

Best Practice for Clinical Hydration Measurement

Dawn M. Minton, ATC • University of South Carolina and Lindsey E. Eberman, PhD, ATC, LAT • Indiana State University

THE NATIONAL Athletic Trainers' Association has released position statements regarding hydration in athletes and the risks associated with dehydration.¹ Dehydration and heat related injuries may result in loss of playing time, decrease in performance, decrease in overall health, and death.² Because dehydration is one of the primary signs of exertional

heat illness,¹ health professionals treating high-risk populations should measure hydration status as a preventive procedure.

Urine specific gravity (U_{sg}), change in body mass (BM), urine color (U_{col}), urine osmolality (U_{osm}), and plasma osmolality (P_{osm}) are common measures of hydration status, and

each method presents advantages and limitations. Some measures of hydration status are more appropriate for a laboratory setting, whereas others are more appropriate for clinical measurement. Tools that provide greatest measurement accuracy and reliability are preferred for research,³ but tools that require little technical expertise and low expense are customarily utilized in a clinical setting. Researchers disagree about the technical standard for measuring hydration

status in the clinical setting. Several groups of researchers have evaluated hydration indices to determine the most reliable and valid clinical measurement of hydration status. The purpose of this report is to review the current evidence about the best clinical hydration measurement technique.

Hydration Measures

Urine Specific Gravity

The National Collegiate Athletic Association suggests U_{sg} as the most practical, cost-efficient measurement of hydration status for athletes.⁴ U_{sg} is a measure of the ratio between the density of urine and the density of water.^{2,3,5,6} Urinary concentration is determined by the number of particles (electrolytes, phosphate, urea, uric acid, proteins, glucose, and radiographic contrast media) per unit of urine volume.^{2,7} A fluid that is more dense than water will have a measurement greater than 1.000 μ G.³ A normal value for U_{sg} ranges between 1.002 to 1.030 μ G;⁶ minimal dehydration is associated with values in the range of 1.010 to 1.020 μ G,¹ and severe dehydration produces values above 1.030 μ G.^{1,5} A small volume of urine is required for this rapid, non-invasive, and inexpensive measurement.^{3,7} Two popular U_{sg} measurement techniques are the use of a urine reagent strip (URS) and refractometry.

KEY POINTS

When measuring hydration, clinicians should use a tool that is practical, inexpensive, and does not require technical operation, while providing both reliable and accurate measures.

Urine specific gravity, measured by a refractometer, is a reliable clinical measure of hydration status.

Although current research supports the use of a refractometer for measurement of U_{sg} ,^{5,7-9} less contemporary findings suggest that URS measurements are equally reliable.^{10,11} URS measurement is cost-efficient, easily accessible, and can provide an estimate of U_{sg} .^{2,7} When a URS is immersed in urine, a chemical reaction occurs in the small pads that depends on the urine concentration. Protons are released in the presence of cations, which changes the color of the strip.^{2,5,7} A variety of manufacturers produce URS, each of which has specific instructions for proper immersion procedure and interpretation of the result. Failure to follow a manufacturer's specifications is a common cause of an inaccurate test result.¹²

Urine refractometry identifies the point at which concentrated fluid breaks normal light in comparison to that of water.^{2,7} This technique detects particles according to mass rather than number.⁷ U_{sg} measurement by refractometry is a more sensitive indicator of mild hypohydration than blood plasma or hematocrit measurements.¹³ The increase in U_{sg} sensitivity compared to the "gold standard" may be explained by the body's desire to maintain homeostasis, resulting in little plasma change until a certain level of hypohydration occurred.¹⁴

The relationship between refractometry and URS has been less than satisfactory.^{12,15,16} The correlation between URS and refractometry measurements is low ($r = 0.573$; $p < 0.05$), and URS values are typically greater than refractometer values (mean difference of 0.002 ± 0.007).⁶ URS has good specificity (83%) but poor sensitivity (38%) for identification of abnormal hydration status in minimally hypohydrated participants.⁶ Among three manufacturers' URS types, the values provided were moderately correlated with values derived from refractometry ($r = 0.491$, $r = 0.712$, and $r = 0.689$; $p < 0.01$).⁹ On the basis of available research that has compared URS and refractometry values, refractometry is the preferred method for U_{sg} measurement.

Change in Body Mass

Water comprises 50-70% of the body's total mass. Athletes who exercise in a hot and humid environment may lose 5% of body mass, or more in extreme cases.² A common clinical measurement for determination of hydration status in athletes is BM (calculated from preexercise and postexercise body mass measure-

ments).³ Although commonly used, BM has limitations. There must be a protocol for standardization of measurements obtained for each athlete. Considerations include accurate determination of baseline body mass, minimal clothing, removal of excess sweat from the skin, bladder voiding, and removal of sweat-soaked clothing.^{2,3} Day-to-day body mass fluctuations may affect the accuracy of measurements. Measurements obtained over a period of several weeks cannot be compared due to changes in body fat mass over the course of training.³ Furthermore, hypohydrated athletes who immediately ingested fluid equal to 5% of preexercise body mass did not immediately return to baseline P_{osm} values.⁸ Although BM is an inexpensive and practical method for hydration measurement, steps must be taken to ensure the validity and reliability of body mass values.

Urine Color

U_{col} is an inexpensive and reliable³ indicator of hydration status. Normal U_{col} is described as light yellow,^{2,3} whereas severe dehydration is associated with U_{col} that is described as brownish-green.³ U_{col} does not provide the accuracy or precision of U_{sg} or U_{osm} , and it tends to underestimate the level of hydration. U_{col} may be misleading if a large amount of fluid is consumed rapidly, and it may be altered by the consumption of vitamins and some vegetables.³ U_{col} may provide a valid means for self-assessment of hydration level when precision is not necessary, however.

Urine Osmolality

U_{osm} quantifies the number of dissociated solute particles per kilogram of solution, which is measured in osmoles.^{2,5} Because U_{osm} measurement requires an osmometer and a trained technician, it is not practical for clinical use.³ Although osmolality is the most accurate indicator of total solute concentration, it may not accurately reflect hydration status immediately after activity due to water turnover, intercultural differences, and regulatory mechanisms.³

Plasma Osmolality

P_{osm} is the most widely used hematological index of hydration, and it is considered the "gold standard" for determination of hydration status.³ P_{osm} is positively correlated with hydration status; P_{osm} will proportionally decrease when dehydrated and it will increase when

euhydrated. P_{osm} is measured by an osmometer (like U_{osm}), which is expensive and requires training. Thus, P_{osm} is also considered impractical for clinical use.³

Summary

Measurement of hydration status is essential for prevention, recognition, and treatment of heat-related illness. Clinicians should develop a protocol for assessment of preexercise hydration level and subsequently monitor athletes during and after high-risk activity.² Clinicians need a tool that is inexpensive and does not require technical operation while providing accurate and reliable measurements. Refractometry is more reliable than URS for clinical measurement of U_{sg} . Therefore refractometry, in conjunction with BM and U_{col} , should be used to monitor the hydration status of at-risk athletes who exercise in extreme environmental conditions. ■

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Dawn M. Minton is with the Physical Education Department at the University of South Carolina in Columbia.

Lindsey E. Eberman is with the Athletic Training Department at Indiana State University in Terre Haute.

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