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2013 J. Phys.: Conf. Ser. 434 012063

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Percentile curves for body fatness and cut-offs to define malnutrition in Russians

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Abstract. Here, we report first results of the large-scale ongoing bioelectrical impedance body composition study in Russians. By the end of 2012, 216 out of 800 Russian Health Centres submitted raw bioimpedance data on 844,221 adults and children aged 5-80 years, representing nearly 0.6% of the Russian population, who were accessed cross-sectionally using the same type of bioimpedance meter, ABC-01 Medas. Estimates of overweight, obesity, and normal weight obesity prevalence in the general population, as well as characteristics of diagnostic sensitivity and specificity of the conventional WHO BMI-based criteria of obesity depending on age are obtained. The smoothed reference centile curves for percentage fat mass are constructed, and localized cut-offs for fatness and thinness are provided that can be used both at the individual and epidemiological levels.

1. Introduction

One of the disadvantages of using body mass index for defining obesity, undernutrition and associated health risks lies in its low diagnostic sensitivity, or high rates of false-negative results [1]. Bioelectrical impedance analysis is a widely used method that enables more direct assessment of body composition [2,3]. In this study, we aimed at the construction of population reference centile curves for bioimpedance percentage body fat mass, as well as at the providing localized cut-offs for classification of fatness levels using large population-based sample of Russian citizens.

2. Subjects and methods

844,221 adults and children aged 5-80 years (see Table 1), who were visitors of the Russian Health Centres in 2010-2012, were accessed cross-sectionally by the same type of bioimpedance analyzer, namely, ABC-01 Medas (SRC 'Medas', Russia). Our sample group represented nearly 0.6% of the Russian population from the all eight Federal Districts of the Russian Federation and 48 out of 83 Federal Subjects in them.

Table 1. Characteristics of the study group (the data as submitted by the end of December, 2012)

	Males	Females	Both sexes
Children and adolescents (5-19 years)	159,293	149,979	309,272
Adults (20-80 years)	123,616	411,333	534,949
Total number (5-80 years)	282,909	561,312	844,221

Standing height and weight were measured using the same type of stadiometer and digital scale with an accuracy 0.5 cm and 0.1 kg, respectively. Body mass index (BMI) was calculated as body mass (BM) divided by standing height (Ht) squared. The whole-body impedance was measured on the right hand side of the body according to a conventional tetrapolar scheme at electrical current frequency 50 kHz. Fat-free mass (FFM) was assessed using appropriate equations for healthy adults and children [4,5]. Fat mass was calculated by subtraction of FFM from the BM, and the percentage fat mass (%FM) was obtained as $(FM/BM) \times 100\%$.

The smoothed reference centile curves for BMI and %FM were constructed using LMS-method [6] in the software program BIAStatistica [7]. The conventional WHO criteria of malnutrition according to BMI [8,9] were explored to obtain the correspondent localized cut-offs in terms of the %FM. Sensitivity and specificity of the BMI cut-off values for obesity were obtained as a percentage of true-positive and true-negative results, respectively, compared to the bioimpedance %FM criteria taken as a reference.

3. Results and discussion

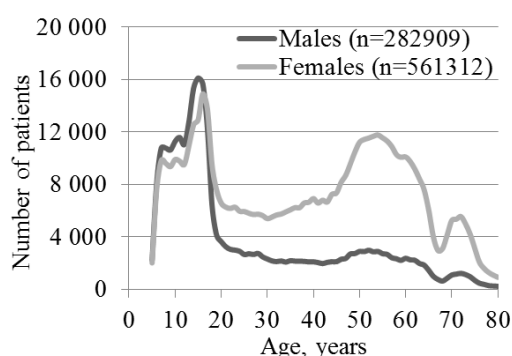


Fig. 1. Distributions of males and females in our sample according to age.

83% in men and women, respectively, by 60-65 years. This result is in agreement with the high prevalence of hypertension, diabetes, cancer, metabolic syndrome and other chronic non-infectious diseases in Russians in this age group.

Fig. 1 shows distributions of males and females under study according to age. It can be seen that women visited Health Centers almost twice as much as men ($p < 0.01$). An observed first peak of attendance reflects a primary focus of attention on childhood and adolescent years, and the second peak at the interval between 50 and 65 years of age corresponds to the age dependence of cardiovascular morbidity and mortality. The local minimum of attendance at the age interval between 65 and 70 years may reflect significant depopulation of the Russian nation during the WW2.

Fig. 2 shows that the prevalence of overweight according to the conventional WHO criteria increases steadily with age reaching a maximum of 76% and

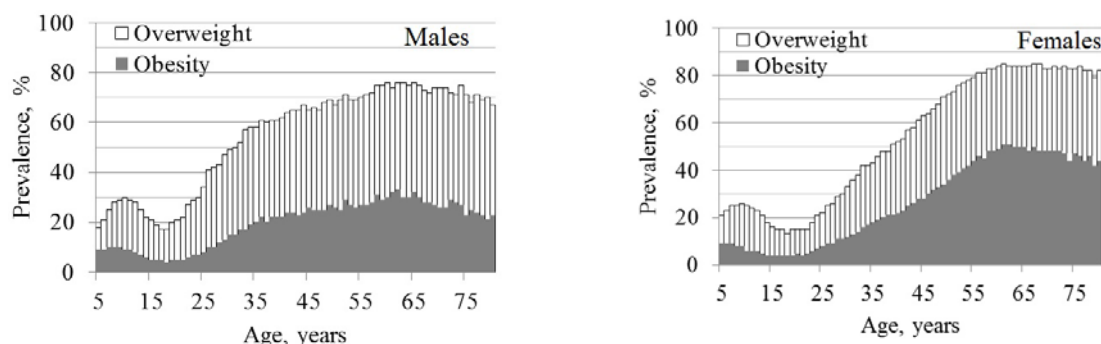


Fig. 2. Estimates of overweight and obesity prevalence in Russians according to age.

Our data show that the diagnostic sensitivity of the conventional WHO criteria for obesity according to BMI differs significantly in adult men and women (55% and 70%, respectively) with the specificity decreasing down to 75-85% with age (see Fig. 3).

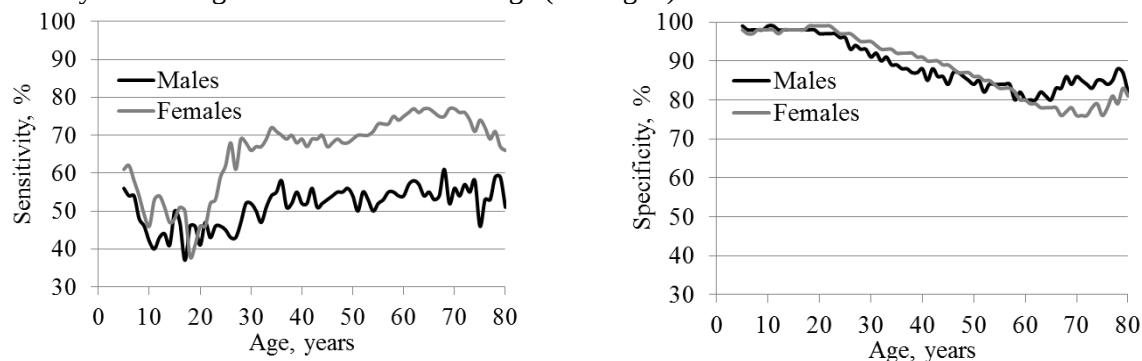


Fig. 3. Sensitivity and specificity of the conventional WHO criteria for defining obesity in Russians.

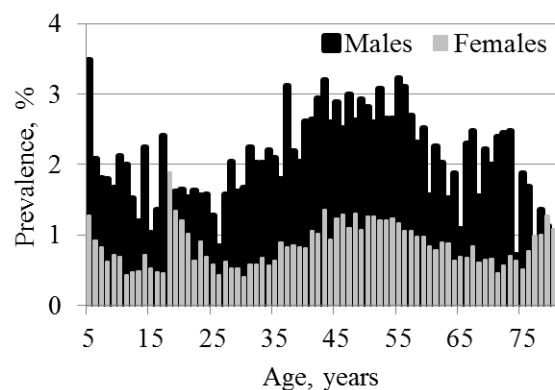


Fig. 4. The prevalence of normal weight obesity in Russians according to age.

As a consequence of low BMI sensitivity, the normal weight obese (NWO) individuals were present in the study group who had high %FM content and normal BMI. Similarly to ‘usual’ obesity, NWO is associated with an increased risk of metabolic syndrome and cardiovascular morbidity [10,11]. Fig. 4 shows that the prevalence of NWO in Russian population was 1.5-3% in males and 0.5-1.3% in females depending on age (for comparison, see [12]).

The smoothed reference centile curves for %FM, from 10th to 90th, with the median depicted in bold, are presented in Fig. 5.

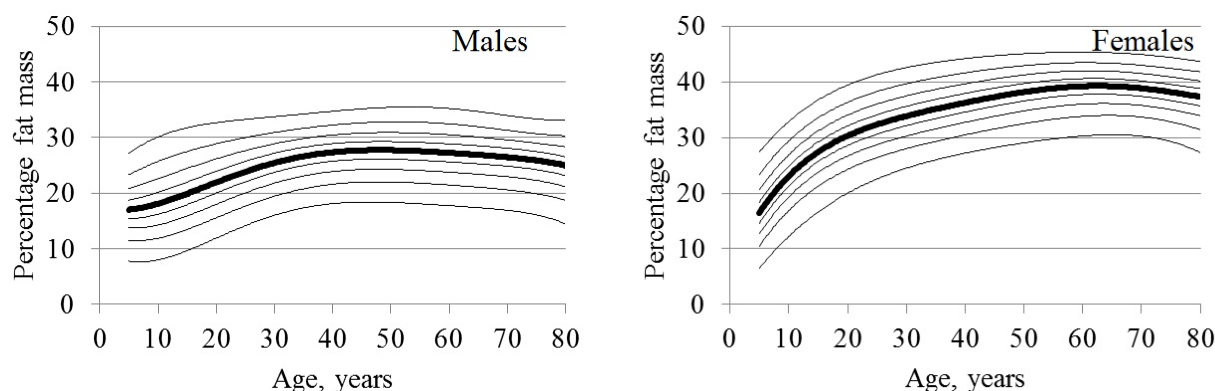


Fig. 5. The smoothed reference centile curves for percentage fat mass in Russians.

The cut-off values of the percentage fat mass for defining underfatness, overfatness and obesity were constructed by the comparison of BMI and %FM age specific distributions in males and females (Table 2). These were defined using the conventional BMI cut-offs 18.5, 25 and 30 kg/m², respectively.

Table 2. Bioimpedance %FM cut-off values to define malnutrition in Russians.

Age, years	Females			Males		
	Underfat	Overfat	Obese	Underfat	Overfat	Obese
5	12.4	21.6	26.1	9.1	18.7	22.2
6	11.9	22.4	27.0	9.2	19.5	23.4
7	10.9	23.2	28.2	9.0	19.6	24.3
8	10.3	24.1	29.8	7.8	20.5	25.5
9	12.2	25.4	31.4	8.5	21.5	27.0
10	13.2	26.4	32.7	9.4	22.5	28.4
11	15.1	27.2	33.3	10.1	23.5	30.1
12	15.7	27.6	33.9	10.4	23.7	31.1
13	16.3	29.3	35.2	9.6	22.9	31.2
14	18.0	31.3	36.9	9.3	23.4	31.4
15	19.3	32.9	37.9	9.5	24.0	32.2
16	20.9	33.9	39.0	10.9	24.8	32.3
17	21.0	34.4	39.2	12.2	26.9	33.9
18	22.4	36.5	41.1	12.5	27.9	34.0
19	25.8	38.5	42.7	13.8	28.0	34.0
20-30	24.1	37.7	42.3	13.2	27.6	33.4
30-40	21.2	36.4	41.3	10.9	26.2	32.0
40-50	17.5	34.9	40.3	9.7	25.4	31.2
50-60	16.3	33.9	39.7	9.4	24.6	30.7
60-70	15.2	32.7	38.9	8.6	23.2	29.8
70-80	14.7	31.8	38.3	7.9	22.8	29.5

4. Conclusion

Using our dataset on the whole-body bioimpedance measurements of 844,221 adults and children from the Russian Health Centres, we obtained estimates of obesity and overweight prevalence at the national level, as well as diagnostic %FM thresholds for use in epidemiological and clinical studies. Development and validation of BIA predictive equations based on representative sample of healthy Russian adults and children is needed for more accurate data interpretation and comparisons. Further developments may include localized cut-offs for malnutrition in terms of other bioimpedance body composition screening indexes, such as fat-free mass and skeletal-muscle mass relative to height and, probably more importantly, of phase angle which is directly measurable and not depends on any prediction formula.

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