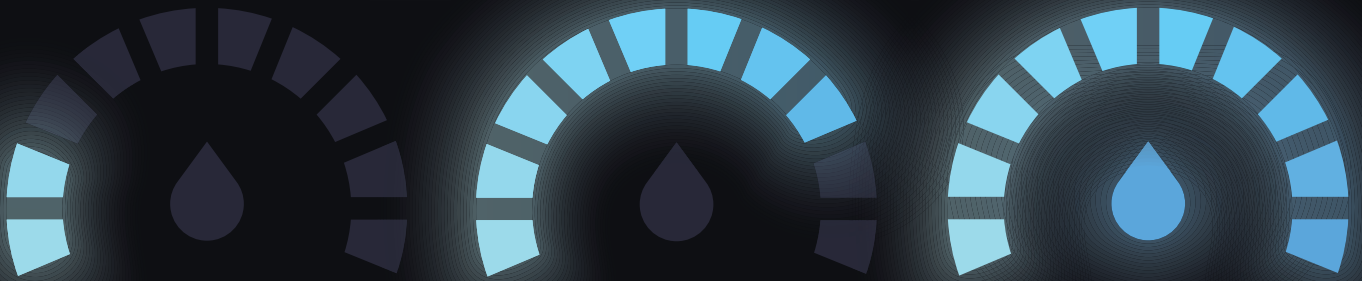# SOLVING THE QUESTIONS OF WATER CONSUMPTION

HOW AI AND PREDICTIVE MACHINE LEARNING MODELS ARE HELPING TO DETERMINE HOW MUCH WATER YOU SHOULD DRINK

By Chris Torres

For years, the common recommendation has been that you should drink at least eight 8-ounce glasses of water per day to be adequately hydrated. Drinking those 64 ounces of water a day was the goal—no matter your gender, race, weight, or the environment you live in. But due to advancements in technology in recent decades, along with new discoveries about the human body and its uses of and needs for water, the quest to determine the ideal amount of water that one should consume throughout the day has become a more complicated, and a more individualized, issue.

QUESTIONNAIRE QUICK TAKES

A study currently being conducted by Michael Bergeron, PhD, and Colleen Muñoz, PhD, and partially funded by the Drinking Water Research Foundation, includes a questionnaire that asks participants a series of questions to determine behavioral trends and other distinctive characteristics between low- and high-water drinkers. Below is a summary of some of their preliminary findings.

Most high-water drinkers:

- Drink fluids at least once per hour when awake.
- Drink fluids even when they aren't thirsty.
- Believe they consume more than 64 oz. of fluids per day.
- Have confidence they are well-hydrated on a typical day.
- Are used to drinking fluids regularly and don't have to think about it.
- Have a habit of drinking fluid regularly.
- Are not often too busy to get a drink.

Most low-water drinkers:

- Believe they consume less than 64 oz. of fluids per day.
- Do not think they are well-hydrated on a typical day.
- Are more likely to stay hydrated if someone checks with them about their fluid intake.

Both high- and low-water drinkers equally said the following:

- They usually have a beverage within arm's reach.
- Carrying a bottle with them during the day doesn't bother them.
- Carrying a bottle during the day makes them more likely to stay hydrated.
- Seeing other people drinking fluids encourages them to also drink fluids.
- They dislike using the restroom often because of drinking and will avoid drinking if they know they won't be near a restroom.
- They think it's important to have clear activity and daily fluid consumption goals.
- Monitoring their fluid consumption helps them stay hydrated.

Today, expert opinions vary on how much water men and women should drink, and those recommendations are typically determined because more criteria (e.g., gender, age, health status, and physical activity) are now considered. But even when you include those factors, the answer to "how much water should I drink a day?" is still not fully realized.

Two scientists working on behalf of the Drinking Water Research Foundation (DWRF)—a nonprofit that educates the public about drinking water (including bottled water, tap water, and filtered water) and the associated health benefits of consuming water—are learning more about individualized hydration; what makes someone a high or low daily water drinker; and how artificial intelligence (AI) and predictive machine learning models and advanced analytics, which use statistical learning to predict outcomes, can help make those determinations. Taking on this project are Michael Bergeron, PhD, a clinical and scientific advisor in the Department of Performance Health for the Women's Tennis Association (WTA), and Colleen Muñoz, PhD, an associate professor in the Department of Health Sciences at the University of Hartford. Both have backgrounds in exercise and performance-based research and health promotion, and the role of hydration has been an integral part of their previous studies. Their current work examines common and novel hydration biological markers (referred to as "biomarkers") in characterizing optimal hydration, related chronic health status or risk, and how well hydration profiles can be predicted when taking several factors into account (e.g., gender, race, height, weight, diet, perceptions, and behaviors).

What intrigued DWRF about this project was that for the first time, original data collection from healthy young adults of diverse backgrounds would
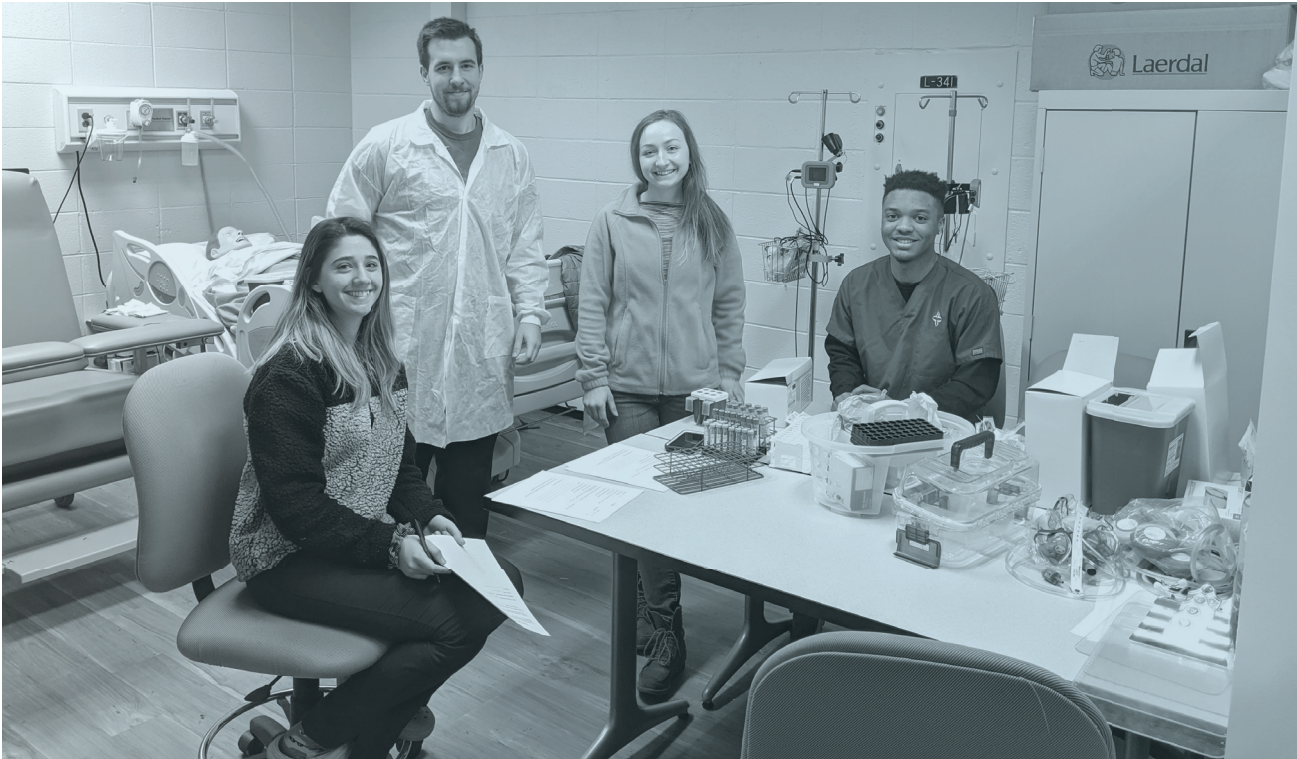
University of Hartford students and future healthcare providers (from left) Joana Lalaj, Kyle Murphy, Beata Abramek, and Cameron McFarlane collected dietary data and blood and urine samples daily from participants of the research project.

be combined with comprehensive data mining, AI, and machine learning to address the important topic of water intake for human health. Papers explaining the novel research results are being submitted to recognized peer-reviewed scientific journals for publication. The articles from those outlets could be posted on the DWRF, IBWA, and other websites for the public and IBWA members to use to promote healthy hydration information to their customers. In addition, the important research initiative will be helpful leverage when advocating for the development of daily water intake guidelines that reinforce effective drinking water behavior and highlight the associated acute and long-term health benefits of water consumption.

Why Measuring Hydration Is Important

Many currently available hydration studies and guidelines offer valuable

HYDRATION BEHAVIOR AND PATTERNS ARE MORE INDIVIDUALIZED THAN PREVIOUSLY THOUGHT; THUS, A ONE-SIZE-FITS-ALL RECOMMENDATION IS NOT APPROPRIATE OR EFFECTIVE.

insight, but they can also be viewed as isolated one-offs that try to categorize people into different groups based on a small set of simplified criteria. But hydration and health are not that simple, Bergeron says. Due to the complexity of measuring adequate water intake and the relevance of more than several complex biological and behavioral systems and factors (with some mattering more than others at various times), Bergeron and Muñoz

are employing a multidomain approach for this research. One area of the study examines biomarkers in the blood. A biomarker is an objective measure that captures what's happening in a cell or an organism during a given moment. Biomarkers are important because they can serve as early warning systems for your health. For example, if too much iron is found in your blood, then you may need to be tested for nervous system and cognitive
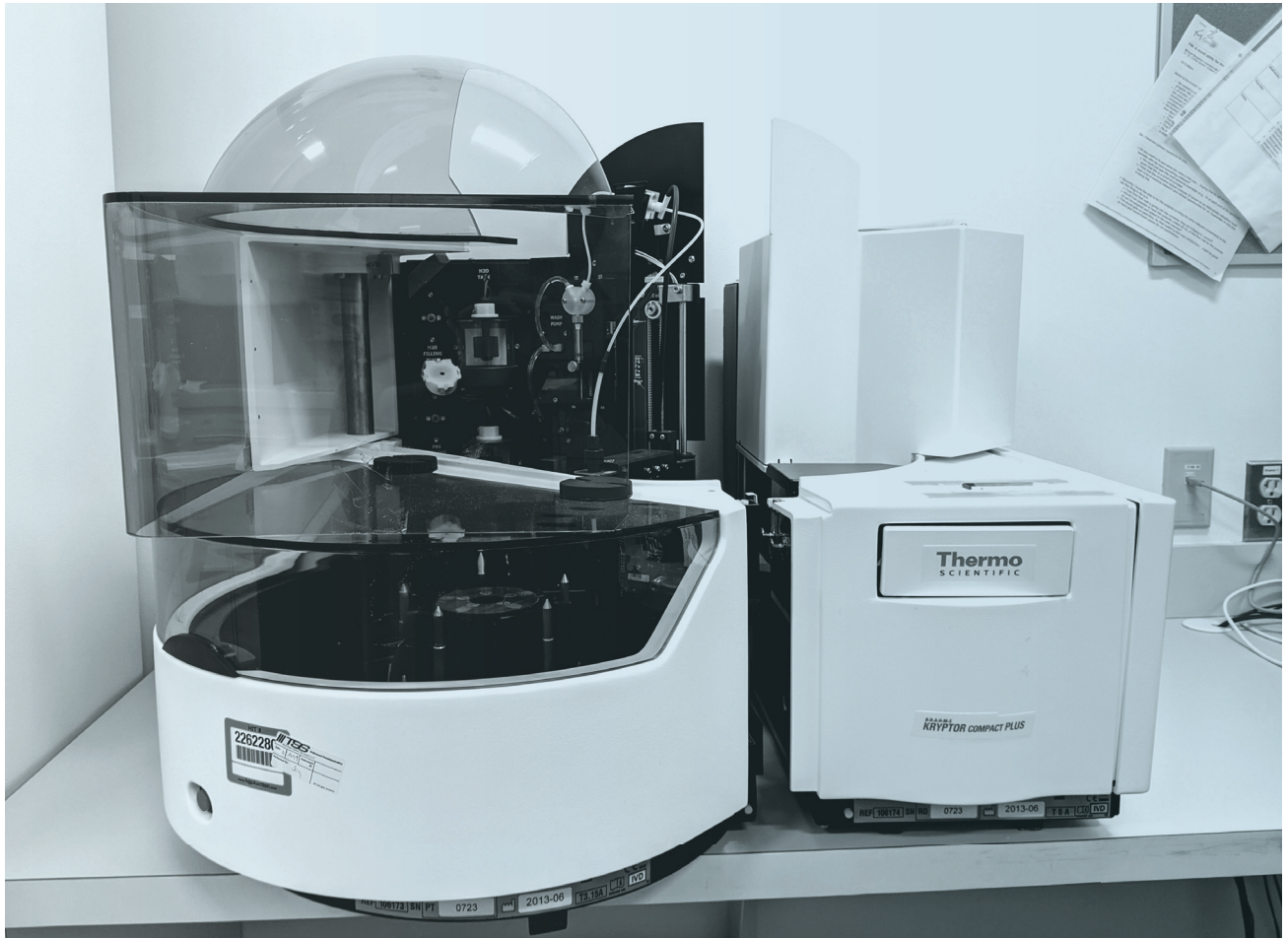
A BRAHMS Kryptor, the gold standard equipment for the measurement of highly valuable biomarkers (such as plasma copeptin) was partially funded by DWRF.

RESEARCH PARTICIPANTS UNDERWENT FIVE CONSECUTIVE DAYS OF OBSERVATION AND DATA COLLECTION WHILE PERFORMING THEIR NORMAL DAILY ROUTINES.

disorders. Bergeron and Muñoz are also exploring how an individual's hydration knowledge, attitudes, and behaviors affect his or her routine water consumption. This is a novel approach, as most hydration recommendations don't factor an individual's perceptions and attitudes, or self-awareness tendencies and practices.

Bergeron and Muñoz are using AI and predictive machine learning to analyze all the data gathered from study participants to then classify them as low- or high-water drinkers. They are also able to ascertain what factors matter most when determining if someone is a low- or high-water drinker. Both researchers believe that the lack of more robust knowledge about high- and low-water drinkers challenge current guidelines. Muñoz states that this project could also help us learn more about the relationship between hydration and chronic health risks.

"There's a lot that's involved with hydration that's not so clear," Bergeron says. "Whether you're talking about guidelines, health-related issues . . . clarity and precision with all of that has been fairly elusive. Part of the reason is that [the topic of hydration] is extraordinarily complex." However, he notes that technological advances with analytics and AI/machine learning tools can shed light on some of the fundamental and ambiguous characteristics of hydration.

Study Details

Bergeron and Muñoz began this DWRF study in 2019, and they completed the data collection stage shortly before the COVID-19 pandemic began in 2020. Research participants underwent five consecutive days of observation and data collection while performing their normal daily routines. The purpose of the study was not disclosed to participants because researchers wanted to receive unbiased data. Subjects provided blood and 24-hour urine samples each day, along with first-morning urine that is traditionally identified as a good indicator of hydration status. In addition, they documented their sleep, thirst, physical activity, food and beverage intake, how long they were outdoors or indoors, along with other measurements. Participants also completed three questionnaires related to their hydration knowledge, behaviors, and perceptions.

From the 10 algorithms used to analyze and sort the data, the highest performing resulting models ranged from 84 to 87.5 percent accuracy in predicting whether the participants were generally low or high consumers of fluids. A surprise to both Bergeron and Muñoz was that a closer look at the models showed that, of all the data and measurements considered, the factors related to behaviors, attitudes, and beliefs about hydration consistently carried more priority and influence with the models than any of the physiological measurements (e.g., blood concentration and thirst level).

"We both went through our education process thinking that your blood concentration is going to be your biggest determinant in beverage intake because that's what your brain is sensing that's telling you you're thirsty," says Bergeron. But that wasn't apparently the case here, and Bergeron admits, "That was a big surprise. . . and a finding that conflicts

WHY WATER INTAKE COULD HELP MITIGATE MUSCLE LOSS

As we get older, we develop sarcopenia, an age-dependent loss of muscle mass and function. The risk factors for sarcopenia include age, gender, and level of physical activity (*bit.ly/Sarcopenia_Defined*). Fortunately, drinking water can have a positive impact on this naturally occurring condition.

Sarcopenia is driven in part by circulating reductions in the hormone apelin, which can be used as an early diagnostic support tool for identifying this condition. Apelin is also a known fluid balance hormone and is thought to increase in concentration with elevated water intake, meaning that a lack of hydration can also be a contributor to sarcopenia.

Along with hydration, routine exercise is another way to help increase apelin and combat sarcopenia. The impact of routine hydration practices on apelin, however, has not yet been addressed in chronic health publications.

with and contrasts to what many people think, and certainly to what's been generally promoted."

"We really don't have a good grasp on how much we should be drinking on a daily basis," says Muñoz. "That's quite evident when you look at the guidelines from different countries. We also know, and it's notable, that we don't see water a lot in the [U.S.] national guidelines. So, from that standpoint, it's interesting that we don't prioritize learning more about water and its impact on health to make it more prominent in official dietary recommendations."

Although the 2020-2025 Dietary Guidelines for Americans (DGAs) include several mentions of water in reference to the importance of establishing a healthy diet, it does not make any specific recommendations on how much water should be consumed. And currently, water is not featured on the MyPlate nutrition graphic, a very prominent public resource that stems from the DGAs. IBWA is actively working to have water added to MyPlate, in addition to diary.

EVEN WITH ALL THAT WE KNOW ABOUT THE BENEFITS OF WATER CONSUMPTION TODAY, IT IS ABSENT FROM SOME PROMINENT FORMS OF GUIDANCE, SUCH AS THE MYPLATE NUTRITION GRAPHIC.

University of Hartford research assistant Hinal Rana measures plasma apelin from collected blood samples.

IN ADDITION TO AGE, GENDER, PHYSICAL ACTIVITY, THIRST, AND THE OTHER "USUAL" FACTORS THAT INFLUENCE HYDRATION HABITS, THIS RESEARCH EXPLORES HOW AN INDIVIDUAL'S HYDRATION KNOWLEDGE, ATTITUDES, AND BEHAVIORS AFFECT HIS OR HER DAILY WATER CONSUMPTION.

How Much Water Should You Drink?

Bergeron and Muñoz's findings show there's a lot more to learn about water consumption and hydration. Their research also demonstrates that hydration behavior and patterns are more individualized than previously thought; thus, a one-size-fits-all recommendation is not appropriate or effective.

Based on her past work, Muñoz suggests that people should drink at least 2 liters (basically 8.5 cups) of water per day; however, other hydration experts around the world would offer other recommendations. Just as the DGAs help shape policy and dietary recommendations in the United States, the Eatwell Guide is a policy tool used to define government recommendations on eating healthily and achieving a balanced diet to U.K. citizens—and it suggests drinking 6-8 cups of fluid per day (*bit.ly/UK_EatWell*). Canada's Dietary Guidelines take a similar approach to the DGAs, recommending water as the beverage of choice but acknowledging that the amount one may need to consume per day to be hydrated can vary based on environmental conditions and other factors (*bit.ly/CA_DietaryGuidelines*).

A set of people living in the same environment and conditions drinking the same amount of water can have varying states of hydration due to the unique characteristics of each individual. The differing influential impacts and complex relationships among an integrated set of variables, Bergeron and Muñoz note, are why analytics and modern technology have entered this space.

Although this project doesn't make conclusive determinations, Muñoz says that their research has revealed "small pieces" showing that optimal hydration could help lessen risk factors for some chronic diseases (e.g., heart disease), health con-

ditions (e.g., high blood pressure), and related catastrophic events (e.g., a heart attack). "Water is very likely to be one piece of the puzzle," she says. (For more on how meeting or exceeding water recommendations could help lessen the negative impact of some diseases, read "Does Drinking Water Play a Critical Role in Healthy Aging?" on p.10.)

Helping Shape the Future of Hydration Learning

"We can go for days, weeks, or even months without some nutrients, but we can only go a few days without water," says Muñoz. Even with all that we know about the benefits of water consumption today, it is absent from some prominent forms of guidance, such as the MyPlate nutrition graphic. IBWA will be able to use this research when talking with policymakers to help them understand why the topic of healthy

hydration should be included in any nutritional guideline. Active promotion of the benefits of water consumption in U.S. nutritional guidance materials is especially important because research shows that 54.4 percent of children are not adequately hydrated throughout the day (*bit.ly/Inadequate-HydrationAmongChildren*).

Bergeron also thinks it's possible to use this research in the development of a user-friendly tool, such as a mobile application—and it would be unlike any hydration app currently available. "People might be providing just four or five simple things [e.g., water intake, gender, weight, etc.] in some kind of hydration tool, but the reasoning and value behind those simple items is the extensive research in validating their utility, giving us the confidence to say 'yes,' based on those four or five metrics, under these conditions, these

are recommendations specific to you," says Bergeron. "You're never going to have people in the real world replicate everything we're going to look at—from genetics to behavioral indicators, or other physiological measures. But if you're going to use something like first morning urine, we gave it a ranking or weight because of everything else we did beforehand to justify that metric or a few additional metrics to help guide somebody. You're translating a very complex system and analysis into a simpler set of measurements that somebody could use more practically in the real world, but it's coming from a more informed perspective." **BWR**

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