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Letter to the Editor: Normal Reference Plots of the Bioelectrical Impedance Vector for Healthy Korean Adults

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Real-time classification of hydration in patients with altered fluid status remains a priority with increasing efforts focused on bioelectrical impedance vector analysis (BIVA) because of the reliance on impedance measurements independent of body weight and sample-specific regression equations to predict fluid volumes.[1,2] Oh et al.[3] derive reference BIVA plots for healthy Korean adults and identify population-specific differences in impedance vector positions and distributions on resistance-reactance (RXc) plots. They attribute these disparities principally to ethnic differences in body composition and health status and only mention in passing the potential impact of impedance instruments as a causal factor.

Variations in the technical characteristics of the bioimpedance analyzers used to obtain the BIVA reference values (**Table 2** and **Fig. 3**) include impedance technology (single frequency, phase-sensitive compared to multiple frequency spectroscopy with modeling), electrode placement (whole-body or wrist-to-ankle compared to segmental electrode location), electrode type (hydrogel versus metal), and calibration (point or single frequency compared to modeling of a wide spectrum of frequencies) that directly affect *in vivo* impedance measurements. Investigators report significant and biologically meaningful discrepancies exceeding 10% in R and up to 20% in Xc with various impedance instruments compared to the 50 kHz phase-sensitive instrument used in development of the BIVA.[4-6] Additionally, failure to use contact electrodes with low inherent impedance results in mis-classification of hydration with BIVA.[7]

The observed disparity in BIVA reference data on the RXc plot (**Fig. 3**) highlight apparent population differences in body composition confounded with a moderating effect of impedance device. Data for the Italian and Spanish samples came from a 50 kHz phase-sensitive device.[8,9] In contrast, a phase-sensitive 50 kHz impedance unit with questionable calibration[10] provided measurements to construct the US population reference BIVA data[11] while a multi-frequency spectroscopy device yielded modeled impedance data for the Korean sample.[3]

Whereas individual impedance device measurement reliability is generally high, an absence of international manufacturing standards, coordination of technology and cross-calibration of electrical accuracy contributes to significant inter-instrument measurement variability.[12,13] These findings emphasize the lack of inter-changeability among bioimpedance instruments and underscore the need for consistency in the selection of a bioimpedance instrument in research and clinical applications of hydration assessment in which standards for classification and evaluation of the effects of treatment are needed.

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Response

The Author's Response: Normal Reference Plots for the Bioelectrical Impedance Vector in Healthy Korean Adults

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It is of paramount importance to obtain an appropriate assessment of a patient's hydration status, for their diagnosis and management in diverse situations. However, estimating the volume status is difficult, because the clinical signs and symptoms for over- or under-hydration are neither sensitive nor reliable.[1] In this regard, bioimpedance analysis (BIA) serves as a convenient and attractive aid for assessing body fluid volume. However, the performance of BIA is compromised by its reliance on population-specific regression equations and erroneous assumptions about body geometry and composition.[2] As a result, bioelectrical impedance vector analysis (BIVA) has emerged as an attractive alternative to BIA, due to its ability to detect and rank changes of < 500 mL in tissue hydration levels without requiring prediction equations or knowing the body weight. Although a precise impedance measurement is the only requirement for BIVA, it is still affected by several potential sources of error. These error sources include the malposition of electrodes, using high-impedance electrodes, increased skin temperature, and using a non-phase-sensitive device that cannot directly measure reactance (X_c) or phase angle.

InBody S10 is a tetrapolar eight-point tactile electrode system capable of measuring the impedance, X_c, and phase angles of each of the 5 body segments (right arm, left arm, trunk, right leg, and left leg) at 3 different frequencies (5, 50, and 250 kHz). However, as pointed out in the letter by Lukaski, there has been a concern that impedance measurements might be affected by the characteristics of the analyzer, resulting in varying readings between different analyzers.[3] Some factors considered responsible for these errors include the properties of the cables and electrodes, the positions of the current-injecting and the voltage-sensing electrodes in tetrapolar systems, and the ability to sustain a constant current while measuring impedances.[4,5] We also agree that differences between the reference ellipses of various ethnic groups might be caused by differences in analyzer characteristics used in other research. This study highlights the importance of considering the devices used in bioimpedance measurements when interpreting the study results.

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