RESEARCH LETTER

Body Surface Area, Creatinine Excretion Rate, and Total Body Water: Reference Data for Adults in the United States

To the Editor:

Anthropometric calculations based on weight and height are widely used in medicine. Body mass index is probably the most prominent example. Although reference data for its population-wide distribution are available,[1] these are lacking for other commonly used calculations.

In this report, we provide population-level data for anthropometric equations relevant to nephrology, notably body surface area (BSA), creatinine excretion rate (CER), and total body water (TBW).

The National Health and Nutrition Examination Surveys (NHANESs)[2] conducted by the National Center for Health Statistics are commonly used to estimate health-related statistics representative of the total noninstitutionalized civilian US population. Details about sample design and estimation procedures for the 2015 to 2018 period have been published.[3]

With the data on age, sex, race, weight, and height, we calculated BSA, CER, and TBW for study participants. We used the Du Bois formula[4] for BSA, equation D in Ix et al[5] for CER, and the formula by Chumlea et al[6] for TBW. The Black/non-Black racial categorization that is used in the formulas for CER and TBW was applied according to data provided by NHANES. The calculations were done using Mathematica (version 12.0.0.0; Wolfram Research), the code is shown in Item S1.

Using the survey package[7] in R (example code provided in Item S2; R-project), we then obtained the mean and 5th, 10th, 15th, 25th, 50th, 75th, 85th, 90th, and 95th quantile values of the respective anthropometric estimates. Data were weighted with 4-year calculated examination sample weights to produce national estimates. Standard errors were estimated using Taylor series linearization.[8,9]

For BSA, we calculated these values for men and nonpregnant women 20 years and older, as well as the age subgroups 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and older than 80 years. For CER and TBW, for which age is a variable of the equations, we had to exclude the age range 80 years and older because exact age values are not publicly available in this group due to privacy concerns. We successfully reproduced published distributions of weight, height, and body mass index for the 2011 to 2014 NHANES[1] to confirm the correctness of our data selection and analysis process. This paper also served as a blueprint for the design of our output tables. For all our analyses, we used only publicly released fully anonymized data sets. Therefore, no additional ethics approval or informed consent procedure was necessary.

The results are provided in tabular form. Data for the entire age range are shown in Tables 1 and 2 for nonpregnant women and men. The online supplementary tables contain the results for age subgroups (BSA in Tables S1 and S2, CER in Tables S3 and S4, and TBW in Tables S5 and S6) and CER in mmol/d (Tables S7 and S8). All tables depict values for the noninstitutionalized civilian US population for 2015 to 2018 across all racial and Hispanic origin groups.

We believe that knowing the range and levels of these commonly applied anthropometric measures will support their reasonable use in clinical practice. For example, in medicine, we express kidney function as estimated glomerular filtration rate (eGFR) normalized to BSA of 1.73 m^2. The figure 1.73 originated from life insurance data from the early 20th century.[10] Table 1 not only demonstrates that it does not apply to the current US population, but the wide range of the BSA values underscores the necessity to correct eGFR for actual BSA when using it for drug dosing.

Also, protein in spot urine samples is commonly quantified per creatinine concentration and serves as a surrogate of 24-hour proteinuria. Because CERs differ widely across the population, proteinuria in many patients will be over- or underestimated.

We have to emphasize that the formulas used for our calculations are not perfect. Thus, the results presented here are possibly giving a biased picture of the true values of BSA, CER, and TBW in the population. Nevertheless, we believe that this is still far better than having no distribution information at all. More importantly, in many cases it is the calculated values that have been used in clinical applications. This is, for example, the case with BSA in eGFR or with TBW in dialysis quantification (Kt/V).

By choosing the Du Bois, Ix, and Chumlea formulas, we are not claiming that these equations are necessarily better than others. We selected Du Bois because it was used in the derivation of the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula, equation D as it derived from CKD-EPI subsamples, and Chumlea because it originated from a rather contemporary US cohort.

Our tables should help clinicians appraise values of BSA, CER, and TBW in individual patients. They allow up-to-date specifications of average values and common ranges for these equations.

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SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Item S1: Mathematica code

Item S2: R code

Table S1: Body surface area (BSA) in women.

Table S2: Body surface area (BSA) in men.

Table S3: Creatinine excretion rate (CER) in women.

Table S4: Creatinine excretion rate (CER) in men.

Table S5: Total body weight (TBW) in women.

Table 1. Body Surface Area for Nonpregnant Women and Men 20 Years and Older, United States, 2015 to 2018

Parameter)	Sex	No. of Examined Persons	Mean	Standard Error of the Mean	Percentile								
					5th	10th	15th	25th	50th	75th	85th	90th	95th
Body surface area, m^2	Female	5,381	1.80	0.007	1.48	1.53	1.58	1.64	1.78	1.94	2.03	2.11	2.22
	Male	5,076	2.05	0.007	1.71	1.76	1.81	1.88	2.03	2.20	2.29	2.36	2.46

Table 2. Creatinine Excretion Rate and Total Body Water for Nonpregnant Women and Men Aged 20 to 79 Years, United States, 2015 to 2018

Parameter	Sex	No. of Examined Persons	Mean	Standard Error of the Mean	Percentile								
					5th	10th	15th	25th	50th	75th	85th	90th	95th
Creatinine excretion rate, mg/d	Female	5,027	1,187	9.1	802	872	919	994	1,136	1,340	1,460	1,567	1,740
	Male	4,750	1,736	8.2	1,338	1,418	1,463	1,540	1,694	1,887	2,009	2,122	2,276
Total body water, L	Female	5,022	34.1	0.14	27.3	28.4	29.2	30.6	33.3	36.8	39.2	40.9	44.0
	Male	4,745	49.3	0.20	39.3	40.7	42.0	43.9	48.2	53.2	56.6	59.2	63.5

Table S6: Total body weight (TBW) in men.

Table S7: Creatinine excretion rate (CER) in women (mmol/d).

Table S8: Creatinine excretion rate (CER) in men (mmol/d).

ARTICLE INFORMATION

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