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## TOTAL BODY WATER IN ELDERLY ADULTS—ASSESSING HYDRATION STATUS BY BIOELECTRICAL IMPEDANCE ANALYSIS VS URINE OSMOLALITY

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### To the Editor

Dehydration is the most common fluid disorder. It is responsible for morbidity and mortality and accounts for substantial hospital expenditures. Early diagnosis is sometimes difficult because the classical signs may be absent or misleading in older adults. In acutely ill older adults, anthropometric estimates of total body water (TBW) do not reliably reflect fat-free mass because of disturbances of intracellular water (ICW) caused by protein malnutrition, changes in TBW, and changes in the ratio of ICW to extracellular (ECW) because of injury and inflammation.<sup>1</sup> Excessive fluid retention in the extracellular space causes greater morbidity in acutely ill individuals. Bioelectrical impedance analysis (BIA) has been shown to predict TBW in acutely ill elderly adults.<sup>2</sup> Urine osmolality (U Osm) has also been used to estimate hydration status<sup>3–5</sup> but has not been independently validated to predict TBW. This study examined the relationship between TBW predicted using BIA, U Osm, and clinical criteria including hospitalization status, severity of illness (Acute Physiology And Chronic Health Evaluation (APACHE) score), intravenous fluid or diuretic administration, sex, and renal and nutritional status in a group of older adults to assess the utility of single measure of clinical estimates of hydration status.

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**Author Contributions:** James Powers and Maciej Buchowski: Developed the study concept and design, planned the acquisition of participants and data, analysis and interpretation of data, and preparation of the manuscript. Antoinette Otoo-Boameh and James Powers: Acquired the participants and data for the study. Li Wang: Analyzed the study data.

**Conflict of Interest:** James Powers is a member of the Pharmacy Advisory Committee of Health Spring, has provided expert testimony in long-term care. Supported in part by Vanderbilt CTSF Grant UL1 RRO 24975 from the National Center for Research Resources, National Institutes of Health and Health Services and Resource Administration, Bureau of Health Professions Geriatric Education Centers Grant 1D31HP08823–10–00.

## METHODS

Older adults were randomly recruited between 2005 and 2010 from patients admitted to a university hospital Acute Care for the Elderly service or seen in the geriatric primary care outpatient department. Eighty-two volunteers provided informed consent, 19 participants were excluded because they were current smokers; had an amputation; had implanted cardiac devices, metal pins, plates, or joint prostheses; or withdrew before completing the study protocol. Sixty-three participants (36 outpatients, 27 inpatients) were included in the final data analysis. The Vanderbilt institutional review committee approved this study, and all participants provided informed consent.

All studies were completed at patients' bedsides within 1 to 3 days of admission or in the Senior Care Outpatient Center at the time of routine office visits. The hospital clinical laboratory measured U Osm. For four participants, urine specific gravity (U Sg) was used to estimate U Osm. None of the four participants had received contrast media or had high urinary glucose concentrations. The APACHE II score was calculated for each participant and used to estimate the severity of illness in inpatients and outpatients.<sup>6</sup> TBW and ECW were measured using BIA (Real Time Analyzer; RJL Systems, Clinton, MI), as previously described.<sup>2</sup>

Continuous variables were represented as medians with interquartile ranges. Categorical variables were summarized using percentages. The association between U Osm and the other clinical factors were assessed using Spearman rho correlation coefficients. Linear models using least squares were applied to test whether there was any association between TBW measured using BIA and U Osm, with adjustment for age, sex, and disease status. All statistical analyses were performed using R version 2.13.1 ([www.r-project.org](http://www.r-project.org)). All tests were two tailed.

## RESULTS

The mean age of participants was 78.5 (range 66–95), and body mass index (BMI; kg/m<sup>2</sup>) was 27.7 (range 12–47). Participants had multiple comorbidities and were classified according to major presenting diagnosis, including hypertension (22), diabetes mellitus (9), urinary tract infection (8) chronic obstructive pulmonary disease or pneumonia (6), Alzheimer's disease or psychosis (5), congestive heart failure (3), trauma with acute fracture (3), stroke or syncope (2), sepsis or cellulitis (2), chest pain (1), colon carcinoma (1), and acute pancreatitis (1). Detailed information on inpatient and outpatient groups is included in Figure 1A, with a plot of TBW versus U Osm in Figure 1B.

There was no relationship between TBW and the single measure U Osm. There was no relationship between phase angle (BIA measurement) or predicted TBW and U Osm, age, and administration of diuretics or intravenous fluids. Predicted TBW tended to be higher in men.

## CONCLUSION

BIA-derived markers of hydration and U Osm were not related to disease category or severity, diuretic or intravenous administration, BMI, age, sex, or renal function in hospitalized or outpatient older adults. Others have found that single measures of U Osm do not correlate with acute dehydration states.<sup>7</sup> Changes in U Osm and U Sg are variably responsive to incremental changes in hypertonic dehydration in young athletes and may lag behind plasma osmolality in acute dehydrational states.<sup>8</sup> Water consumption can change in U Osm in young volunteers, but TBW and BIA are unchanged.<sup>9</sup> Despite their clinical importance, there is little valid information available regarding signs of dehydration in aging

(Hooper L, personal communication). For clinical use, single measures of U Osm and BIA must be interpreted in relation to clinical findings.

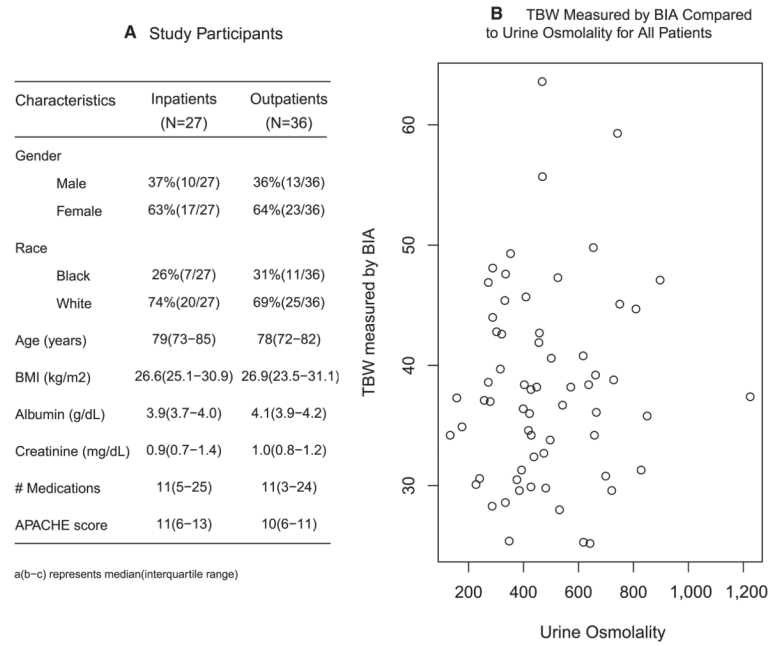
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**Figure 1.** (A) Study participants. (B) TBW measured by BIA compared to urine osmolality for all patients.