WHITEPAPER

White Paper: Use of the MX3 Hydration Testing System for hydration assessment

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CONTENTS

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EXECUTIVE SUMMARY

Effective hydration management supports health, safety and performance during work, exercise and heat exposure. The MX3 Hydration Testing System provides a rapid, portable and non-invasive measurement of salivary osmolarity using less than 1 μL of saliva, making routine hydration assessment practical in field settings.

The MX3 HTS has demonstrated strong analytical performance compared with laboratory osmometers (R^2 = 0.98; mean difference = -0.7%) and moderate-to-excellent reliability (ICC = 0.75-0.93). Minimal detectable changes of approximately 18-21 mOsm provide practical guidance for interpreting serial measurements.

< 1 μL	R^2 = 0.98	18-21 mOsm
The volume of saliva required for the MX3 HTS.	Internal laboratory-osmometer comparison.	Minimal detectable change reported across independent reliability studies.

By making hydration assessment rapid, scalable and easy to implement, the MX3 HTS enables organisations and practitioners to move beyond occasional hydration testing towards proactive, individualised monitoring. Its greatest value is as part of a structured hydration-management program in which serial results are considered alongside symptoms, environmental conditions, work or exercise demands and relevant individual factors.

KEY POINT

The MX3 HTS can be used as a rapid, non-invasive method to support hydration assessment, particularly when measurements are collected serially under standardised conditions.

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MEDICAL DISCLAIMER

The MX3 Hydration Testing System is **not** a registered medical device outside of the United States. The MX3 Hydration Score and MX3 Hydration Categories are not medical advice and are not intended to diagnose, cure, mitigate, treat, or prevent any disease or health condition. MX3 Hydration Categories are guidelines only and may vary depending on the individual.

If you or the individual being measured are experiencing headaches, nausea, or other symptoms of dehydration or heat strain before, during, or after work or exercise, please seek immediate medical attention.

03

THE IMPORTANCE OF HYDRATION

Occupational Health and Safety

Adequate and regular fluid and electrolyte intake is essential for offsetting fluid losses when working in physically demanding occupations. Where fluid losses are not appropriately replaced, dehydration can result in cognitive and physical impairment[1].

A decrease in body water content can also reduce sweat rate. As evaporative cooling from sweating is the primary mechanism for thermal regulation when working in the heat, dehydration can result in a reduced ability for the body to regulate temperature, resulting in an increased risk of heat strain[2].

Hydration alone may not be sufficient to avoid heat strain when working in extreme conditions where evaporative cooling is impaired or insufficient, such as very high temperature, high humidity and/or low airflow environments as well as when heavy protective equipment is being worn[3].

While fluid replacement is key for avoiding heat strain, hydration alone is not sufficient to avoid heat strain in all contexts and should be used in combination with appropriate heat stress management, acclimation, and control programs.

Hydration testing should be interpreted within the context of a comprehensive heat stress management framework. MX3 Diagnostics supports worksite heat-stress management through training, environmental monitoring and heat-related risk assessments with our Heat Stress Management Toolkit.

The toolkit features three core modules aimed at predicting and reducing the risk of heat-related injuries:

- Heatmap Page: Offers real-time environmental monitoring enhanced by predictive AI, providing insights into heat index, apparent temperature, and Wet Bulb Globe Temperature (WBGT) across worksites. Alerts notify teams in real-time when conditions warrant action.
- Monitoring Page: Streamlines thermal risk assessments by integrating environmental data with individualized risk factors identifying high risk workers, tasks or locations.
- MX3 University: Highly customizable training modules developed by occupational safety experts to help organizations meet regulatory requirements and educate staff on heat stress management.

Sports and Fitness

Fluid loss, including water and electrolytes, during exercise of greater than 1% body mass (BM) begins to impact cognition and decision making[4] . Fluid loss greater than 2% BM results in reduced muscular strength and endurance and increases the risk of heat-related injury[5]. The higher the degree of dehydration, the more pronounced and consistent the impact on physical and cognitive performance.

While a certain amount of fluid loss is expected during training or competition, if an athlete begins exercising in a fluid deficit, dehydration and reduced performance will occur faster, with chances of injury increasing with duration of exercise. Therefore, management of the hydration status of athletes such that they start training or competition fully hydrated can help maintain performance by providing a buffer to the adverse effects of exercise related dehydration[6].

Tracking hydration for an athlete is a continuous challenge, so pre-exercise preparation needs to be coupled with adequate and appropriate hydration during exercise and effective rehydration and recovery post-exercise.

Military and Defense

In addition to the occupational health and safety risks described above, which are of relevance for military groups during training and deployment[7], the impact of fluid deficit on physical exertion can significantly reduce physical and mental performance and potentially compromise mission safety and objectives[8,9].

Dehydration as little as 2% body mass loss (BML) causes significant performance deficits and much greater dehydration - up to 6% BML - has been reported in short duration (<125mins) training flights and missions[10]. At this level of dehydration there is a great risk of heat exhaustion, heat stroke, loss of consciousness, and organ damage[6].

Monitoring hydration can guide warfighters to be optimally hydrated prior to missions, as well as effectively rehydrate and recover. This may improve performance and the likelihood of meeting mission objectives as well as overall mission safety.

04

HYDRATION AND FATIGUE

Dehydration may contribute to fatigue through a combination of increased physiological strain, altered perceptions of effort, reduced capacity for sustained muscular work, and in some circumstances, impaired cognitive performance. These responses can reduce both endurance and physical work capacity and are exacerbated by hot environmental conditions[41].

The effects of dehydration are most apparent during prolonged, repeated or submaximal tasks. A systematic review of 23 studies found consistently reduced fatigue resistance during sustained contractions, repeated efforts and muscular-endurance tasks[38]. Fatigue is also perceptual and cognitive - **mild dehydration of 1.6% of body mass increased self-reported fatigue in healthy men and produced impairments in vigilance and working memory**[39]. At greater levels of dehydration, the effects of fatigue become more apparent. A meta-analysis of 33 studies found that dehydration (>2% body mass) significantly reduced cognitive performance, with attention, executive function and motor coordination the most susceptible[37]. Hot environmental conditions can amplify these effects. A 2018 study found that **dehydration (2% body mass), combined with increased core temperature reduced cognitive, motor and visuomotor tracking tasks**[36]. The same level of dehydration did not significantly impair performance when the increase in core temperature was more moderate, indicating that dehydration and heat strain can act together to accelerate fatigue and degrade complex task performance.

These findings are particularly relevant in occupational settings, where workers may be exposed to heat, sustained physical workloads, protective clothing and inadequate recovery across consecutive shifts. Field evidence shows that increasing occupational heat stress is associated with higher heart rate, core temperature and skin temperatures and lower manual work capacity[40]. Many workers may also begin a shift already dehydrated, increasing the likelihood that fatigue will develop as heat exposure and physical strain accumulate[36]. **Occupational heat and dehydration can therefore reduce work output, compromise work quality, increase time off task and contribute to a greater risk of errors, accidents and heat related illness**[35].

<u>Summary</u>

Overall, the evidence indicates that dehydration is a strong contributor to physical, perceptual and cognitive fatigue. The adverse affects of dehydration are most consequential during prolonged or repeated work, and are exacerbated by increasing dehydration and when combined with environmental heat, insufficient rest or inadequate recovery.

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DEHYDRATION BEYOND HEAT EXPOSURE

Dehydration can develop in cool, cold and high-altitude environments through continued sweating, respiratory water loss, increased urine production and inadequate fluid intake. Its effects depend on the environment, task demands and the mechanism of fluid loss.

Cooler Environments: Cool conditions do not eliminate dehydration risk. During 90-minute soccer sessions at approximately 10°C, 45% of players arrived hypohydrated, almost two-thirds consumed less than 250 mL, and some lost more than 2% of body mass[42]. Reduced thirst and limited drinking opportunities may contribute to increased dehydration, while sweating can remain meaningful during strenuous work or when insulating clothing is worn. **In workers, dehydration in cold environments can still reach 3-8%** of body mass which is attributed to cold-induced diuresis, respiratory water loss and cold-protective clothing (i.e., sweat loss due to overdressing) and minimised fluid intake to minimise urination[47]. Furthermore, a **study of 60 workers demonstrated that a greater proportion of workers had elevated pre-work serum osmolality in winter than in summer**[48]. This demonstrates that inadequate hydration may be prevalent during colder conditions and highlights the need for hydration monitoring throughout the year.

Dehydration in cool environments can also impact exercise performance. For example, **in 20°C, 3% dehydration impaired cycling performance by 8% compared to euhydrated subjects**[43]. Another study in runners also demonstrated a **4% impairment** in running performance in temperature conditions (21°C)[44].

Altitude: At altitude, low humidity and increased ventilation can **increase respiratory water loss**, while early **altitude exposure may cause diuresis (i.e., increased urine output)** and plasma-volume contraction. Reduced thirst and changes in routine or fluid availability may further increase dehydration risk[45].

Altitude and hypohydration may also have additive effects on physical performance. In one study summarized by Castellani et al., performance was reduced by 11% with simulated altitude alone, 17% with 4% hypohydration at sea level and **34% when altitude and hypohydration were combined**[46].

Summary

Dehydration risk extends beyond heat exposure. **Cool environments may reduce thirst** without eliminating sweat loss, while **altitude increases respiratory and urinary fluid losses.** Performance impairment is less consistent in cold conditions, but hydration access and monitoring remain important across all environments.

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EVIDENCE FOR THE USE OF SOSM AS A HYDRATION ASSESSMENT BIOMARKER

Salivary osmolarity (SOSM) is the number of solute particles per litre saliva. In some contexts, salivary osmolality, the number of solute particles per kg of saliva, is reported instead. Given that the relative density of saliva is <1.01[11], these terms may effectively be used interchangeably.

Appendix 1 details the literature investigating the use of SOSM for hydration assessment, where SOSM is benchmarked against plasma osmolarity or changes in nude body mass (BML) or other gold standard measures of dehydration. Broadly speaking, these studies can be summarised as follows:

- Most studies investigating SOSM as a hydration biomarker have been conducted in populations of young and healthy adults, observing changes in SOSM before, during and after active (physical activity-induced) dehydration, or looking at various methods of passive dehydration such as extended heat exposure, fluid restriction, and chemical induced sweating.
- In general, SOSM demonstrates a greater responsiveness to physical activity-induced dehydration than passive dehydration, serving as an effective indicator of fluid loss with regard to nude BML. Where these studies have also integrated urinary measures, SOSM typically has superior or equivalent performance in active dehydration contexts.

Sports and Fitness. Most evidence for SOSM as a hydration biomarker has been collected in a sports science context. Specific studies which investigate SOSM in exercise-related contexts of various intensity and have demonstrated utility for tracking hydration include Walsh (2004)[12], Oliver (2008)[13], Munoz (2013)[14] and Kitson (2021)[15].

Workplace Hydration Monitoring: Several studies have specifically examined SOSM measurements in a context intended to simulate a strenuous work environment. In one study, changes in SOSM during active dehydration were assessed during extended exercise trials while wearing either light clothing or heavy protective equipment[16]. Changes in SOSM were strongly correlated with percentage body mass loss, with a significantly higher SOSM observed when wearing heavy protective equipment. In the same cohort, change in body mass was not highly correlated with change in urinary osmolality. Another study investigating changes in SOSM and urine parameters in firefighters undergoing training in full structural firefighting bunker-style gear and a self-contained breathing apparatus demonstrated a significant increase in SOSM before and after training which significantly correlated with change in body mass, while no changes in urine parameters was observed[17].

The available firefighter and PPE studies provide promising occupationally relevant evidence, however the evidence base remains limited to relatively small samples and specific work or training contexts. Further real-world studies are needed across complete work shifts, diverse worker populations, levels of heat acclimation, industries and environmental conditions.

Clinical Settings: SOSM has been investigated in a clinical context, specifically, assessment of hydration in older adults presenting to the emergency department[18]. In this context, SOSM was reported as the most sensitive and specific method for diagnosing dehydration out of a panel of physical signs, urinary biomarkers, and salivary biomarkers, when benchmarked against plasma measures of hydration status.

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LIMITATIONS OF SOSM HYDRATION ASSESSMENTS AND HOW THESE ARE ADDRESSED BY MX3

Several limitations associated with SOSM have been reported[14,19]. During the development of the MX3 HTS we sought to address these limitations or reduce the impact they have on hydration measures.

There may be significant inter- and intra-individual variation in SOSM values, and characterisation of this variation may require assessment across multiple days.
Due to the cost and complexity of laboratory-based osmometers it has been difficult to generate a measurement dataset for effective characterisation of variation in SOSM. Due to the rapid and accessible nature of the MX3 HTS, it is much more achievable to collect multiple SOSM measurements for this dataset. Using the “Baseline” feature of the MX3 Mobile App (see the MX3 HTS User Manual), an individual’s typical SOSM range in a well hydrated state can be measured by the MX3 HTS and used to personalise hydration categories to allow for more individualised hydration assessment.

Where baselining is not practicable, comparison to the MX3 reference ranges is still useful given the typically large changes in SOSM which are observed during moderate or severe dehydration compared to typical variation in hydrated individuals.

Sample collection can be difficult after strenuous physical activity, where it is difficult to generate a large volume of saliva. Additionally, some individuals may naturally have more viscous saliva independent of hydration status.
Unlike conventional osmometers which require tens or hundreds of microliters of saliva for a SOSM measurement, the MX3 HTS requires less than a single microlitre. This allows for measurement in the context where only a small amount of saliva can be generated. Additionally, MX3’s patented salivary test strip microfluidics is designed to accommodate even highly viscous saliva.

Recent food or drink intake can interfere with measurements.
As water typically has a very low osmolarity, a measurement made immediately after drinking water may result in a very low SOSM. Other food and beverages, such as high salt sports drinks, have a quite high osmolarity (300+) so a measurement made immediately after drinking or eating may result in an artificially increased SOSM.

To avoid this confounding factor, we have a set of measurement instructions (see example protocol below) which serve to minimise the potential impact of food or drink, including the production of fresh saliva for analysis and a recommendation to wait at least 5 minutes between eating/drinking and performing an MX3 measurement.

To help ensure this suggestion is implemented, users can be asked to make a declaration that they did not eat/drink in the last 5 minutes before taking a measurement using the MX3 App. Additionally, abnormal SOSM measures are detected with specialised error detection algorithms and reported to organisation administrators through the MX3 Web Portal to highlight misuse of the MX3 HTS.

The Within-Day, Test-retest Reliability and Minimal Detectable Change of the MX3 Hydration Testing System

Two independent peer-reviewed studies have evaluated the reliability of the MX3 Hydration Testing System using complementary study designs.

Pettersson et al.[33] evaluated 230 first-morning saliva samples collected from 118 Olympic-level elite athletes. Each collected saliva sample was measured three consecutive times using a new hydration test strip for each measurement. Repeated measurements from the same sample demonstrated excellent reliability (ICC = 0.93; 95% CI: 0.91-0.94), with a standard error of measurement of 7.9 mOsm and a minimal detectable change of 18.4 mOsm at the 90% confidence level. The mean difference between repeated measurements was close to zero, with no apparent proportional bias.

Because these measurements were performed repeatedly on the same collected saliva sample, the results primarily represent **device and test-strip repeatability under standardised conditions**, with variability arising from saliva collection and transient changes in the oral environment largely removed. The average coefficient of variation across repeated same-sample measurements was 6.4 ± 6.7%. The authors described these results as an indication of the upper limit of device repeatability under controlled measurement conditions.

Winter et al.[29] evaluated the reliability of two independently collected saliva samples obtained 3-5 minutes apart in 75 adults. This study found moderate-to-good reliability (ICC = 0.75), a standard error of measurement of 9.2 mOsm and a minimal detectable change of 21.3 mOsm at the 90% confidence level. Unlike the same-sample design used by Pettersson et al., this approach incorporated both analytical variability and the normal variability associated with generating and collecting a new saliva sample.

Taken together, these studies indicate that the MX3 Hydration Testing System provides highly repeatable results when the same saliva sample is measured multiple times. Slightly greater variation should be expected when separate saliva samples are collected, because the composition of a small saliva sample may vary according to differences in salivary-gland contribution, salivary flow and transient oral conditions. **In practice, differences smaller than approximately 18-21 mOsm may reflect analytical and sampling variability rather than a definite physiological change.** Serial changes should therefore be interpreted alongside the magnitude and direction of change, the conditions under which samples were collected and other relevant indicators of hydration and heat strain.

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ANALYTICAL PERFORMANCE OF THE MX3 HYDRATION TESTING SYSTEM (HTS)

Two independent studies have benchmarked the MX3 HTS against a conventional laboratory freezing-point depression osmometer on a panel of saliva samples. Both studies reported an excellent correlation between MX3 HTS reported SOSM values and values measured by an osmometer (Study 1[20]: R^2 = 0.95 **Figure 1**, Study 2[21]: R^2 = 0.92).

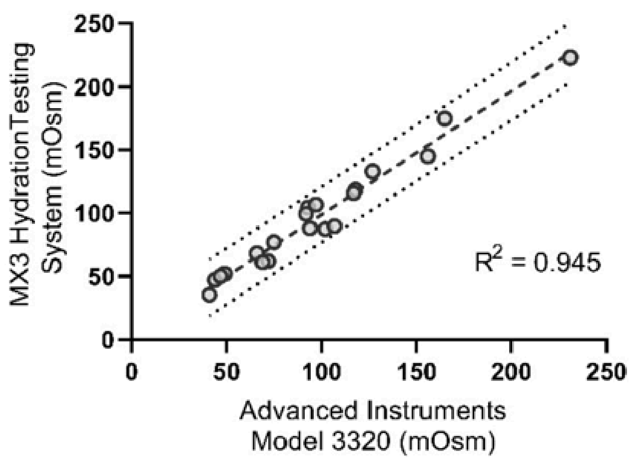

Figure 1: Correlation of SOSM readings for 20 saliva samples measured with the MX3 Hydration Testing System (average of triplicate measurement, each replicate used to calculate correlation coefficient) and an Advanced Instruments Model 3320 laboratory osmometer (single measurement). Dotted lines represent 95% prediction bands.

Serial measurement of saliva sampled directly from the tongue will typically exhibit a larger amount of variation due to the confounding effects of sampling variation. As each MX3 measurement only uses 1 microlitre of saliva, the precise composition of this sample will vary depending on the contribution of various salivary glands. In these contexts, a higher CV of 10±5% is expected, and measurements may vary by up to 25%. Where a more precise measurement is required, a larger sample should be collected in an appropriate sampling receptacle, for example an MX3 sampling tray, and mixed prior to measurement.

Our internal validation demonstrates an excellent correlation between our HTS and a benchtop osmometer (R^2: 0.98; **Figure 2A and Table 1**). Further analysis demonstrates that the mean difference between the HTS and a benchtop osmometer is -0.7% (95% Limits of Agreement: -13.8, 12.5). Replicate readings of collected saliva samples have a typical CV of approximately 4.8 ± 1.2% (**Table 1**).

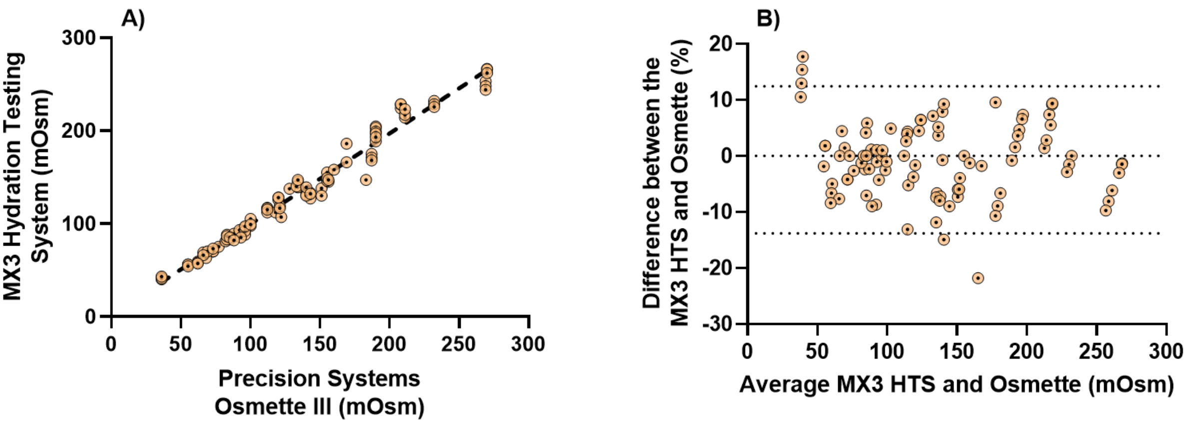

Figure 2. A) Correlation between the MX3 Hydration Testing System and a benchtop Osmometer. B) Bland-Altman plot demonstrating the mean difference between the MX3 Hydration Testing System and a benchtop Osmometer.

Table 1: Precision and Accuracy of Hydration Test Strips

	MX3 Hydration Test Strips
Validation Samples (n)	2164
Correlation with Reference Osmometer (R^2)	0.98
SOSM range	36 - 270
Slope	0.9743
Y-Intercept	2.103
Average CV (Replicate Saliva Readings)	4.8 ± 1.2%

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HYDRATION CLASSIFICATION WITH THE MX3 HTS

The MX3 HTS reports both salivary osmolarity values in milliosmoles (mOsm) and a hydration classification into four categories; Hydrated (<66 mOsm) Mildly Dehydrated (66-100 mOsm), Moderately Dehydrated (101-150 mOsm) and Severely Dehydrated (151+ mOsm).

These categories are intended as practical screening and monitoring ranges rather than universally validated diagnostic thresholds. The evidence supporting SOSM is strongest when serial measurements are used to monitor active dehydration caused by exercise or physically demanding work, particularly where fluid loss occurs through sweating.

These classifications are indications of hydration status derived from literature reports of salivary osmolarity and the observed distribution of SOSM values in the general population. They are intended to assist in the identification of individuals with an abnormal SOSM value for further investigation. Both health conditions and medication may impact SOSM readings (see Section 10 below).

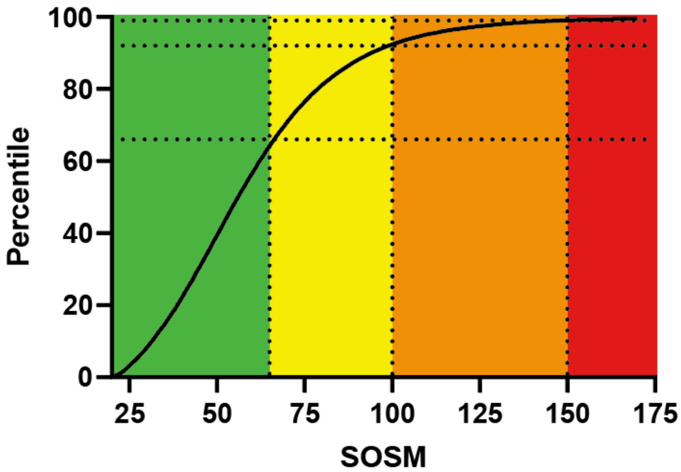

Figure 3. Distribution of over 250,000 SOSM measurements conducted by our customers between Jan 2019 - Dec 2021. Approximately 66% of measurements are below 65 mOsm, 92% of measurements are below 100 mOsm and 99% of measurements are below 150 mOsm during regular use.

Important interpretation note: The MX3 Hydration Categories are practical interpretive bands and have not been validated as diagnostic thresholds across all populations, environments or forms of dehydration. The boundaries do not correspond to a precisely defined percentage of body-mass loss, plasma osmolality value or clinical outcome. Results close to a category boundary should not be considered meaningfully different solely because they fall into adjacent categories.

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IMPACT OF HEALTH CONDITIONS AND MEDICATION ON SOSM VALUES

Like all biomarkers in bodily fluids, SOSM measurements may be impacted by medication or underlying health conditions.

While there are no published reports demonstrating the influence of specific medications and health conditions on the use of SOSM measurements as a hydration indicator, there is a significant body of research reporting the impact of medication and health conditions on the incidence of Xerostomia (dry mouth) as well as Sialorrhea (drooling or excess salivation).

As such, these medications and health conditions may impact salivary flow rate and increase or decrease SOSM readings. In addition, other medications that target changes in fluid balance for therapeutic benefit (e.g., diuretics) may also influence SOSM. Certain medical conditions, including viral infections, diabetes, and other autoimmune disorders, can also increase the incidence of Xerostomia. Various neurological and oral conditions have also been associated with an increase in saliva secretion.

A detailed list of medications and health conditions that can cause Xerostomia or Sialorrhea can be found in Mortazavi et al. 2014[22], Miranda-Rius et al. 2015[23], and Wolff et al., 2016[24].

If MX3 measurements are to be undertaken in individuals with existing health conditions and/or who are on medications that may impact salivary flow (and therefore SOSM), we recommend the following actions to ensure consistent and relevant sampling and measurement data:

- Baseline values are recorded for individuals when they are fully hydrated to generate a personalised SOSM reference range for hydration assessment that will be more relevant to their health/medication status. This can be carried out through a baselining protocol, such as the one outlined in the MX3 HTS manual.
- Prior to measurements ensure the user swallows all existing saliva in their mouth and generates a fresh saliva sample. In the case of excessive dry mouth (Xerostomia), ask the user to consume a small amount of water and wait 5 minutes prior to measurement.
- When medication dose is changed, or additional medications are added to any regimen we recommend re-baselining the SOSM range for the individual to ensure accurate hydration status assessment. This can be done by deleting all baseline measurements within a user's MX3 profile and replacing these with new baseline SOSM values.

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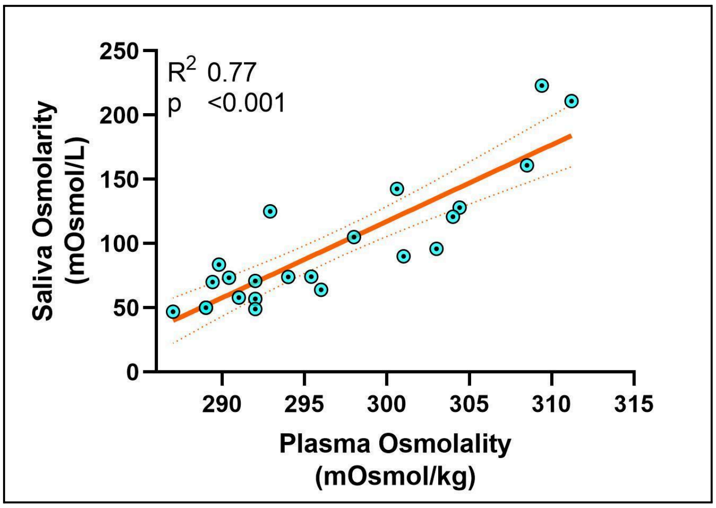
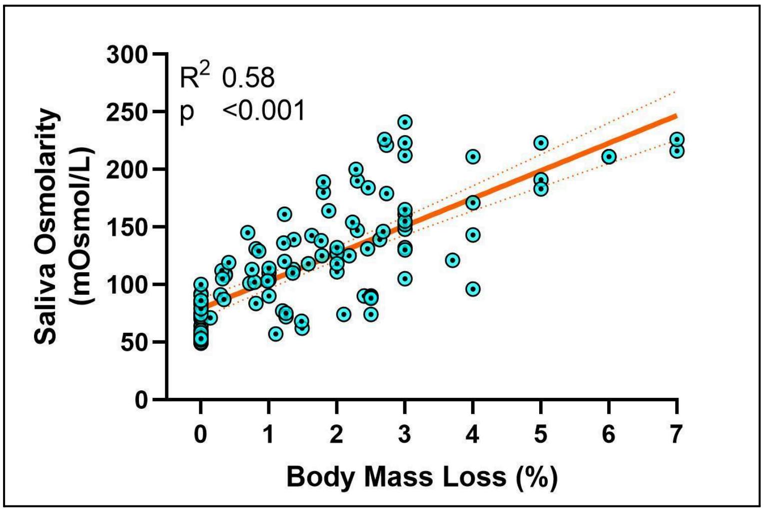
RELATIONSHIP BETWEEN SOSM AND GOLD-STANDARD MARKERS OF HYDRATION STATUS



Plasma/serum osmolality (POSM) is one of the most accepted laboratory markers of extracellular fluid concentration[34]. During exercise-induced dehydration, particularly in the heat, sweat loss reduces body water and can increase extracellular fluid osmolality[34]. In this context, SOSM appears to respond in the same general direction as POSM: as systemic osmolality rises, saliva also becomes more concentrated. In a combined dataset from six studies, the relationship between SOSM and POSM was strong, with $R^2 = 0.77$, meaning that approximately 77% of the variation in SOSM was explained by variation in plasma/serum osmolality across the extracted study timepoints.



Body mass loss is one of the most practical ways to quantify acute exercise-induced dehydration, particularly when fluid loss occurs over a short period of exercise[34]. In a combined analysis with data from 11 studies, SOSM showed a clear positive relationship with BML, with $R^2 = 0.58$. This means that approximately 58% of the variation in SOSM was explained by the degree of body mass loss across the extracted study timepoints.

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COMPARISON OF SOSM AND URINE SPECIFIC GRAVITY MEASUREMENTS

Urine specific gravity (USG) is a widely used, non-invasive measure of urine concentration. However, USG and SOSM reflect different physiological processes and should not be expected to agree in every circumstance. USG primarily reflects the renal response to recent fluid and solute intake, whereas SOSM is influenced by salivary secretion and the concentration of the oral fluid sample. Consequently, disagreement between the measures does not necessarily indicate that one measurement is incorrect.

Several recent studies have cast doubt on the appropriateness of USG spot-checks as an indicator of hydration status due to many confounding factors, including the influence of physical activity, diet and fluid intake on urine production and concentration[25-28]. These studies have all demonstrated that USG spot-checks have a very poor specificity, meaning that upwards of half of hydrated workers could be incorrectly classified as dehydrated when using this method. USG measurements using first morning voids are the only validated urine measurements that can, in the absence of underlying health conditions and medications, be used to indicate hydration status. Urine measurements nevertheless remain useful in several settings. First-morning urine samples collected under standardised conditions can provide information about overnight renal concentration and are commonly used to monitor habitual or pre-activity hydration practices.

Our own internal studies have found good correlation (R^2 = 0.55) between SOSM measurements and first-morning void USG **(Figure 4)**.

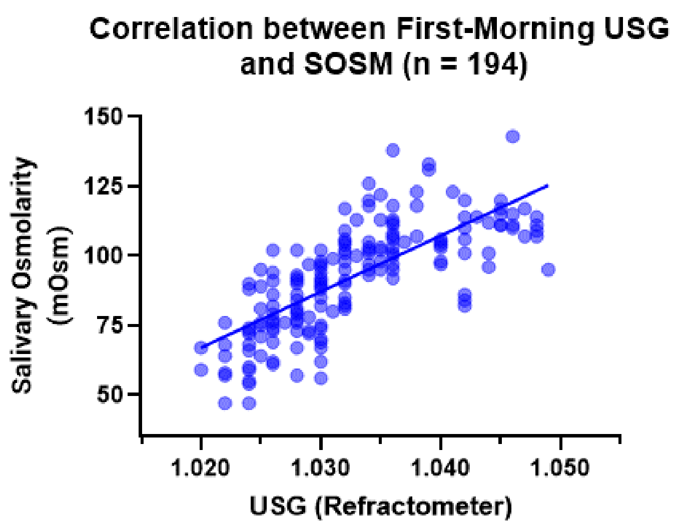

Figure 4: Correlation of first-morning void USG (refractometer) and Salivary Osmolarity in a population of 194 older adults with hypertension (R^2 = 0.55)

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EXAMPLE PROTOCOL FOR THE MEASUREMENT OF SOSM

Before measurement

1. Ensure all individuals operating the MX3 HTS have received training on how to operate the MX3 HTS, sample saliva, identify confounding factors, and interpret SOSM measurement results (see below).
2. Confirm with the individual being measured (the 'user') that they have not ingested any food or fluids for at least 5 minutes.

Performing an MX3 SOSM Measurement

1. Log into the MX3 App and select the user's profile.
    - <u>Do not</u> use one user account to record measurements for multiple users. Each measurement should be linked to a single user.
    - <u>Do not</u> have multiple operators use a single account to make measurements. Each operator should use an independent account. For an organisation this can be achieved through assigning Admin rights to operators from the main parent account.
2. Follow the prompts in the MX3 App, instructing you to turn on the MX3 LAB (where required), sync the MX3 LAB (where required) to transfer local measurements to the App and insert a hydration test strip.
3. Ask the user to swallow all saliva in their mouth, then to generate a fresh saliva sample (as if they were going to spit) and position the sample on their tongue.
4. Ask the user to stick out their tongue. Ensure a good amount of saliva is present on the user's tongue. The tongue should be noticeably wet.
    - If insufficient saliva is present, ask the user to swallow and generate a fresh sample.
    - If the saliva sample is highly bubbly, ask the user to swallow and generate a fresh sample.
    - If food debris is present in the saliva, ask the user to rinse their mouth with water and return for a measurement in 5 minutes.
5. Tap the tip of the test strip against the saliva sample at a downward angle until the MX3 LAB beeps, indicating that enough saliva has been collected.
6. Wait for the sample to be analysed; you will hear a second beep when completed
    - <u>Do not</u> remove the test strip during this period.
7. The result will then be displayed in the MX3 App together with the hydration classification.
8. Eject the hydration test strip into a waste container using the eject button.

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INTERPRETATION OF MX3 MEASUREMENTS

MX3 hydration classifications are not medical advice and are not intended to diagnose, cure, mitigate, treat, or prevent any disease or health condition or to monitor or modify any physiological process. Where a user is experiencing any symptoms of heat strain or dehydration such as prickly heat, fatigue, nausea, or dizziness these individuals should refrain from further physical activity and seek medical attention.

Measurement interpretation will be specific to your environment and should be considered in combination with other heat stress and dehydration indicators.

SOSM results should be interpreted with consideration of normal analytical and saliva-sampling variability. In a study[29] where two independently collected saliva samples were obtained 3–5 minutes apart, the minimal detectable change at the 90% confidence level was 21.3 mOsm. This indicates that differences smaller than approximately 20 mOsm may reflect normal sampling and measurement variability rather than a definite physiological change. A subsequent study[33] found a minimal detectable change of 18.4 mOsm when the same collected saliva sample was measured repeatedly. This represents device and test-strip repeatability under standardised conditions and does not include the additional variability associated with generating a new saliva sample. As such:

- Small changes of less than approximately 20 mOsm should generally be interpreted cautiously and, where practicable, confirmed with a repeat measurement.
- Results close to a hydration-category boundary should not automatically be considered meaningfully different from results immediately above or below that boundary.
- Immediate action should still be taken where the individual has symptoms of heat strain or dehydration, or where environmental conditions, work demands or other risk indicators warrant intervention.

MX3 results should not be used in isolation when recent food, fluid or mouth rinsing, medications, acute illness, heat-illness symptoms, category-boundary values or extracellular fluid loss may affect interpretation. In these situations, repeat testing and supporting information such as symptoms, body-mass change, fluid intake and other hydration assessments should guide decisions.

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MX3 HYDRATION CLASSIFICATIONS

Hydrated

Before Work/Exercise: Your score indicates you are in a well-hydrated state and regularly consuming enough fluid to prepare for work or exercise.

After Work/Exercise: Your score indicates you have stayed well-hydrated during work or exercise and are consuming enough fluid to offset losses and maintain performance.

Mildly Dehydrated

Before Work/Exercise: Your score suggests you are slightly dehydrated. Increase your regular fluid intake to better prepare for work or exercise. For most people, we would recommend consuming approximately 500 mL of water prior to starting work or exercise.

After Work/Exercise: Your score indicates you are slightly dehydrated. This is a normal score after work or exercise. Eating and drinking as normal over the next few hours should allow you to fully recover. If possible, re-test after at least 1 h to re-assess your hydration status.

Moderately Dehydrated

Before Work/Exercise: Your score indicates you are quite dehydrated. We recommend consuming approximately 800 mL of a low sodium concentration beverage (300-500 mg/L) over 1 h, prior to starting work or exercise. If possible, re-test your hydration after 1 h to re-assess your hydration status.

After Work/Exercise: Your score indicates you are quite dehydrated. We recommend you actively consider consuming a mid-sodium concentration containing beverage (400-600 mg/L) at a rate of 800 mL/h*^ for at least 1 h and then rehydrate consistently for the next few hours with water. In future, increase your fluid intake during work or exercise. In the future, monitor your hydration post-exercise on an ongoing basis to ensure the corrective measures you implement are working.

Severely Dehydrated

Before Work/Exercise: Your score indicates you are severely dehydrated. This result suggests you may not have fully recovered from prior dehydration or have not consumed adequate fluids recently. If possible, refrain from work or exercise until you have had a chance to rehydrate. We recommend that you immediately consider consumption of a high-sodium concentration beverage (600-800 mg/L) at approximately 800 mL/h^ and then rehydrate consistently for the next few hours. You should serially re-assess your hydration status and your ability to work or exercise, ideally with the input of your supervisor/trainer.

After Work/Exercise: Your score indicates you are significantly dehydrated. We recommend you actively consider consuming a very high sodium electrolyte beverage (800-1000 mg/L) at a rate of approximately 800 mL/h*^ for at least 1 h to assist in your recovery and then rehydrate consistently over the next few hours with water. In future, increase your fluid intake during work or exercise. It is advisable to avoid further work or exercise for the immediate future and to discuss ongoing and future hydration strategies with your trainer or supervisor. You should serially re-assess your hydration status and your ability to work or exercise, ideally with the input of your supervisor/trainer.

*The recommended volume is a general guide. Individual fluid requirements may vary according to body mass, recent fluid intake, the degree of dehydration, environmental conditions and any medical conditions or medications that impact fluid balance. Where relevant, fluid intake should be adjusted under the guidance of an appropriately qualified healthcare professional.

^This volume is recommended as scientific studies indicate that absorption rates of fluid can be maintained at approximately 700-1000 mL/h, depending on beverage composition and level of dehydration.

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PUBLISHED RESEARCH USING THE MX3 HTS

The MX3 Hydration Testing System has been used to quantify hydration status in several peer-reviewed articles spanning sports and performance and occupational health and safety and medicine. Examples are shown below. Please reach out to MX3 for additional information.

Sport and Exercise

A 2025 study examined **40 highly trained, male youth footballers** across four 90-minute matches played in warm to hot conditions (24-33°C WBGT). SOSM was measured pre- and post-match to assess hydration status[30]. Pre-match SOSM averaged **65.4 ± 20.1 mOsmol**, increasing to **102.6 ± 42.0 mOsmol post-match**, demonstrating a clear shift toward dehydration during match play. Based on the predefined hydration categories, **52% of players were NOT optimally hydrated before kick-off**, and this increased to **80% post-match**, with 16 players classified as moderately and 14 as severely dehydrated after matches.

Occupational Health and Safety

In a longitudinal study of 23 recruit firefighters completing a 12-week Fire School + 1 week transition, SOSM was measured at the start (AM) and end (PM) of each workday with opportunity to intervene according to results obtained[31]. There was a significant effect of week on both AM and PM SOSM ($p < 0.001$), with **values progressively decreasing over time**. The lowest osmolarity values occurred in weeks 12 and 13, indicating improved hydration status. Recruits were on average **mildly dehydrated during weeks 1-8, but shifted into the hydrated range during weeks 9-13, despite increasing physical and thermal demands**.

Medicine

A prospective diagnostic accuracy study investigated whether point-of-care (POC) SOSM could detect dehydration in **148 hypertensive adults aged ≥60 years,** stratified by diuretic use. First-morning urine specific gravity (USG, refractometer) was used as the reference measure. Diuretic users had significantly higher USG and SOSM values than non-users, with 86% classified as dehydrated at a USG threshold of 1.030 (vs 55% in non-users). S**OSM strongly correlated with USG ($r = 0.78$, $p < .0001$).** ROC analysis showed good diagnostic performance: at a USG ≥1.030 classifier, an SOSM threshold of 93 mOsm yielded 78.6% sensitivity and 91.1% specificity (AUC = 0.90)[32]. The authors concluded that POC SOSM is a rapid, non-invasive tool that **aligns well with best-practice urinary measures** and may be **suitable for routine hydration screening in older at-risk populations.**

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APPENDIX 1: PEER-REVIEWED STUDIES INVESTIGATION SOSM AND HYDRATION STATUS

This table contains a chronological list of peer-reviewed studies that investigate Salivary Osmolarity and Hydration Status. To be included on this list SOSM must be directly compared with either plasma osmolarity or changes in body mass. Where urine measurements were also performed this has been noted.

Study	Population	Summary
Walsh, 2004	15 volunteers All Male, Age = 23 ± 3	**Link:** https://journals.lww.com/acsm-msse/Fulltext/2004/09000/Saliva_Parameters_as_Potential_Indices_of.12.aspx **Study:** SOSM and UOSM were benchmarked against changes in body mass and POSM during active dehydration with and without fluid replacement **Outcome:** • During exercise with fluid restriction SOSM increased from 50 ± 11 mOsm to 105 ± 41 mOsm at 3% BML. • No change in SOSM was observed during the fluid replacement trial. • SOSM strongly correlated with plasma osmolarity (r = 0.87)

		• SOSM remained unchanged immediately or 15 minutes after consuming a beverage (data not published) **Urine Comparison:** in this study UOSM was also shown to increase during fluid restriction, but several participants were unable to provide a urine sample at 2.1 and 3% BML. UOSM was significantly lower during the fluid intake trial when compared to pre-exercise. UOSM strongly correlated with plasma osmolarity (r = 0.83)
Oliver, 2008	13 volunteers All Male Age = 21 ± 1	**Link:** https://www.sciencedirect.com/science/article/abs/pii/S0003996908001453?via%3Dihub **Study:** Investigation of the responsiveness of SOSM measures to normal fluid intake (CON), fluid restriction (RF) across 48 hours and fluid and energy restriction (RF+RE) across 48 hours as well as during an active dehydration and rehydration trial. **Outcome:** • At 48 h body mass loss exceeded 3% on RF and RF + RE. • SOSM increased during 48 h on RF (54 ± 3 to 73 ± 5 mOsm) and RF + RE (52 ± 3 to 68 ± 5 mOSM) and was significantly greater than CON at 48 h (52 ± 2 mOsm). • SOSM identified the additional dehydration associated with exercise and returned to within 0 h values with rehydration. • Given the large amount of variation between individuals, the authors recommended that a euhydrated reading is determined for saliva markers for each individual. **Urine Comparison:** Urine osmolarity used to verify hydration status at the start of each protocol but was not tracked during the various protocols.
Cheuvront, 2010	18 Soldiers 13M, 5F Age = 24 ± 4	**Link**: https://academic.oup.com/ajcn/article/92/3/565/4597438 **Study:** Comparison of plasma, urine, and saliva biomarkers for static (euhydrated) and dynamic (active dehydration benchmarked against body mass loss) hydration assessment **Outcome:** • Plasma osmolarity was the only body fluid that was considered to have appropriate inter- and intra-individual variation to provide a correct diagnosis of dehydration from a static individual value. SOSM displayed an approximate 10% within-subject CV.

		● SOSM displayed an 80% sensitivity and 83% specificity for identifying dynamic dehydration with a threshold value of 83 mOsm. SOSM values increased from 88±32 mOsm in the hydrated group to 147 ± 88 mOsm after dehydration. ● SOSM measurements conducted 1 minute after a water mouth rinse dropped to 81 ± 25 mOSM even though volunteers were still dehydrated – highlighting the need for food/drink restriction prior to measurement. **Urine Comparison:** In this study urinary markers were also considered to be inappropriate for static (euhydrated) assessment due to large amounts of inter- and intra-individual variation. USG outperformed SOSM with a sensitivity of 89% and a specificity of 91% using a threshold value of 1.025 units.
Ely, 2011	8 healthy volunteers 6M, 2F Age = 22 ± 7	**Link:** https://journals.lww.com/acsm-msse/Fulltext/2011/06000/Limitations_of_Salivary_Osmolality_as_a_Marker_of.21.aspx **Study:** POSM, SOSM and USG were benchmarked against changes in body mass during active dehydration following a 3-day euhydration protocol. **Outcome:** ● SOSM displayed a within-subject CV of 6.6% ● SOSM increased from 58 ± 8 mOsm to 96 ± 28mOsm after active dehydration. ● SOSM had a correlation of r = -0.71 with change in body mass, while POSM had a correlation of r = -0.87 ● Saliva osmolarity decreased after an oral rinse but returned to pre-rinse values after 15 minutes and remained similar at 30 minutes. **Urine Comparison:** In this study USG was shown to increase from 1.018 during euhydration to 1.028 after active dehydration. The correlation between USG and changes in body mass was not reported.
Smith, 2011	8 Healthy volunteers All Male Age = 24 ± 5	**Link:** https://www.tandfonline.com/doi/abs/10.3109/10903127.2011.614044 **Study:** POSM, SOSM and UOSM compared with BML during two exercise trials, one wearing shorts and t-shirt (EX), the other wearing firefighting personal protective equipment (EX+PPE) **Outcome:**

		• POSM did not significantly increase during either trial, despite a 0.81 ± 0.3% BML during EX and 2.18 ± 0.54% BML during EX+PPE. • SOSM increased significantly in both trials, 73.4 ± 12.4 to 125.1 ± 30.3 mOsm (EX+PPE) and 70.1 ± 12.5 to 83.6 ± 17.7 mOsm (EX); with the increase in the EX+PPE trial significantly greater than the increase in the EX trial. • Changes in salivary osmolality were strongly correlated with percent BML (r = 0.80) **Urine Comparison:** Urine osmolality increased significantly from pre to postexercise time points in both trials, but there was no significant difference between trials.
Horn, 2012	35 firefighters 31M/4F Age = 35 ± 10	**Link:** https://www.tandfonline.com/doi/abs/10.3109/10903127.2012.664243?journalCode=ipec20 **Study:** SOSM, BML and Urine measures measured before and after 3 hours of firefighter training exercise. Participants wore full structural firefighting bunker-style gear and a self-contained breathing apparatus (SCBA) during all firefighting activities **Outcome:** • Participants lost an average of 1.1 ± 0.8 kg (1.4%) of body mass ($p < 0.001$). During the firefighting activity, 63% lost more than 1% of their body mass, 26% lost more than 2% of their body mass, 9% lost more than 3% of their body mass. • There was a significant increase in SOSM after firefighting exercises ($p<0.001$). • There was a significant correlation of r = 0.56 (p = 0.001) between changes in body mass and the salivary osmolality measures. This correlation improved to r = 0.62 (p = 0.002) when considering only participants who showed a change in body mass of greater than or equal to 1%, while there was no correlation for firefighters who experienced less than 1% change in body mass (r = 0.05). **Urine Comparison:** No significant changes in urinary measurements were detected between pre- and post-firefighting values
Taylor, 2012	12 volunteers All Male Age not reported	**Link:** https://link.springer.com/article/10.1007%2Fs00421-011-2299-z **Study:** SOSM and BML tracked during three exercise and heat induced dehydration trials (7%, 3% and 7% dehydration). **Outcome:**

		- SOSM increased linearly during dehydration, though baseline and rate of change varied among and within subjects between trials, with an average correlation for each individual of r = 0.81, r = 0.5 and r = 0.70 for trials 1, 2 and 3 respectively. - Looking across all data, SOSM was a sensitive and specific discriminator of >3% or >6% binary dehydration classification (sensitivity and specificity ~ 80%). - Given the inter-individual variability the authors highlight the need for a pre-exposure baseline SOSM measures when attempting to perform more fine-grain hydration assessments. **Urine Comparison:** USG was used to verify hydration status at the start of each protocol but was not tracked during the various protocols.
Munoz, 2013	23 volunteers All Male Age = 22 ± 3	**Link:** https://www.nature.com/articles/ejcn2013195 **Study:** Measurement of body mass change, SOSM, UOSM, USG during 5 hours of passive heat exposure (PAS) and active exercise (ACT) in the heat. **Outcome:** - While an average BML of 1.4± 0.3% was observed during PAS, neither SOSM or POSM was significantly elevated - During ACT SOSM most effectively diagnosed dehydration ⩾2% (sensitivity=86%; specificity=91%), followed by POSM (sensitivity=83%; specificity=83%). ~35mOSM increases in SOSM were observed per percentage BML during active dehydration. SOSM increased from 64 ± 9 before active dehydration to 90 ± 24 at 1% BML. **Urine Comparison:** In this study USG was shown to be an effective indication of mild dehydration during passive heat exposure, with a significant increase at 1% BML. USG was also an effective hydration indicator during active dehydration, performing slightly worse than SOSM with a sensitivity of 81% and a specificity of 81%.
Perrier 2013	52 adults 11M, 41F Age = 25 ± 3	**Link:** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3714557/ **Study:** Measurement of urine (accumulated AM/PM collection), SOSM (every 1-2 hours) and POSM (AM/PM) across an inpatient cross-over trial. Condition 1: fluid restriction across 2 days, Condition 2: Euhydration. **Outcome:**

		• No difference was observed in SOSM between water intake conditions. No difference in POSM was observed as well. • SOSM varied throughout the day, but at no point averaged over 95 mOsm or below 75 mOsm. Drops of ~10 mOsm were observed ~ 30 minutes after each meal. Urine Comparison: Urinary hydration biomarkers were responsive to changes in water intake, but the extended collection method makes it unclear how representative spot-check measurements would be in this context.
Pross 2013	20 healthy adults All Female Aged = 25 ± 1	**Link:** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3553795/ **Study:** Measurement of USG, POSM and SOSM during 24 hours of fluid restriction vs fully hydrated control condition • No change in POSM was observed during fluid restriction. • A small but significant SOSM increase was observed after 24 hours fluid restriction (57.3 vs 68.6 mOsm) Urine Comparison: USG was significantly elevated at all timepoints during fluid restriction,
Ely, 2014	24 healthy volunteers 17M, 7F Age = 23 ± 4	**Link**: https://link.springer.com/article/10.1007%2Fs00421-013-2747-z **Study**: Paired euhydration and dehydration trials. Dehydration achieved using furosemide (diuretic) administration and 12 hour fluid restriction (extracellular dehydration) **Outcome:** • SOSM changes were marginal (<10 mmol/kg) and weakly correlated with changes in absolute or relative plasma volume losses • Strong agreement was observed between SOSM collection methods (Expectoration: 61 ± 10 mOsm, Salivette: 61 ± 8 mOsm. Urine Comparison • Extracellular dehydration was also not detectable using USG.
Fortes, 2015	130 Older Adults	**Link**: https://www.jamda.com/article/S1525-8610(14)00614-8/fulltext

	59M, 71F Age = 79±9	**Study:** Comparison of physical signs, urinary biomarkers, and salivary biomarkers against plasma osmolarity and BUN/Creatinine ratio when presenting to a hospital emergency department. **Outcome:** ● SOSM demonstrated superior diagnostic accuracy when compared with physical signs and urine markers and was able to detect both water-loss and water-and-solute loss dehydration. ● Water-loss dehydration: 70% sensitivity, 68% specificity, OR = 5.0 ● water-and-solute-loss dehydration: 78% sensitivity, 72% specificity, OR = 8.9 **Urine Comparison:** In this study neither USG nor urine colour were able to discriminate between dehydration and euhydration
Stookey, 2017	5 healthy adults All Male Age = 20-25	**Link:** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5704074/ **Study:** Investigation of various hydration indices associated with an increase in total water intake across 6 weeks in individuals with chronic dehydration. **Outcome:** ● Body weight increased significantly by a mean ± SEM of 1.8% ± 0.5% from baseline over 4 weeks of increased fluid intake and SOSM decreased significantly ● Baseline saliva osmolality significantly modified responses to chronic water intake ● Saliva osmolality decreased significantly between Week 1 and Week 6 by an average ± SEM of 4 ± 1 mmol/kg per week ● Only the saliva osmolality classification predicted significantly modified responses to sustained higher water intake over subsequent weeks. **Urine Comparison:** Urine sodium, potassium, and osmolality decreased significantly by an average ± SEM of 11 ± 4 mmol/L, 8 ± 2 mmol/L, and 85 ± 15 mmol/kg per week, respectively. “The results of this study suggest that saliva osmolality may be a more sensitive and specific indicator of change in chronic total body water than serum or urine osmolality. At baseline, only the saliva osmolality classification varied between participants.”

Dulson, 2019	12 endurance athletes All Male Age = 29± 3	**Link:** https://onlinelibrary.wiley.com/doi/full/10.1002/tsm2.73 **Study:** Investigating the impact of caffeine ingestion on various salivary biomarkers during exercise **Outcome:** ● Participants lost ~2.5% of their body mass in fluid loss over the course of a 70 minute intense run. ● Over the course of the run SOSM increased from ~55mOsm to ~75 mOsm mid-exercise and ~85mOSm post-exercise. One-hour post-exercise where participants consumed water to rehydrate, SOSM had reduced to ~55mOsm. (exact values for whole cohort were not reported). ● Salivary osmolarity was significantly higher mid- and post-exercise compared to pre-exercise and post-recovery ($P<0.0001$) and significantly higher post-exercise than mid-exercise ($P<0.01$) **Urine Comparison:** Urine samples were not analysed in this study.
Harris, 2019	17 participants 9M, 8F Age = 20-25	**Link:** https://jissn.biomedcentral.com/articles/10.1186/s12970-019-0282-y **Study:** Investigating the effect of various beverages on the recovery from 3% BML caused by active dehydration **Outcome:** ● SOSM significantly increased ($p < 0.0001$) with loss of body mass during the dehydrating exercise protocol. ● Baseline SOSM was not affected by sex in the stimulated (females 94.39 ± 14.90 vs males 113.00 ± 63.84), or the unstimulated (females 94.06 ± 26.62 vs males 95.51 ± 33.27) saliva samples, ● Peak SOSM was not significantly impacted by either study group designation or sex in the stimulated (females 180.29 ± 60.37 vs males 256.96 ± 104.57), or the unstimulated (females 235.04 ± 105.99 vs males 297.14 ± 102.39) saliva samples. ● At the completion of 3% body mass loss, all participants achieved a significant ($p < 0.0001$) increase in averaged SOSM over baseline values **Urine comparison:** Urine was not collected in this study
Owen, 2019	15 healthy volunteers All Male Age = 23 ± 5	**Link:** https://journals.humankinetics.com/view/journals/ijsnem/29/6/article-p604.xml **Study:** comparison of physical signs and symptoms, urinary, salivary and tear biomarker for identifying mild intracellular (fluid restriction) and extracellular dehydration (chemical induced). **Outcome:**

		• SOSM significantly increased during intracellular dehydration (56 ± 12 mOsm to 64 ± 13 mOsm) but did not increase during extracellular dehydration • Urine colour, urine specific gravity, plasma osmolality, saliva flow rate, saliva osmolality, heart rate variability and dry mouth identified mild fluid restriction induced dehydration (ROC-AUC; range 0.70-0.99) **Urine Comparison:** USG and UOSM were superior predictors of intracellular dehydration due to fluid restriction, with a ROC AUC of 0.99 (SOSM = 0.7)
Kitson, 2021	27 healthy volunteers M = 13, F = 14 Age = 25 ± 8	**Link:** https://www.mdpi.com/2072-6643/13/10/3313 **Study:** Study investigating the perception of various rehydration beverages when exercising in the heat. SOSM, USG and BML measured at various timepoints during exercise. **Outcome:** • Body mass significantly decreased by 1.36 ± 0.39% following 60 minutes of exercise, considered by the authors to be "sub-clinical" dehydration (<2%) • SOSM gradually and consistently increased over the course of the trial from a median of 85 to a median of 113 after 60 minutes. A significant difference was observed between the 0- and 60-minute timepoints **Urine Comparison:** USG and UOSM were measured at 0- and 60-minute timepoints. A significant change in USG was observed across the exercise trial (1.014 to 1.017) but there was no significant change in UOSM
Francisco, 2024	38 athletes M = 21, F = 17 Age = 18 - 39	**Link:** https://doi.org/10.1016/j.clnu.2024.08.003 **Study:** This study aimed to analyse the performance and determine the value of serial measurements of salivary (SOSM), urinary (UOSM, USG, UCol) and serum biomarkers for assessing progressive dehydration. **Outcome:** • SOSM increased significantly during exercise-induced dehydration (Pre: 74 ± 23, Post: 143 ± 57) • At 2% BML, SOSM achieved 83% sensitivity and 83% specificity. **Urine Comparison:** UOSM did not increase significantly ($p = 0.100$) whereas USG ($p = 0.003$) and UCol ($p < 0.001$) did. At 2% BML, urine indices were not able to accurately detect dehydration.

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