advancing health and well-being" is a priority direction of research. In particular, nutritional status and intervention for its improvement are recognized as specific topics of interest.

Nutritional status is closely related to health conditions. During aging, physiological, social and psychological factors expose individuals to the risk of Protein Energy Malnutrition (PEM) (2). The impact of PEM on the quality of life can be considerable and its relationship with increased morbidity and mortality has been well documented (3). Conversely the excess weight in advanced age does not seem to increase the mortality risk. It has been observed that BMI values associated with minimum hazard increase with age (4). Emerging data indicate that obesity is linked to better survival in chronic disease states and advanced age (5). This "risk factor paradox" may result from the overwhelming short-term harmful effect of undernutrition with respect to the long-term effect of obesity. However undernutrition often goes unrecognized (6, 7). This occurs because of the lack of methodological standardization and reference data. In effect, there is no general agreement on the appropriate cut-offs for the diagnosis of undernutrition in the elderly. Chen et al. (8) estimated a variation between 10% and 85% in the assessment of the prevalence of malnutrition using different methods. Further, more detailed information about the nutritional status in the healthy aged population is necessary, especially in very old individuals. The expression of sexual dimorphism also needs to be better documented.

The aim of this study was to evaluate sex- and age-related variations of the nutritional status in the aged population of Orroli (Sardinia), a zone representing a hot-spot for "successful aging" and longevity, especially in men (9-17), although the environment and culture might also play a role (14). To our knowledge, this is the first study of the nutritional status of the elderly in Sardinia.

Methods

The population

The municipality of Orroli is in the eastern-central region of Sardinia, 115 km from Nuoro and 67 km from Cagliari. The town is situated in a hilly environment (mean altitude 550 m) on the slopes of the Pranemuru basaltic plateau. The name derives from the oak woods (orroli in Sardinian) present in the area. The economy is traditionally agricultural-pastoral. The resident population at 1 January 2005, the time of sampling, was 2647 (men: 1341; women: 1306).

The socioeconomic status, based on occupation and educational level, is low. The mean income at the time of the investigation was 67 % of the regional income and 57 % of the national one (18). Illiteracy is widespread, affecting 4.3% of the general population (18).

The population lifestyle, including nutritional habits, has remained almost unchanged over the years and cultural and ethnic traditions are deeply rooted. The social relationships are structured in an intense network, involving the whole elderly population: the men gather daily in various meeting places

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(town squares, cafes, etc.) to talk and play cards; the women interact mainly with the family, their neighbors and the church. The family is the traditional type, still with many members, who treat the elders with affection and respect. The population is characterized by strong physical activity, even in advanced age: the men are habitually involved vegetable gardening and the care of domestic animals, while the women take care of domestic activities well into old age, included the preparation of complex foods like bread and sweets.

Several genetic studies based on classical and DNA markers have shown that the Sardinian population, particularly the inhabitants of the central mountainous zone, has peculiar genetic features due to the effects of geographical isolation, genetic drift, high endogamy and low immigration (19, 20).

The epidemiological picture shows particularly favorable health conditions. In particular, the diffusion of cardiovascular and ischemic heart diseases, especially in the men, is lower than for Italians (16). The prevalence of long-lived individuals is higher than in Sardinia as a whole and in the rest of Italy, particularly with regard to men (female/male ratio over 90 y = 1.6 vs. 2.0 and 2.9, respectively). In 2003, Giovanni Frau died in Orroli, the town where he was born, at the age of 112 years, which at that time made him the oldest man in Europe and the third oldest in the world.

The sample

The sample consisted of 200 individuals (100 men, age 81.0 ± 7.0 years; 100 women, age 81.5±7.3 years). Table 1 shows the sex and age composition of the sample and the population. The sample represents 44.4% of all people over 70 years of age in the municipality of Orroli in the study year (2005). The representativeness of each class is over 33%. The individuals were contacted in their home. All the participants were informed about the objectives and methods of the survey and consented to take part in the study. Detailed personal, behavioral and medical history information was collected by means of a structured interview. No individuals had been admitted to hospital in the 3 months before the research or were under medical treatment for acute pathologies.

Methods

All measurements were taken by an experienced operator according to standard procedures (21, 22).

Height was measured with a portable anthropometer with an accuracy of 1 mm. Weight was measured with a portable spring scale to the nearest 0.1 kg. The following body circumferences were measured to 1 mm with a metal tape measure: upper arm, waist, hip, thigh and calf. The Body Mass Index (BMI, kg/m^2) was calculated.

The nutritional status was assessed by means of mini nutritional assessment (MNA) (23), which involves the compilation of a questionnaire consisting of 18 items divided into three sections: anthropometry; dietary habits; cognitive and disability status. A score lower than 17 indicates malnutrition, 17-23.5 indicates a risk of malnutrition, and 24 or higher indicates normal nutrition. The sensitivity and specificity of MNA in detecting states of malnutrition are 96% and 98% respectively (24). The level of reliability (R) is 0.89 (25).

Body composition was assessed by means of bioelectrical impedance vector analysis (BIVA) (26). By an empirical approach, this analysis allows a semi-quantitative evaluation of the nutritional and tissue hydration status. BIVA is more accurate than the conventional bioimpedance technique, as it does not require the use of predictive equations, or biophysical assumptions regarding body geometry and characteristics of human tissues. Whole body impedance measurements (resistance: R, Ω; reactance: Xc, Ω) were taken with a single-frequency impedance analyzer (BIA 101, Akern, Florence, Italy) using an operating frequency of 50 kHz at 800 μA. The accuracy was checked with a calibration circuit of known impedance (R = 380 Ω, Xc = 47 Ω, 1% error). The R and Xc values were standardized by height (H) to remove the effect of conductor length (26). Moreover, to eliminate the effect of transverse measures the R and Xc values were adjusted for body circumferences with covariance analysis (27). This method uses the correlation between the five independent variables (upper arm, waist, hip, thigh and calf circumferences) and the dependent variables (R and Xc). The coefficients obtained with the corresponding multiple linear regression equations were included in the standard model for the calculation of the adjusted bioelectrical values. The analysis was carried out separately in males and females. The phase angle (degrees) was calculated as arctan (Xc/R); the impedance vector (Z) as $(R^2 + Xc^2)^{0.5}$. Individual vectors (R/H, Xc/H) were plotted in tolerance ellipses (RXc-graph). The vector position within the R-Xc graph allows the semiquantitative examination of nutritional status: the minor axis indicates cell mass (more cell mass on the left side) and the major axis refers to hydration status (dehydrated individuals towards the upper pole). Individuals were considered normal when impedance vectors fell inside the 75% ellipse, malnourished when they fell outside the 75% ellipse (overweight in the left side, underweight in the right side), and at risk of dehydration when their values fell outside the 75% ellipse towards the upper pole. The differences between the mean impedance vectors in the different age and sex groups were assessed with Hotelling's T2 test. Mahalanobis distance D was also calculated.

The complete model of two factors with fixed effects analysis of variance was applied to evaluate the role of age and sex, and the possible interaction between them, on the anthropometric, bioelectrical and MNA variations.

Structured interviews were conducted to assess socio-economic and lifestyle characteristics: marital status (never married, married, separated, divorced and widowed), living conditions (in the subject's own home or in that of a relative), number of sons, work activity (past and present activity), smoking habits (non-smoker, former smoker, current smoker), alcohol consumption (only at meals, also at other times, never), reading and television (every day, a few times a month, never), educational level (illiterate, elementary school, middle school, high school, university degree), daily activity (cooking,

vegetable gardening, social activities, religious activities).

Neuropsychological problems and health in comparison with age peers were rated using the specific questions from the MNA.

The association between socio-economic and lifestyle indicators, and MNA was evaluated using ANCOVA with age as the covariate.

Statistical analyses were carried out with Statistica 4.0 (Statsoft Inc.). The bioelectrical impedance vector analysis was performed with specific BIVA software (28).

Results

General health and lifestyle

Most of the men and women of the sample lived in their own home (men: 87%; women: 84%). Most of the subjects were married (men: 79%; women: 40%), a small percentage never married (men: 6%, women: 9%), while about half the women were widows (51%) and a small percentage of the men were widowers (15%); 30.8% of the widowed subjects lived in their sons' houses (men: 60%; women: 22%). The mean number of sons was 3.6, ranging from 0 to 11.

The illiteracy rate was 26.6%, while most participants had an elementary school education (65.4%) and only few had a middle (6.6%) or high school (1.4%) diploma. Most of the men (93%) did manual work (44%: farmer-shepherd; 36%: laborer; 13%: artisan), while 90% of the women were housewives. At the time of sampling, 66% of the men still carried out manual labour activities and 65% of the women still performed domestic activities.

Although 93% of the men and 95% of the women watched TV every day, reading was rarer: 40% of the men and 51% of the women never read, 29% of the men and 29% of the women rarely read, and 31% of the men and 20% of the women read every day.

The consumption of alcoholic drinks was very frequent in the men (83%) but also common in the women (43%). Smoking was rare in both sexes (3% men, 2% women). However, while 50% of the men smoked in the past (38% had stopped more than 20 years ago), the women had never smoked.

All the individuals appeared to be in good health. The great majority of participants rated their health status as excellent or good (men: 95%; women: 80%). Only a small percentage of women (4%) considered their health not as good as other people of the same age. The remaining part of the sample "did not know". However many individuals (men: 40%; women: 43%) stated that they had suffered a serious pathological condition during their lifetime. The most frequent chronic diseases involved the cardiovascular system (men: 21%; women: 10%) while past parasitic diseases, such as malaria, typhus, echinococcosis, were also frequent (men: 12%; women: 12%). Almost the entire sample had good psychological health ("no psychological problems", men: 98%; women: 93%). Only one women (1%) declared that she had suffered severe depression and a small part of the sample (men: 2%; women: 5%) had experienced mild depression.

Table 1
Sex and age composition of the sample and the population

	Men			Women		
Age class	**Sample size**	**Resident population**	**Covered percentage**	**Sample size**	**Resident population**	**Covered percentage**
70-79 y	52	130	40%	51	155	33%
80-89 y	36	50	72%	30	71	42%
90+ y	12	15	80%	19	24	79%
Total	100	195	51%	100	250	40%

70-79 y, 70 to 79 years; 80-89 y, 80 to 89 years; 90+ y, over 90 years.

Nutritional status

Table 2 shows the nutritional status in the total sample, assessed with MNA and BIVA. According to the MNA, most subjects (62.9%) were normal nourished, while 35.9% were at risk of malnutrition and only 1.2% were malnourished.

Fig. 1 shows the results of the bioelectrical impedance analysis. Most subjects (74.2%) were normal, i.e. inside the 75% tolerance ellipse. A small percentage of the sample (3.9%) showed high body cell mass while the prevalence of low body cell mass was 10.7% and that of dehydration 11.2%.

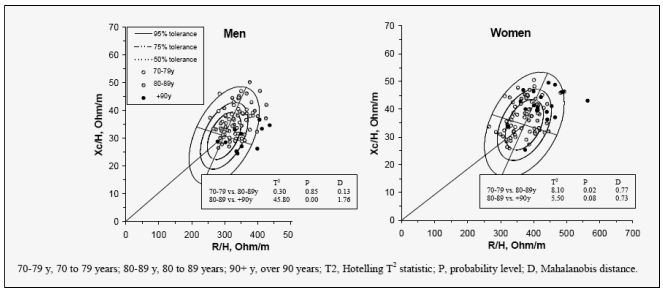
Table 2
Nutritional status in the total sample

		Men		Women		Total	
		N	**%**	**N**	**%**	**N**	**%**
MNA (Guigoz et al., 1994)	Normal (MNA≥24)	68	73.1	39	50.6	107	62.9
	At risk (17≤MNA<24)	24	25.8	37	48.1	61	35.9
	Malnutrition (MNA<17)	1	1.1	1	1.3	2	1.2
BIVA* (Piccoli et al., 1994)	High BCM	2	2.3	5	5.4	7	3.9
	Normal	58	66.7	74	81.3	132	74.2
	Low BCM	16	18.4	3	3.3	19	10.6
	Dehydrated	11	12.6	9	9.9	20	11.2

MNA, Mini Nutritional Assessment; BIVA, Bioelectrical Impedance Vector Analysis. * Individuals were considered normal when impedance vectors fell inside the 75% ellipse, malnourished when they fell outside the 75% ellipse (overweight in the left side, undernourished in the right side), and at risk of dehydration when their values fell outside the 75% ellipse towards the upper pole.

Figure 1

The individual Z vectors plotted on the reference bivariate tolerance ellipses representing the median, 3rd quartile and 95th percentile of the Italian population. a. males, b. females. R/H, resistance/height; Xc/H, reactance/height



70-79 y, 70 to 79 years; 80-89 y, 80 to 89 years; 90+ y, over 90 years; T2, Hotelling T^2 statistic; P, probability level; D, Mahalanobis distance.

No significant correlations between socioeconomic and lifestyle indicators, and nutritional status (assessed by MNA) were found.

Sex and age variations of nutritional status

Table 3 shows the descriptive statistics and two-factor ANOVA for the comparisons between sex and age.

The mean BMI did not differ significantly between the sexes. The mean values significantly decreased with age. This trend was due to the progressive weight loss (men: 2.7 kg/decade; women: 4.3 kg/decade) which countered and overwhelmed the height reduction with age (men: 1.2 cm/decade; women: 2.3 cm/decade). The body weight reduction was accompanied by decreased trunk and limb circumferences.

MNA was significantly higher in the men than in the women and decreased significantly with age in both sexes. The men presented a normal nutritional status in the total sample and in the 70-79 y and 80-89 y age classes, while MNA underwent an abrupt decrease in the >90 class, indicative of risk of malnutrition (MNA= 21.6±2.4). The women presented a mean nutritional status slightly below normal in the total sample, a normal condition in the youngest age class (70-79 y) and risk of malnutrition in the 80-89 y and >90 classes (MNA= 22.9±2.6 and 21.0±3.0, respectively). The percentage of malnourished individuals increased with age (men, 70-80= 0%, 80-90= 0%, >90= 9.1%; women 70-80= 0%, 80-90= 0%, >90= 9.1%). The risk of malnutrition was higher in the women (48.1%) than in the men (25.8%).

BIVA provided different diagnoses in the two sexes. Most subjects, especially the women, were normal (men: 66.7%; women: 81.3%). The prevalence of low body cell mass was 18.4% in men and 3.3% in women and that of dehydration 12.6% in men and 9.9% in women.

The variation of the bioimpedance vector with age was different in the two sexes, as shown by the significant interaction between sex and age. In the men, there was relative homogeneity in the first two age classes (Fig. 1) while the >90 class showed significantly different characteristics (T^2=45.8, p=0.000): a decreased phase angle with a shift toward the region of the RXc graph corresponding to low body cell mass. In the women, there was a gradual progression in the three age classes toward the region of the RXc graph corresponding to low body cell mass and dehydration (lengthening of the Z vector). The differences were significant (T^2=8.1, p=0.024) in the comparison between women aged 70-79 y and 80-89 y.

Discussion

The indicators agreed in the diagnosis of a generally good nutritional status in the aged population of Orroli (Table 2). Most subjects (between 62.9% and 74.2%, according to the method) presented normal conditions. On the basis of MNA, only a few (1.2%) could be classified as malnourished, and the rest of the sample 'at risk of malnutrition'. The BIVA technique

Table 3

Descriptive statistics and two-factor ANOVA for the comparisons between age and sex

	Overall sample		70-79 y		80-89 y		90+ y				
	Men	Women	Men	Women	Men	Women	Men	Women			
	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Fsex	Fage	Fsex x age
Age (years)	81.0 ± 7.0	81.5 ± 7.3	75.6 ± 2.7	75.5 ± 2.5	84.1 ± 2.9	84.5 ± 2.2	94.9 ± 2.8	93.0 ± 3.0	1.518	644.702*	2.101
MNA score	24.6 ± 2.2	23.4 ± 2.5	25.0 ± 1.8	24.3 ± 1.6	25.1 ± 1.9	22.9 ± 2.6	21.6 ± 2.4	21.0 ± 3.0	9.382*	23.783*	2.328
Stature (cm)	155.6 ± 6.6	144.0 ± 6.2	157.1 ± 6.1	146.7 ± 6.0	154.2 ± 7.0	142.2 ± 5.0	153.4 ± 6.7	139.8 ± 5.1	152.146*	12.793*	0.911
Weight (kg)	64.7 ± 10.1	54.7 ± 11.7	67.3 ± 9.8	58.7 ± 11.5	62.7 ± 9.9	53.2 ± 10.7	59.3 ± 9.0	45.9 ± 8.6	39.321*	13.265*	0.616
BMI (kg/m²)	26.6 ± 3.4	26.3 ± 5.2	27.2 ± 3.4	27.2 ± 4.8	26.3 ± 3.1	26.5 ± 5.8	25.2 ± 3.5	23.6 ± 4.7	0.476	5.131*	0.512
Waist crf (cm)	95.2 ± 8.7	93.2 ± 11.3	96.4 ± 8.4	96.0 ± 11.3	94.0 ± 9.4	92.6 ± 11.1	93.5 ± 7.2	86.8 ± 9.0	3.162	4.932*	1.185
Hip crf (cm)	97.2 ± 8.5	99.0 ± 10.3	96.8 ± 9.2	100.8 ± 10.7	98.1 ± 7.0	99.3 ± 9.8	96.0 ± 9.7	93.6 ± 6.5	0.373	2.376	1.536
Thigh crf (cm)	40.2 ± 3.7	38.9 ± 5.3	40.7 ± 3.1	39.4 ± 4.3	39.9 ± 4.4	40.0 ± 5.9	38.7 ± 4.0	35.9 ± 6.0	3.391	4.756*	1.148
Calf crf (cm)	32.1 ± 2.6	31.3 ± 3.5	32.7 ± 2.2	31.7 ± 2.9	31.4 ± 2.7	31.3 ± 3.7	31.2 ± 3.6	30.0 ± 4.6	2.388	3.540*	0.505
Upper arm crf (cm)	26.2 ± 2.6	25.2 ± 3.1	27.4 ± 2.5	26.4 ± 2.5	25.3 ± 2.1	24.9 ± 3.3	24.0 ± 2.4	22.6 ± 2.8	5.106*	24.467*	0.406
R (Ω)	521.2 ± 63.1	548.6 ± 74.2	517.3 ± 53.4	523.4 ± 67.8	517.8 ± 68.6	558.7 ± 65.6	551.9 ± 78.9	593.9 ± 78.5	7.044*	6.802*	1.540
Xc (Ω)	54.9 ± 8.6	54.4 ± 8.4	55.6 ± 7.8	53.4 ± 9.2	56.5 ± 9.3	54.4 ± 7.6	47.1 ± 6.0	56.7 ± 7.5	1.611	1.766	5.826*
R/H (Ω/m)	336.2 ± 40.8	382.5 ± 55.3	330.7 ± 31.1	357.6 ± 45.6	335.8 ± 45.4	393.8 ± 45.1	359.9 ± 54.9	425.5 ± 59.8	44.139*	13.301*	3.154*
Xc/H (Ω/m)	35.4 ± 5.7	37.9 ± 6.2	35.5 ± 4.8	36.5 ± 6.3	36.7 ± 6.6	38.4 ± 5.8	30.7 ± 4.2	40.6 ± 5.9	18.508*	1.615	6.605*
Phase angle (degrees)	6.1 ± 1.0	5.7 ± 1.0	6.2 ± 1.0	5.9 ± 0.9	6.3 ± 1.1	5.6 ± 1.0	4.9 ± 0.6	5.5 ± 1.0	0.572	7.862*	4.092*
Radj /H (Ω/m)	335.5 ± 40.2	383.2 ± 52.5	330.0 ± 32.0	359.5 ± 42.3	335.1 ± 45.1	392.3 ± 44.1	358.9 ± 49.1	426.3 ± 55.9	50.207*	13.789*	2.976
Xcadj /H (Ω/m)	35.3 ± 5.7	38.0 ± 6.3	35.9 ± 4.8	36.2 ± 6.4	36.3 ± 6.3	38.6 ± 5.5	29.9 ± 4.1	41.5 ± 5.8	24.374*	1.351	10.504*
Phase angleadj (degrees)	5.6 ± 1.1	5.2 ± 0.9	5.8 ± 1.1	5.3 ± 1.0	5.7 ± 1.0	5.1 ± 0.8	4.4 ± 0.7	5.1 ± 0.9	0.310	7.221*	4.841*

70-79 y, 70 to 79 years; 80-89 y, 80 to 89 years; 90+ y, over 90 years; ANOVA, analysis of variance; s.d., standard deviation; F, F test of two-way ANOVA for sex, age, and sex-age interaction; MNA, mini nutritional assessment; BMI, body mass index; crf, circumference; R, resistance; Xc, reactance; adj, adjusted value; * P <0.05

Table 4
Literature data on the MNA in elderly individuals by sex

Men	Women	Total	Parameter	Population	Reference
25.8 %	48.1 %	35.9 %	17 < MNA < 24	200 free living subjects (70-100 y, mean age, men:	Present research
1.1 %	1.3 %	1.2 %	MNA < 17	81.0 ± 7.0, women: 81.5 ± 7.3; Orroli, Sardinia, Italy)	
24.6 ± 2.2	23.4 ± 2.5		Mean MNA ± s.d.		
No gender difference in nutritional risk		31.9%	17 < MNA < 24	69 free-living elderly, aged 50-90 years	Davidson and Getz, 2004
		2.9%	MNA < 17		
71.1 %	79.9 %	76.0 %	17 < MNA < 24	1,564 free living subjects (mean age, men: 71 ± 9;	Kucukerdonmez et al., 2005
6.5 %	8.8 %	7.8 %	MNA < 17	women: 70 ± 9 y; Ankara, Turkey)	
52.8 %	66.5 %	61.7 %	17 < MNA < 24	303 free living and institutionalized subjects	Han et al., 2004
1.9%	7.1 %	5.3 %	MNA < 17	(mean age = 74.1 y; Korea)	
22.8 ± 3.2	21.5 ± 3.2		Mean MNA ± s.d.		
24.8 ± 3.6	22.3 ± 5.0		Mean MNA± s.d.	253, general population (>85 y; northern Sweden)	von Heideken Wågert et al., 2006
24.6 ± 3.9	25.4 ± 3.7		Mean MNA± s.d.	22 007 community-dwelling subjects (>65 y; Spain)	Cuervo et al., 2009
32.5 %	48.1 %	38.7 %	MNA < 24	204 subjects (>65 y; Israel, multiethnic origin).	Castel et al., 2006
18.2 %	34.5 %	30.0 %	MNA < 17	80 subjects receiving home care (79-90 y; Stockholm,	Ödlund Olin et al., 2005
68.2 %	55.2 %	58.7 %	17 < MNA < 24	Sweden)	
31.3 %	35.6 %	37.0 %	17 < MNA < 24	81 institutionalized subjects (61-98 y; Belgium)	Griep et al., 2000
0 %	3.1 %	2.0 %	MNA < 17		
24.6 ± 2.6	23.4 ± 2.8		Mean MNA ± s.d.		
14.7 %*	20.7 %*	18.3 %	MNA < 17	153 institutionalized subjects (mean age, men: 74.6 ± 9.5,	Alves de Rezende et al., 2005
44.3%*	46.7 %*	45.7 %	17 < MNA < 24	women: 78.5 ± 9.5 y; Uberlandia, Brazil)	

*recalculated from summary data

revealed the prevalence of two anomalous conditions: low body cell mass (10.7%) and dehydration (11.2%).

The over-70-year-olds of Orroli presented better nutritional conditions than other free-living individuals of the same age. In an extensive literature review on MNA, Guigoz (29) found a mean frequency of malnutrition in community-dwelling elderly of 2±0.1% and of risk of malnutrition of 24±0.4%. It should be noted that the considered age classes were heterogeneous and included individuals younger than those of the Orroli sample. The only North American sample with mean age (82±9 y) similar to that of the Orroli sample (81.2±7.1) presented a worse nutritional status (malnutrition: 5%; at risk of malnutrition: 39%) (30).

The multidimensional nutritional indicator showed a better condition in the men than in the women. Almost three-quarters of the men (73.1%) vs. half of the women (50.6%) were well nourished. In contrast, BIVA revealed a worse condition in the men than in the women. The pattern revealed by BIVA is mainly attributable to the different frequency of individuals with a low body cell mass, which can be related to the generally higher frequency of sarcopenia in men (31).

On the basis of literature data on MNA (Table 4), the sex difference in the Orroli population, with a better nutritional status in men, is also present in other populations (32-38), with rare exceptions in which no sex differences were observed or in which the women had a better nutritional status (39-40). The gender discrepancy in Orroli is generally greater than in other populations. The observed sexual dimorphism of nutritional status is consistent with the "morbidity-mortality paradox", according to which women have higher morbidity but live longer than men (41). The nature of this paradox is uncertain. The most common explanations are based on differences in health and behavior: the higher mortality of men is usually attributed to biological vulnerability and lower health care use, while the greater morbidity of women is related to illness and health-reporting behavior (41). Recently, Kulminski et al. (42) provided evidence for traditional and inverse morbidity paradoxes when particular subsets of deficits, respectively more prevalent in females or in males, were studied.

The multidimensional indicator showed a worsening nutritional status with age, particularly after 90 years. The proportion of malnourished individuals increased from 0% to 9.1% from 70-79 to >90 years. This age-related trend has been reported in the literature on free-living individuals (32, 36, 38, 39, 43-45). This pattern has also been recorded in studies of physiological aging carried out with BMI (46) and with BIVA (27, 47-49).

In summary, the MNA results showed that the elderly of Orroli presented a better nutritional status than their age peers from other regions, a similar worsening with age, a better condition in the men than in the women and generally higher sexual dimorphism than in other populations.

The results of the present study are consistent with the general epidemiological picture of the region. The population of eastern-central Sardinia is known to enjoy good health conditions and its longevity is higher than in the rest of Italy, especially among men. The high frequency of extremely old people has been attributed to predisposing or protective genetic factors (10-18), although the environment and culture might also play a role (15). For example, the low incidence of cardiovascular diseases (16) has been related to both genetic and environmental factors, e.g. the use of locally produced red wine (50). In general, nutrition and other lifestyle habits of this region are rather conservative and healthy (15). The Orroli population, especially the elderly component, is characterized by strong common cultural traditions, involving a complex family structure in which the older members play an important role, large social networks, ancient nutritional practices and routine physical activity even in advanced age. In our sample, almost all the subjects appeared to be in good health and rated

their health status as excellent or good. However, there were no association between the lifestyle indicators and nutritional status. Social factors correlated with malnutrition in other populations, such as living alone in one's own home, do not seem to have much effect in Orroli. Apparently the community life of this small town counters the discomforts of the elderly.

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