LETTERS

INADEQUATE HYDRATION OR NORMAL BODY FLUID HOMEOSTASIS?

Kenney et al. reported that 54.5% of 4134 children were inadequately hydrated, as defined by a single urine osmolality (Uosm) of 800 or greater milliosmoles per kilogram of water.[1] This "dehydration" threshold was inferred from experimental data first described in 1965,[2] with subsequent studies on US, Jewish, German, and Swedish children demonstrating mean values above this threshold.[3] Despite the lack of necessary corroborative data on plasma indicators of dehydration, Kenney at al. and others have come to the surprising conclusion that a majority of the world's children are dehydrated. Of great public health concern is the potential detrimental effects of dehydration on cognitive performance.[1] However, the data are not convincing: in the cited Italian study, the intervention and control groups were not considered separately in statistical analyses (reference 7 in article),[1] and the cited Israeli study found a significant difference in only 10% (1/10 total) of cognitive tests (number span) with a possible gender bias confounding the result (reference 6 in article).[1]

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An alternative, physiology-based, interpretation of these data suggests that the majority of these children were in osmoregulatory balance, effectively conserving body water via osmotically appropriate arginine vasopressin (AVP) secretion and not dehydrated by clinically relevant, plasma-based, definitions.[4] As shown in Figure 1, osmotically driven thirst stimulation occurs when plasma osmolality reaches a threshold of approximately 288 to 295 milliosmoles per kilogram of water, which corresponds to a Uosm of 800 to 1200 milliosmoles per kilogram of water and plasma sodium concentrations ($[Na^+]$) within normal ranges. Although there is a high degree of individual variability in the osmotic thresholds for both thirst and AVP stimulation in humans, it is evident from the reported mean values that the children in the present study (except non-Hispanic Blacks) demonstrated Uosms below the average osmotic threshold for thirst stimulation—well within the normal physiological ranges for plasma AVP, osmolality, and $[Na^+]$. Thus, the majority of children with a Uosm of 800 or more milliosmoles per kilogram of water were appropriately conserving fluids to maintain cellular hydration, although some at the very high ranges of Uosm may have met other standard criteria for dehydration. These well-known physiological relations serve to emphasize that measurement of urine osmolality, and particularly as a single measurement, cannot accurately predict body hydration status.

The proposed health benefits of drinking fluids beyond regulatory need is unsubstantiated by scientific evidence,[5] including a panel of experts assembled by the Institute of Medicine.[6] And although the recommendation to drink more water seems harmless enough, the threat of drinking beyond thirst carries the risk of serious medical consequences from low blood $[Na^+]$ (dilutional hyponatremia), especially during exercise, and has resulted in the deaths of two high school athletes in the past year.[7] Thus, we urge public health professionals to critically examine the physiological evidence underlying the use of a Uosm threshold of 800 milliosmoles per kilogram of water for "dehydration" before enacting policies encouraging children to drink beyond their thirst. The potential dangers may outweigh any perceived cognitive or health benefit, with the approximately 33% intake of sugar-sweetened beverages perhaps the more serious detriment to health. ■

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The EAH Consensus Panel 2015

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This letter was accepted July 3, 2015.
doi:10.2105/AJPH.2015.302825

Acknowledgments

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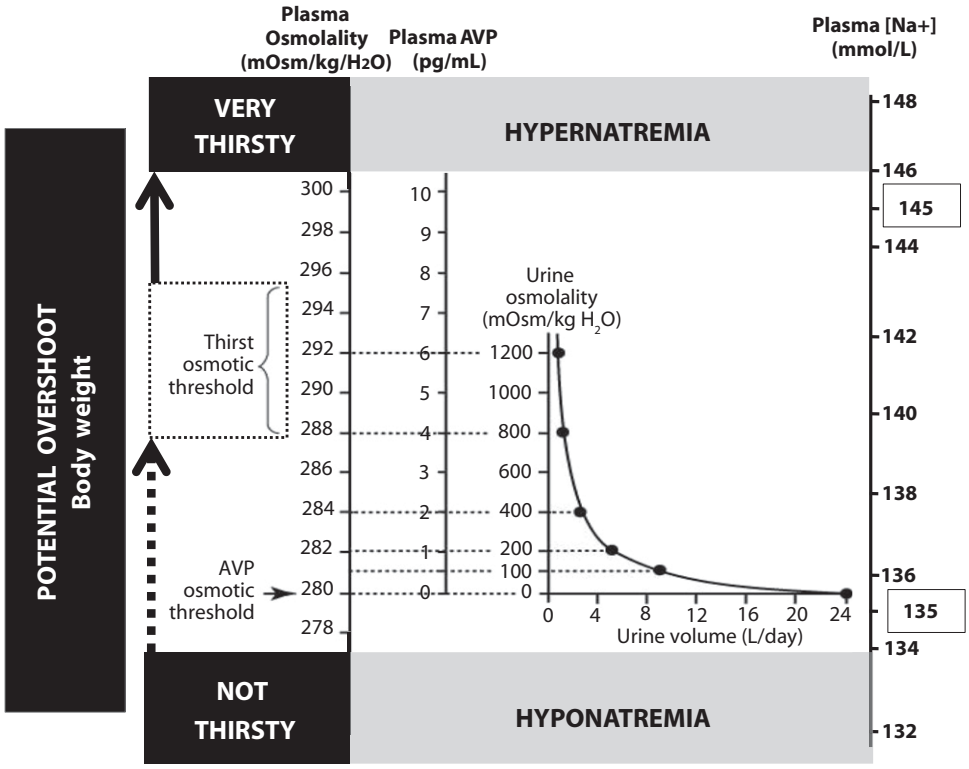

Note. Normal plasma [Na+] is regulated between 135 and 145 mmol/L (normonatremia). Body weight is not a physiologically regulated variable, but is often used as a surrogate measure for fluid homeostasis.

Source. Adapted from Verbalis JG. Disorders of body water homeostasis. *Best Pract Res Clin Endocrinol Metab*. 2003;17(4):471–503.

FIGURE 1—Schematic representation of fluid homeostatic relationships between plasma osmolality, arginine vasopressin (AVP), and sodium concentration ([Na+]); urine osmolality and volume; osmotic thirst threshold; and clinically relevant natremia status.

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KENNEY ET AL. RESPOND

We appreciate the letter from Hew-Butler and the EAH (Exercise-Associated Hyponatremia) Panel regarding our recent study on inadequate hydration among children in the United States. We agree with the author that our data do not support the conclusion that, "a majority of the world's children are dehydrated." We made no such claim. Instead, using the 800 milliosmoles per kilogram urine osmololality (Uosm) threshold for inadequate hydration from previous research,[1] which Hew-Butler and the EAH Panel note is associated with thirst stimulation, we found that more than half (54.5%) of the children in the United States may be inadequately hydrated—or thirsty—at any given time. We specifically used the term "inadequate hydration" rather than "dehydration" because the threshold of 800 Uosm does not serve as a clinical indicator of urgent dehydration.

Despite the challenge of measuring hydration status in a population sample, which remains problematic even when using plasma indicators,[2] we believe that our findings highlight an important public health problem that deserves additional research and action. Our goal was not to argue that more than half of US youths are seriously ill from clinical dehydration. Rather, we aimed to estimate the population prevalence of milder inadequate hydration given that this may be associated with deficits in well-being and cognition. We agree that further research on hydration and cognition in children using stronger study designs is warranted; however, there is a more robust body of literature demonstrating negative effects in adults.[3]

Hyponatremia is harmful to the small number of children who experience it.[4] However, most US youths do not consume adequate water as defined by the Institute of Medicine,[5,6] and many of the spaces where children learn and play have limited water access.[7,8] We do not suggest that well-hydrated children should drink water to excess, but rather that we need