Hydrostasis Geca^{TM} sensitive to <2% weight change due to mild dehydration in healthy adults

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Background

Dehydration affects mood and impairs mental performance, muscle endurance and fine motor skills. A 2-3% loss in total body water is associated with up to 40% decrease in endurance, particularly in hot environments. Even a 1% change in total body water may affect cognitive performance. Dehydration is also a major contributor to heat stroke and heat exhaustion - a growing concern as global temperatures increase.

In addition to detecting acute dehydration, it is also important to prevent chronic dehydration. Older adults are particularly at risk of chronic dehydration: It is estimated that as many as 3 in 4 older adults are chronically dehydrated. Dehydration and malnutrition in US nursing homes has been called a silent epidemic, with as many as 600,000 residents in US nursing homes estimated to be affected.

Few non-invasive measures exist to check hydration status. Invasive, gold standard measures of dehydration such as plasma osmolality can reliably detect relative dehydration of 2% loss of total body water or more. Weight change is considered one of the best non–invasive methods for determining short-term / acute weight changes. Other tests currently on the market include sweat prediction algorithms and saliva testing.

Current state-of-the-art fuzzy piecewise sweat prediction equations can predict weight change with an average error 0.1 - 0.145 l/h (kg/h). Saliva measures of dehydration can detect dehydration with a sensitivity of 86% and specificity of 91%, but are easily contaminated by eating or drinking before the test, and may require lab analysis. We aim to provide similar or better accuracy than these measures, along with more conditions under which it is effective.

Objectives

In this report we focus on the agreement between Hydrostasis Geca^{TM} weight change predictions after dehydration and measured weight changes.

Why measure weight change?

Change in total body weight is traditionally used as a non-invasive marker of short-term hydration change. Our goal is to use predicted weight change to make fluid intake recommendations in order to prevent serious dehydration before it happens.

Specific objectives

1. Evaluate the agreement between weight change predictions made by the Hydrostasis Geca™ sensor and known weight changes, and to
2. Determine the specificity and sensitivity of the Hydrostasis Geca™ sensor's dehydration detection.

Methods

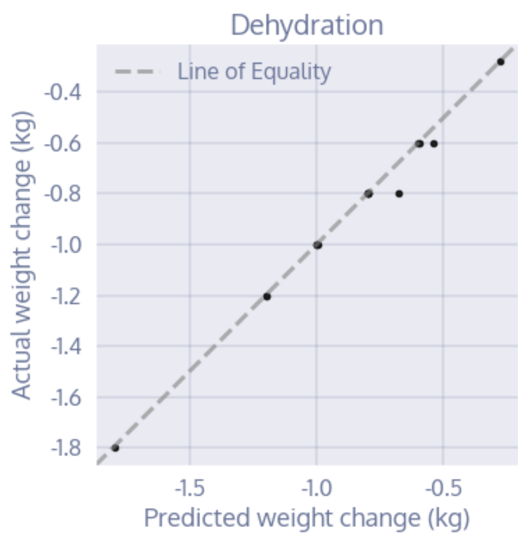
Fifty-four healthy adults between the ages of 27 and 75 participated in this study. Participants were instructed to refrain from eating or drinking fluids 45 minutes before the start of the study and for the duration of the study, unless instructed to do so. Seated measurements were taken on the wrist for 30 minutes before hydrating with 10 fl.oz. of water, for 30 minutes after hydration, and for 15 minutes after exercise (dehydrated state). Weight and urine specific gravity (USG) was measured before hydration, approximately 30 minutes after hydration, and approximately 15 minutes after ending exercise. Weight change predictions were compared against actual weight changes over the course of the procedure. Most participants lost between 0.5 and 0.8% of their total body weight during exercise. Rehydration was defined as increases in weight from baseline, whereas dehydration was defined as stable or decreased weight from baseline.

A machine learning model was trained on 38 participants, and the sensitivity and specificity of the model was computed on the weight change predictions for 16 participants who were withheld from the training sample. Correlation and Bland-Altman analyses for instrument agreement were also conducted to determine whether weight change predictions were within acceptable error limits.

Results

The Hydrostasis Geca™ sensor could predict relative dehydration status with both sensitivity and specificity of 87% (82% precision) on the test data.

When predicting dehydration-related changes, predicted weight change had a Pearson correlation of 0.995 ($p < 0.001$) with actual weight change (*Figure 1*). Bland-Altman analysis of agreement between sensor-predicted weight change and measured weight change after dehydrating showed that most prediction errors fell within -0.02kg (-0.04 lbs) and +0.03kg (+0.07 lbs) of actual weight change, with an average error (bias) of 0.01kg (0.02 lbs) (*Figure 2*).



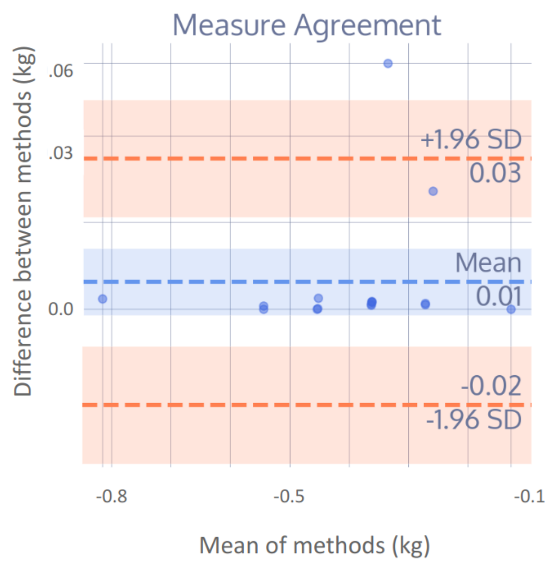


Figure 1. Hydrostasis Geca™ predicted weight changes after exercise-induced dehydration are strongly correlated with true weight changes. The dotted line indicates the line of perfect agreement.

Figure 2. Bland-Altman Analysis of measure agreement between Hydrostasis Geca™ predicted weight changes and true weight changes after exercise-induced dehydration. The mean difference indicated the average error between the two measures. The dotted red lines indicate the upper and lower limits of agreement between these measures. Shaded areas show the 95% confidence intervals around the mean difference and limits of agreement. All values are in kilograms.

Conclusion

The Hydrostasis Geca™ sensor and predictive algorithms were able to outperform current commercial solutions for determining dehydration and dehydration-related weight change. The current algorithm was able to detect dehydration levels under 2% loss of total body weight - the threshold at which it is commonly agreed that physical and cognitive performance is impacted. Hydrostasis was also able to predict weight loss with an average error of 0.01kg (0.02 lbs) ± 0.03kg (0.07 lbs) of actual weight change, giving our users the unique ability to know how much fluids they need in order to properly rehydrate.

In addition to detecting exercise-induced dehydration we are continuing to develop and improve our technology for detecting the amount of fluid consumed during rehydration.

Definitions	
Accuracy	In classification: The proportion of cases correctly classified (both hydration and dehydration. In continuous measurement (e.g. weight): Average error within agreed-upon error limits such as industry standards or clinically relevant thresholds.
Sensitivity	The proportion of users that were correctly identified as dehydrated.
Specificity	The proportion of users that were correctly identified as not being dehydrated.
Precision	The proportion of all dehydration predictions that were correct.
Pearson's Correlation	A measure of how much two measures are (linearly) related to each other. A correlation coefficient of 1 indicates a perfect positive correlation or agreement, a coefficient of 0 indicates no relationship, and a coefficient of -1 indicates a perfect negative correlation.
Bland-Altman Analysis	This analysis compares a new measure with a commonly used / industry standard measure. In this case we compare Hydrostasis Geca™ weight change predictions with weight change as measured on a commercially available scale. The smaller the difference between the two measures, the greater the agreement between the two measures. The lower and upper limits of agreement can be evaluated against clinically significant levels of weight change (e.g. a 2% change in weight, or 1.6 kg/3.5 lbs for an 80 kg/176 lbs adult) or current measurement standards for detecting dehydration-related weight change (0.1 - 0.145 l/h (kg/h)).

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