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Overweight and Fatness in Dalmatia, Croatia: Comparison with the U.S. Population Reference

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A B S T R A C T

Subscapular skinfold, elbow breadth and upper arm indicators of nutritional status were studied in the population of Dalmatia in Croatia. Age- and sex-specific percentiles were obtained from 4373 subjects, 18 to 74 years of age, and compared to the U.S. NHANES I and II reference data. There were significant differences between these data sets in all studied variables. The results complement those reported previously for BMI and triceps skinfold and indicate that high prevalence of overweight in Dalmatians largely reflects their muscularity and skeletal robustness rather than excess body fatness. The findings suggest that the U.S. upper percentiles of BMI and skinfolds are inadequate for the assessment of excess body fatness in Dalmatian population. The obtained population-specific percentile distributions should be used provisionally as the reference data for group comparisons in the Dalmatian region.

Introduction

The excess body fat associated with obesity is considered a risk factor for many chronic diseases, particularly, hypertension, cardiovascular disease, stroke, non-insulin dependent diabetes, gall bladder disease and some forms of cancer[1–3]. However, obesity has been difficult to define and methods used to this aim have often referred to excess weight rather than excess fat.

For epidemiological purposes, body mass index (BMI) was recommended and most often used as an index of total body fatness[4]. However, it is not always clear what is being studied by BMI because it reflects both body fat and lean body mass[5]. It is affected by total body fatness as well as by muscularity, frame size and relative leg length that are influenced by age, gender and ethnicity[6,7]. Thus, it may be misinterpreted when excess weight is caused by excess lean body mass. There is also evidence that the relationship be-

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tween BMI and fatness varies from population to population and that ethnic differences influence the ability of BMI to rank body fatness[8,9]. Consequently, there has been both scientific and professional debate about the applicability of »international« cut-off points for ranking body fatness in different populations[10].

Since no local reference data on BMI are available for the Croatian population, the U.S. reference data are often being used in practice. In a previous survey, the BMI and triceps skinfold of the coastal and insular segment of the Croatian population have been studied[11]. In geographical terms, this population inhabits the region of Dalmatia. It has been shown that both BMI and triceps skinfold distributions in adult Dalmatians differ from the distributions in U.S. whites. The Dalmatians have higher body fatness than the U.S. reference population according to BMI, but lower according to the triceps skinfold. It is not clear whether BMI reflects higher body fatness of the Dalmatian population, in which case more fat is deposited centrally relative to the U.S. population, or indicates larger frame size and/or body muscularity, in which case the appropriateness of U.S. reference data for Dalmatian population is questionable. The elucidation of these effects is rather important having in mind the estimates of 42% overweight and 12% severely overweight Dalmatians according to the NHANES II criteria[12]. Hence, the purpose of the present publication is to provide estimates of body fat deposited on the trunk, frame size and muscularity for Dalmatian adults. The percentile distributions of subscapular skinfold, elbow breadth, upper arm circumference, upper arm muscle area, and arm fat index are compared with the NHANES I and II reference values. Hopefully the results will be of use for nutritional status assessments in the Dalmatian population and informative to the ongoing survey of national and regional patterns of body weight and the health risk factor correlates of obesity.

Material and Methods

This study is based upon a cross-sectional sample of 4373 subjects aged 18 to 74 years, of whom 2028 were males and 2479 were females. It is derived from the extensive material collected in the Dalmatian island and peninsular rural populations since 1971 within the framework of several holistic anthropological projects[13–18]. The sample is basically the same one used in the previous study that provided information on height, weight, BMI and triceps skinfold of the Dalmatian population[11]. It comprises inhabitants from the Northern Dalmatian islands of Pag, Olib, and Silba and the Middle Dalmatian islands of Brač, Hvar, Korčula, and the peninsula of Pelješac. The sample includes 16.5% of the adult population of the 48 studied settlements which is 0.5% less than in the previous study. The difference results from the lack of anthropometric data needed for this study in 0.5% of the basic sample. The sampling procedure has been described previously[11] as well as the detailed anthropometric characterization of the particular island samples[19–24].

The studied anthropometric characteristics are: subscapular skinfold, elbow breadth, upper arm circumference (UAC), upper arm muscle area (UMA) and arm fat index (AFI). The results have been combined with the previously published data on triceps skinfold and BMI. The measurements were taken on the left side of the body (with the exception of elbow breadth) following the IBP protocol[25]. The elbow breadth was measured on the right limb. Calculations of upper arm muscle and fat areas are based on measurements of the upper arm circumference and triceps skinfolds[26]. Upper

arm muscle area was corrected for bone area[26].

Age- and sex-specific means, standard deviations and percentile distributions were developed for each anthropometric characteristic. The comparison with U.S. reference data was carried out using the values from NHANES II for subscapular skinfold and elbow breadth, and the values from combined NHANES I and NHANES II surveys for upper arm anthropometry[12,26]. Statistical comparisons of the Dalmatian and U.S. percentile distributions were made using a nonparametric Kolmogorov-Smirnow two-sample test. Its null hypothesis is identity in distribution for the two samples and it is sensitive to differences in location and dispersion[27]. The Dalmatian sample was divided by age according to the categories used in NHANES surveys. Statistical comparison of Dalmatian and U.S. percentile distributions was performed for each sex and age group.

Results

The sample size in each sex-specific age group exceeded 100 with exception of the extreme age groups (Tables 1 and 3).

Subscapular skinfold thickness

The age- and sex-specific means, standard deviations, and selected percentiles are reported in Table 1. The form of presentation complements that one used previously for triceps skinfold and BMI. The percentiles are also presented graphically, parallelly to the percentiles of the U.S. population (Figure 1). The means of subscapular skinfold increased with age over the entire age range studied and the increase was more pronounced in females. There were similar trends in the

TABLE 1
SUBSCAPULAR SKINFOLD (MM) BY SEX AND AGE: NUMBER EXAMINED (N), MEAN, STANDARD DEVIATION (SD) AND SELECTED PERCENTILES

Age (y)	N	Mean	SD	5th	15th	50th	85th	95th	P†
Males	1974								
18-24	91	14.89	5.77	8.12	9.08	13.40	21.24	22.94	*
25-34	401	15.96	5.33	8.11	10.10	15.40	21.20	24.19	**
35-44	369	17.29	5.97	8.25	11.20	17.00	23.20	28.00	*
45-54	511	17.13	5.75	8.30	11.00	17.00	22.50	27.04	*
55-64	451	17.45	6.26	8.10	11.00	17.00	24.02	28.44	**
65-74	151	18.66	7.18	8.96	11.26	17.70	26.28	31.86	*
Females	2399								
18-24	111	17.09	6.78	9.00	10.48	16.00	23.06	28.70	*
25-34	395	17.72	7.48	8.48	10.20	16.70	24.36	32.76	**
35-44	443	22.25	8.73	9.82	13.10	21.40	31.34	38.48	**
45-54	652	24.30	8.76	11.40	15.10	23.20	33.50	40.20	**
55-64	605	24.69	8.72	11.48	16.00	23.90	34.33	40.75	**
65-74	193	25.23	9.94	9.88	14.37	24.00	36.94	43.36	**

† significance of the differences in distributions between Dalmatian and U.S. populations
n.s., not significant; * p 0.05; ** p 0.01

TABLE 2
ELBOW BREADTH (MM) BY SEX FOR TOTAL SAMPLES: NUMBER EXAMINED (N), MEAN, STANDARD DEVIATION (SD) AND SELECTED PERCENTILES

Sex	N	Mean	SD	5th	15th	50th	85th	95th	P†
Males	1974	74.3	4.3	67.5	70.0	74.0	79.0	82.0	**
Females	2399	66.2	4.5	60.0	62.0	66.0	71.0	74.0	**

† significance of the differences in distributions between Dalmatian and U.S. populations
** p 0.01

medians and the other percentiles. The presence of positive skewness was indicated by ranges from the 50th to the 95th percentiles being larger than those from the 5th to the 50th percentiles. There were sex-associated differences between the corresponding percentile values. All the values in females exceeded those in males in the entire age range studied.

The Dalmatian percentile values of subscapular skinfold were higher than the U.S. values at the 15th and 50th percentiles (Figure 1). The differences were greater in females. At the 85th percentile U.S. values exceed the Dalmatian up to 7 mm. Differences in percentile distributions were significant in all age- and sex-specific groups (Table 1).

Elbow breadth

The distribution parameters are given only at the sex-specific basis because no age-related trends were observed (Table 2). The cumulative percentile distributions are presented in Figure 2 together with the U.S. distributions for comparison. The male percentile values of elbow breadth exceeded those in females and the Dalmatian values were significantly higher than the U.S. values. The difference was more pronounced in females

Upper arm circumference, muscle area and fat index

The age- and sex-specific means are reported in Table 3. Percentile values are

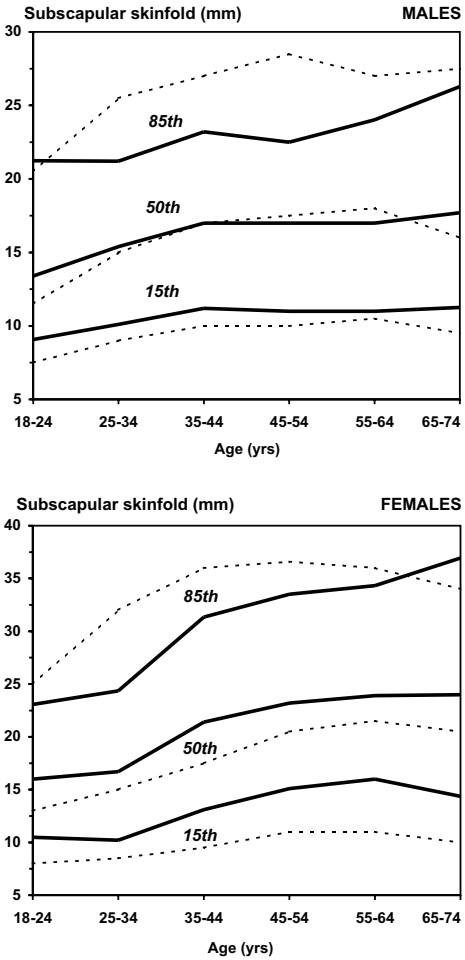


Fig. 1. Selected percentiles of subscapular skinfold thickness in Dalmatian (___) and U.S. population (.....).

TABLE 3
UPPER ARM CIRCUMFERENCE (UAC), UPPER ARM MUSCLE AREA (UMA), AND ARM FAT INDEX (AFI) BY SEX AND AGE: NUMBER EXAMINED (N), MEAN AND STANDARD DEVIATION (SD)

		UAC (cm)			UMA (cm^2)			AFI (%)		
Age (y)	N	Mean	SD	P†	Mean	SD	P†	Mean	SD	P†
Males	1794									
18–24	69	29.4	2.6	**	45.5	9.7	*	19.9	7.1	n.s.
25–29	135	30.5	2.5	**	49.8	9.3	**	19.2	7.4	**
30–34	203	30.8	2.8	**	51.2	11.3	**	19.3	7.4	**
35–39	185	31.7	2.5	**	55.3	10.8	n.s.	19.0	6.5	**
40–44	144	31.6	2.5	**	55.2	10.5	n.s.	18.2	5.8	**
45–49	198	31.2	2.6	**	54.4	11.0	n.s.	17.2	5.8	**
50–54	271	31.6	3.0	**	54.9	12.2	n.s.	18.6	6.6	**
55–59	260	30.9	2.6	**	52.2	10.6	n.s.	18.6	5.4	**
60–64	179	30.3	2.8	**	49.9	11.0	n.s.	18.6	6.2	**
65–69	65	30.1	3.1	**	48.5	11.3	n.s.	19.3	5.1	**
70–74	85	29.6	2.6	**	55.1	9.4	*	21.3	5.5	n.s.
Females	2279									
18–24	96	26.4	2.4	**	30.0	7.5	n.s.	34.7	8.1	**
25–29	182	27.4	2.5	**	32.2	7.0	**	35.3	8.4	**
30–34	177	28.5	3.0	**	34.5	7.4	**	36.3	9.2	**
35–39	212	29.3	2.9	**	35.6	7.5	**	38.0	8.3	**
40–44	196	30.0	2.9	**	37.5	7.5	**	38.5	8.3	**
45–49	299	30.6	3.0	**	39.2	8.6	**	38.8	8.3	**
50–54	323	31.0	2.9	**	39.0	8.3	**	39.6	8.2	**
55–59	322	30.9	3.0	**	40.0	8.4	**	38.9	8.3	**
60–64	279	30.9	3.1	**	40.6	8.4	**	37.8	8.7	**
65–69	107	30.7	3.4	n.s.	40.5	9.6	**	37.3	8.0	**
70–74	86	30.2	3.1	n.s.	39.3	8.7	**	36.8	9.1	**

† significance of the differences in distributions between Dalmatian and U.S. populations
n.s., not significant; * p 0.05; ** p 0.01

shown only graphically in Figures 3, 4 and 5, parallelly with the U.S. percentiles. The results of distribution comparisons are given in Table 3. There are changes in arm circumference and muscle area means with age that are paralleled by trends in percentile distributions. For men, the values generally increased until middle age, and then steadily decreased. For women, both parameters increased progressively until age was well advanced, and then stabilized, or declined, with the onset of senescence. In comparison to the U.S. percentile values, Dalmatian males had systematically and significantly smaller arm circuference while their muscle area was smaller in younger age, and then equaled the U.S. values. Dalmatian females had lower percentile values of arm circumference above the median, and higher values of muscle area at all ages. Arm fat index showed no consistent trends with advancing age in Dalmatian population. Its percentile values were generally lower than the U.S. values and the differences in distributions were significant.

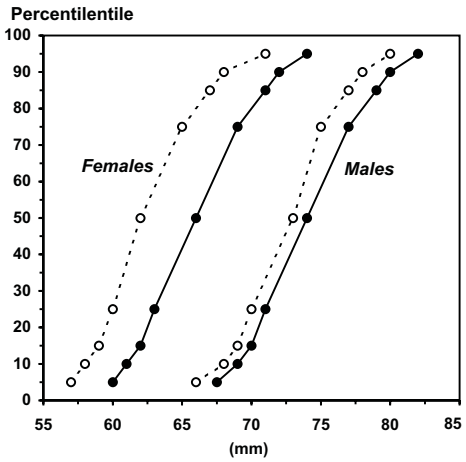
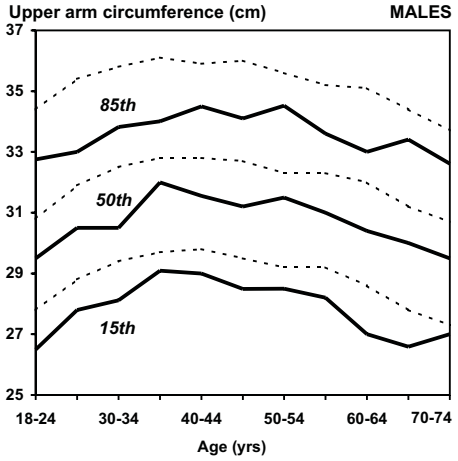


Fig. 2. Cumulative percentile distributions of elbow breadth in Dalmatian (___) and U.S. population (.....).



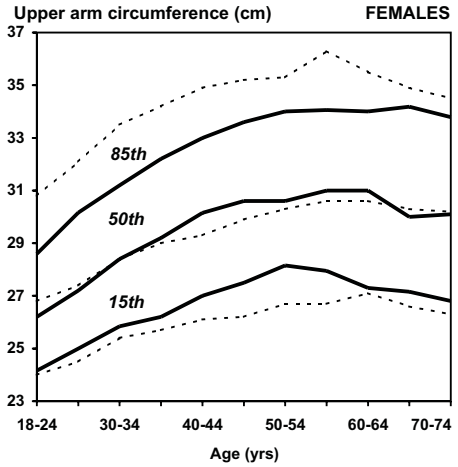
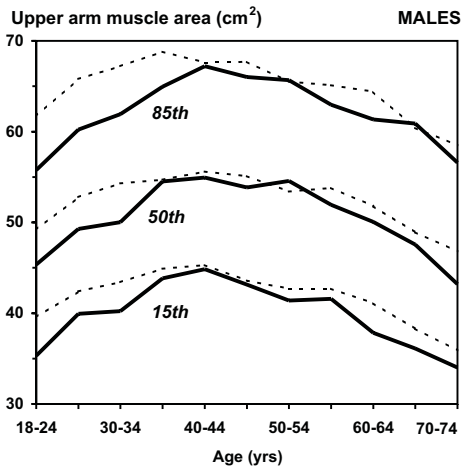


Fig. 3. Selected percentiles of upper arm circumference in Dalmatian (___) and U.S. population (.....).

Discussion

It is generally considered that Dalmatian population is in favorable position relative to the continental Croatian population with regard to overweight due to its dietary habits and other aspects of lifestyle typical for European Mediterranean[28–30]. Interestingly, a prior study identified a situation that rises concern regarding the problem of overweight and severe overweight among the adult Dalmatians[11]. The estimates were based on BMI cut-off points from NHANES II[12]. At the same time, the study questioned the appropriateness of U.S. reference data for the evaluation of nutritional status of this population due to possible differences in body build. Therefore, the present study assessed frame size and muscularity of the Dalmatian population and compared them to the NHANES reference values. Additionally, body fat on the upper trunk was analyzed in order to address the previous suggestion that Dalmatians have more fat deposited in the central region of the body.

Elbow breadth was used as an indicator of frame size since it is less affected by degree of fatness than other anthropometric measures of skeletal breadth[26,31,32]. Upper arm muscle area provided information on body muscularity due to its linear relationship to total body muscle[33]. The subscapular skinfold represented subcutaneous fat deposits in the central region of the body in contrast to the triceps skinfold located peripherally[34–36].



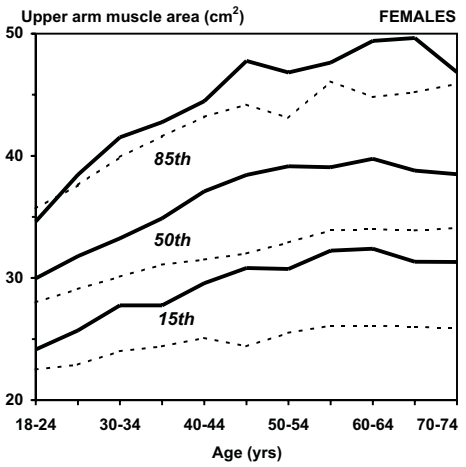
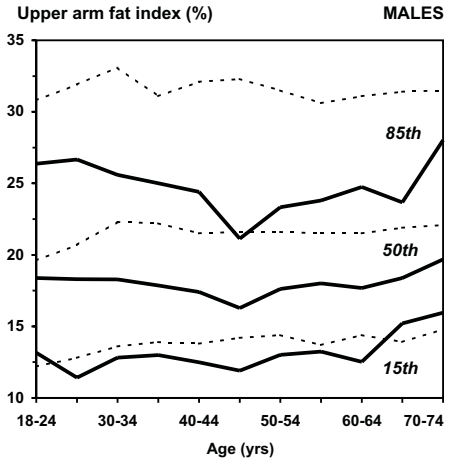


Fig. 4. Selected percentiles of upper arm muscle area in Dalmatian (___) and U.S. population (.....).



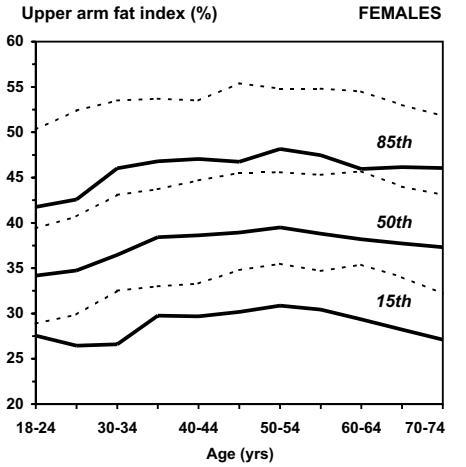


Fig. 5. Selected percentiles of upper arm fat index in Dalmatian (___) and U.S. population (.....).

Significant difference was found in elbow breadth between Dalmatian and U.S. populations that is indicative of larger frame size of the Dalmatians. Their larger muscularity is an another component of their high BMI. This is particularly evident in females whose upper arm muscle area is markedly larger than in the U.S. population. In males, it parallels the muscle area of the Americans. It would probably be larger even in males had it been measured on the right limb due to the well established limb dominance effect[37]. The extent of differences in distributions of the studied body build components between Dalmatian and U.S. populations is visualized in Figure 6, together with the BMI. Z-scores from the U.S. percentile values are used for the presentation and enable comparison among different variables. Although combining all ages lumps together the age-

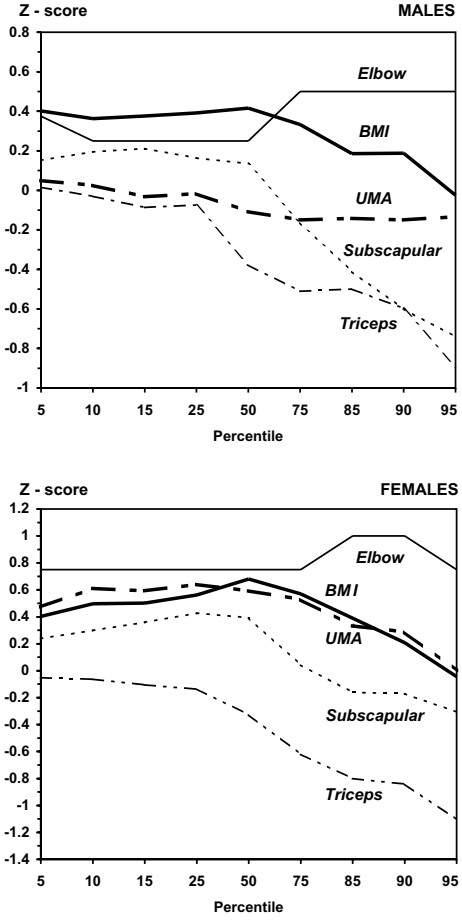


Fig. 6. Z-scores from the U.S. percentile values for BMI and muscularity, frame size and fatness indicators.

related trends, the overall tendency is clear. Z-scores of elbow breadth and of UMA in females are all positive. They follow the pattern of BMI and provide corroboratory evidence for the view that high BMI of Dalmatians largely reflects their muscularity and skeletal robustness.

An additional determinant of higher BMI in Dalmatians might be their higher body fatness that results from the tendency to deposit more fat on the trunk. According to the triceps skinfold, the Dalmatians have much lower quantity of fat deposited peripherally than the Americans. This was also evident when the upper arm fat was expressed in terms of fat area (AFI). According to the subscapular skinfold, about 65–75% of the Dalmatians, all at the lower segment of the skinfold distribution, have more fat located centrally (on the trunk) than have the Americans. The remaining 25–35% of the population that constitutes the upper segment of the skinfold distribution have less fat deposited centrally. These upper extremes of BMI and subcutaneous fatness (85th percentiles) comprise subjects who are overweight and potentially over-fat[12]. The Dalmatian data suggest that the overweight segment of the population (with BMI 85th U.S. percentile) has less fat deposited both peripherally and centrally, and presumably lower total body fatness, than the U.S. population. Their overweight reflects larger contribution of muscle and bone components to their body weight. The data provide evidence that the U.S. upper percentiles of BMI are imprecise indicators of excess body fatness in Dalmatian population. If U.S. reference data will be used in the assessments, several additional anthropometric dimensions are required in order to provide additional diagnostic information on subcutaneous fatness, body muscularity and frame size.

The WHO also recommends the use of BMI to express different degrees of overweight that imply differences in body fatness[4]. According to its criteria, 15.1% of males and 26.8% of females in the Dalmatian population are within »grade 2« and »grade 3 overweight« categories (BMI 30 kg/m^2). The prevalence is high compared to 10–20% observed among whites in the USA and most countries of Europe[38]. NHANES II criteria (BMI 31.1 kg/m^2 for males and 32.3 kg/m^2 for fe-

males) classify 10% of Dalmatian males and 13.6% of females as »severely overweight«. The prevalence estimated this way is again high compared to 7.8% in males and 9.8% in females from U.S. Having in mind the findings of body build of the Dalmatian population, there are reasons to believe that both, the WHO and the NHANES II classifications overestimate the proportion of this population that is over-fat. Further research is, therefore, needed to explore the magnitude of the problem and, if necessary, to develop the cut off-points for BMI and subcutaneous and total body fatness in Dalmatians that will have a basis in morbidity and mortality data. It is suggested that the presently developed population-specific percentile distributions should be used provisionally as the reference data for group comparisons in the Dalmatian region.

In addition to total body fatness, the anatomical distribution of fat in obese individuals has emerged as an important health risk factor. It has been shown that central adiposity more fully explains the chronic disease-obesity relationship than the peripheral and total body adiposity[39,40]. Although overweight in Dalmatians appears to be due to lean body mass rather than to excess fat, the distribution of fat in the body of overweight individuals is an important question. Unfortunately, the U.S. reference values for the »index of centralized fat patterning« (the ratio of the subscapular to the triceps skinfold thicknesses)[35,41,42] are not available for the adults and direct comparison is not possible. Furthermore, using the subscapular skinfold as an indicator of central fat deposits leaves open the problem of intra-abdominal fat. It remains for further analyses to describe the patterns of body fat distribution in Dalmatians using measures of subcutaneous fat (including subscapular/triceps index) as well as indicators of intra-abdominal fat. Additional research is warranted to relate both overweight and pattern of body fat distribution to adverse health outcomes such as levels of physiological risk factors or morbidity variables in the Dalmatian population.

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PREKOMJERNA TEŽINA I DEBLJINA U DALMACIJI: USPOREDBA S AMERIČKIM REFERENTNIM VRIJEDNOSTIMA

S A Ž E T A K

U populaciji dalmatinskih otoka i poluotoka ispitivana je debljina kožnog nabora na leđima (subskapularnog), širina lakta i pokazatelji prehrambenog stanja s poprečnog presjeka nadlaktice. Prikazane su vrijednosti izabranih percentila dobivene na uzorku od 4373 u dobi od 18 do 74 godine života. Podaci su uspoređeni s američkim NHANES I

i II referentnim vrijednostima i utvrđene su razlike u svim ispitivanim svojstvima. Rezultati upotpunjuju prije prikazane podatke za indeks mase tijela (BMI) i kožni nabor na nadlaktici (nad tricepsom) i pokazuju da visoka prevalencija prekomjerne težine u populaciji Dalmacije u velikoj mjeri odražava robustniju i mišićaviju građu tijela, a ne i veću količinu masti u tijelu. Stoga je zaključeno da vrijednosti gornjih percentila indeksa mase tijela i kožnih nabora referentne američke populacije nisu prikladne za procjenu debljine naše populacije. Preporuča se upotreba percentilnih distribucija pokazatelja prehrambenog stanja koje su u radu izvedene za populaciju Dalmacije.