Modeling Hydration Status Given Daily Measures of Body Mass, Urine Color, and Thirst

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Keywords

Machine learning · Copeptin · Vasopressin · Hydration monitoring · Health

Abstract

Background: The ability to monitor changes in daily hydration status is critical for human health and performance. Monitoring changes in body weight (W), urine color (U), and thirst (T) was proposed as a simple, low-cost method for daily hydration monitoring [1]. However, the ability of these metrics to accurately predict 24-h hydration status is yet to be fully tested. **Objective:** The purpose of this study was to assess the degree to which daily monitoring of W, U, and T (i.e., the WUT model) could accurately predict 24-h hydration status. **Methods:** Thirty-five male and female adults (age: 23.4 ± 4.1 years, height: 173.0 ± 10.3 cm, mass: 77.2 ± 18.2 kg, body fat: $18.4 \pm 8.4\%$) were monitored for 8 consecutive days. Assessments on each morning included a 24-h urine sample for urine osmolality (UOSM24), a first void spot urine for urine color (U), nude body weight (W), and perceived thirst (T) using a 1–9 Likert scale. On days 7 and 8, a blood sample was taken for copeptin assessment [2]. If UOSM24 was >800 mOsm·kg⁻¹ on any day, the participants were classified as hypohydrated. Multiple research questions were explored. First, models tested the degree to which W, U, and T

could predict UOSM24 (RQ1). Classification models assessed the ability to predict whether an individual was hypohydrated (UOSM24 >800 mOsm·kg⁻¹; RQ2). Last, models tested the degree to which W, U, and T could predict concentrations of copeptin (RQ3). For each question, 4 separate modeling approaches were used: linear regression (LR), elastic net regression (EN), extreme gradient boosted random forests (XB), and a single hidden layer neural network (NN). Eighty percent of the data (RQ1/RQ2 $n = 207$, RQ3 $n = 49$) were used to train the models, while 20% of the data were held out (RQ1/RQ2 $n = 51$, RQ3 $n = 10$) for model validation. Within the training data, bootstrap samples (XB) and cross-fold validation (EN and NN) samples were used to optimize model hyperparameters. Prediction accuracy for regression analyses were assessed via R^2 and root mean square error (RMSE), and for classification analyses via area under the curve of the receiver operating characteristic. **Results:** The results demonstrated that the NN model performed best when predicting UOSM24 ($R^2 = 0.532$, RMSE = 228 mOsm·kg⁻¹), but all models had relatively poor fit and large errors during validation. All classification models were moderately effective at discriminating between the binary hydration status of individuals (area under the curve of the receiver operating characteristic range: 0.661–0.696). Linear regression (Fig. 1; $R^2 = 0.929$, RMSE = 1.49 pmol·L⁻¹), XB ($R^2 = 0.834$, RMSE = 3.11 pmol·L⁻¹), EN ($R^2 = 0.890$, RMSE = 2.13 pmol·L⁻¹), and NN ($R^2 = 0.930$,

RMSE = 1.84 pmol·L⁻¹) were able to predict copeptin concentrations with relatively low error. **Conclusions:** The WUT model accurately predicts copeptin concentrations on out of training data observations, suggesting that first morning measures of W, U, and T are effective for tracking hydration

status by indirectly monitoring arginine vasopressin. More research is needed to determine potential cut-scores of predicted copeptin levels to aid practitioner decisions.

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Fig. 1. Predicted copeptin from the LR model compared to observed copeptin in the out of training sample observations. The solid gray line represents perfect prediction. LR, linear regression.

Statement of Ethics

All subjects gave their written informed consent, and this study protocol was reviewed and approved by the Institutional Review Board at the University of North Carolina at Greensboro (IRB #18-0063).

Conflict of Interest Statement

Travis Anderson has received speakers fees from Danone Research.

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Author Contributions

Travis Anderson contributed to data collection, conceptualization, data analysis, primary author, critical review, and editing. William M. Adams is the principal investigator and contributed to

data collection, conceptualization, critical review, and editing. Laurie Wideman is the senior investigator and contributed to conceptualization, critical review, and editing.

Data Availability Statement

The data that support the findings of this study are not publicly available due to ongoing analysis but are available from T.A. (t_ander2@uncg.edu) upon reasonable request.

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