The Relationship between %BML, Urine Color, Thirst Level and Urine Indices of Hydration Status

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Abstract

Introduction: Dehydration is known to impair health, quality of daily life, and exercise performance [1]. While several methods are utilized to assess fluid balance, there is no gold standard to assess hydration status [2]. Cheuvront and Kenefick [3] suggested the use of a Venn diagram, which consists of % body mass weight (BML), urine color, and thirst level (WUT) to measure hydration status and fluid needs. However, no study to date has examined the relationship between the WUT criteria and hydration status measured by urine indices. **Objective:** The purpose of this study was to investigate the relationships between urine-specific gravity (USG), urine osmolality (U_{OSM}), and the WUT criteria. **Methods:** Twenty-two females (mean $\pm$ SD; age, 20 ± 1 year; weight, 65.4 ± 12.6 kg) and twenty-one males (age, 21 ± 1 year; body mass, 78.7 ± 14.6 kg) participated in this study. First-morning body mass, urine color, USG, U_{OSM} , and thirst level were collected for 10 consecutive days. First 3 days were utilized to establish a euhydrated baseline body weight. %BML $>1\%$, urine color >5 , and thirst level ≥ 5 were used as the dehydration thresholds. The number of markers that in-

dicated dehydration levels was summed when each variable met each threshold. One-way ANOVA with Tukey pairwise comparison was used to assess the differences in USG and U_{OSM} , followed by a calculation of effect size (ES). **Results:** Figure 1 indicates the differences of U_{OSM} based on the WUT criteria. For U_{OSM} , “2 markers indicated” (mean [M] $\pm$ SD [ES], 705 ± 253 mOsmol [0.43], $p = 0.018$) was significantly higher than “1 marker indicated” (M $\pm$ SD, 597 ± 253 mOsmol). Additionally, “zero marker indicated” (509 ± 249 mOsmol) was significantly lower than “3 markers indicated” (M $\pm$ SD [ES], 761 ± 250 mOsmol, [1.01], $p = 0.02$) and “2 markers indicated” ([ES], [0.78], $p = 0.004$). However, there was no statistical difference between “3 markers indicated” ([ES], [0.65], $p = 0.13$) and “1 marker indicated.” For USG, “3 markers indicated” (M $\pm$ SD [ES], 1.021 ± 0.007 [0.57], $p = 0.025$) and “2 markers indicated” (M $\pm$ SD [ES], 1.019 ± 0.010 [0.31], $p = 0.026$) were significantly higher than “1 marker indicated” (M $\pm$ SD, 1.016 ± 0.009). Additionally, “zero marker indicated” (1.014 ± 0.005) was significantly lower than “3 markers indicated” ([ES], [1.21], $p = 0.005$) and “2 markers indicated” ([ES], [0.54], $p = 0.009$). **Conclusion:** When 3 markers indicated dehydration

Fig. 1. The number of markers (body mass, urine color, and thirst) indicating dehydration in UOSM. (*) = different from 0 and (+) = different from 1 ($p < 0.05$). UOSM, urine osmolality.

levels, U_{OSM} and USG were greater than euhydrated cut points. When 2 markers indicated dehydration levels, USG was higher than the euhydrated cut point. Additionally, U_{OSM} and USG were significantly lower when zero or 1 marker indicated dehydration levels. Thus, the WUT criteria are a useful tool to assess hydration status. Athletes, coaches, sports scientists, and medical professions can use this strategy in the field settings to optimize their performance and health without consuming money and time.

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Statement of Ethics

This research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. Following an explanation of the study procedures, which was approved by the Institutional Review Board at the University of Connecticut (H-18-115), participants provided written and informed consent to participate.

Conflict of Interest Statement

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Author Contributions

Y.S. and C.B. led this study and contributed to all aspects of this study, including planning, data collection, analysis, and writing a manuscript. D.C. and R.S. were PI of this study. Other authors contributed to the data collection and writing the manuscript.