

Measuring Sodium and Potassium Concentrations in Athlete's Sweat

Sweat testing carried out by regional patch sweat collection, syringe sweat extraction, and LAQUAtwin analysis is the simplest and most practical method to assess electrolyte losses of athletes in the field for electrolyte replacement recommendations. During exercise or training, athlete's sweat is collected with absorbent patches applied on skin sites and subsequently extracted with a syringe for rapid determination of sodium (Na⁺) and potassium (K⁺) concentrations with LAQUAtwin Na-11 and K-11 pocket meters, respectively. Baker et al. (2014) compared the results of this field method with those obtained from laboratory-based centrifuge-HPLC and found that they were significantly correlated.



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LAQUAtwin Na-11 Product Page



LAQUAtwin K-11 Product Page

Introduction

Sweating allows the body to regulate its temperature. It causes a decrease in temperature through evaporative cooling at the skin surface. When individuals are in hot weather or their muscles heat up due to physical activity, more sweat is produced in order to cool down. Sweat is mostly water with small amounts of electrolytes, which include sodium (Na⁺), potassium (K⁺), calcium (Ca²⁺), and magnesium (Mg²⁺). As sweating increases, electrolyte composition in the body decreases. The concentrations of electrolyte loss can vary among individuals.

Measuring the electrolyte losses from athletes' sweat could assist health professionals in planning personalized water and electrolyte replacement strategies. This would prevent water/electrolyte imbalances and heat-related whole-body muscle cramps in sports that could impair athletes' performance. While Na⁺ loss is primarily measured since it is the electrolyte lost in the greatest quantities and has the most significant impact on body fluid balance, K⁺ loss measurement can also provide valuable information. Both sweat sodium concentration [Na⁺] and potassium concentration [K⁺] are needed to predict changes in serum [Na⁺] from mass balance equations. Furthermore, sweat [K⁺] can serve as quality control check of sweat sample. A sweat sample with very high [K⁺] can indicate quality issues such as sample evaporation, contamination, or leaching of electrolytes

from skin that would not have been detected from measuring sweat [Na⁺] alone.

To perform sweat testing in the field, sweat can be easily sampled with absorbent patches placed on clean skin of anatomical sites after the athlete established steady-state sweating during exercise or training. The sweat sample is then extracted from each absorbent patch with syringe for immediate analysis with LAQUAtwin Na-11 and K-11 pocket meters.

The LAQUAtwin Na-11 and K-11 waterproof pocket meters measure sodium concentration [Na⁺] and potassium concentration [K⁺], respectively, in microvolume samples and display results in just a few seconds. The sensors are replaceable and each has sample well embedded with flat ion selective electrode paired with a reference electrode. With this unique design, the sensors are capable of measuring samples as little as 0.3ml with direct application or 0.05ml with sampling sheet. The reading in the backlit digital LCD can be expressed as ppm, mg/L, or mmol/L unit.

Method

Meter set-up and calibration

Calibrate the LAQUAtwin Na-11 and K-11 pocket meters according to manufacturer's instructions using

their respective 150 and 2000ppm standard solutions.

Sample collection and measurement

Sweat tests with athletes should be conducted during exercise or training and in conditions representative of their sport.

1. After the onset of exercise or training (~10 mins), clean the following athlete's anatomical skin sites with alcohol wipe or deionized / distilled water rinse and dry with sterile gauze or towel: right anterior mid thigh, right posterior mid forearm, left posterior mid forearm, upper chest, right scapula, left scapula, and forehead.
2. Attach one sterile patch at each site.
3. Remove each patch with sterile tweezers after absorbing sufficient sample but before complete saturation.
4. Place each patch inside the barrel of a 5-ml syringe. Depress the plunger to compress the patch and expel sweat directly onto the sensors of pocket meters or vial for later analysis.
5. Record the stable readings.

Continued at the back

To obtain accurate results, a uniform temperature should be maintained for the standard solutions and samples. If sweat sample volume is not enough to cover the flat sensor, a sampling sheet can be used to disperse the sample on the sensor surface. After measurement, rinse the sensor, tweezers, and syringe with distilled or deionized water and blot dry with soft tissue. For more information on maintenance, refer to **Technical Tip 2: LAQUAtwin Ion Sensor Maintenance Procedures.**

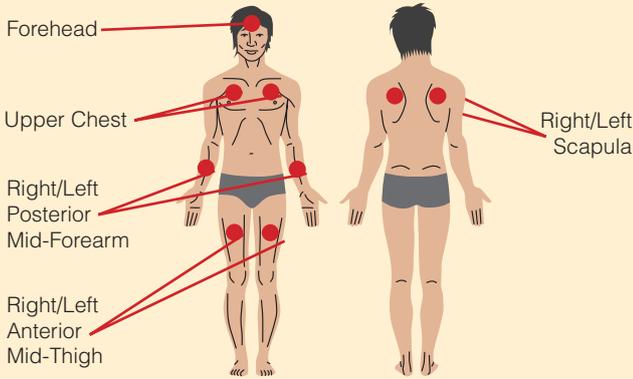


Table 1: Validity of field technique using syringe extraction of sweat and LAQUAtwin analysis: SYRINGE LAQUAtwin vs. CENTRIFUGE HPLC for sweat [Na⁺] and [K⁺].

	Sweat [Na ⁺]	Sweat [K ⁺]
Mean Difference ± SD (mEq/L)	3.97 ± 10.87*	0.50 ± 0.48*
95% CI of mean difference (mEq/L)	2.49-5.45	0.42-0.59
ICC	0.93*	0.84*
SEE (mEq/L)	8.68	0.44
TEM (mEq/L)	7.68	0.34
CV (%)	12.54	8.48

n = 210 for sweat [Na⁺] and 116 for sweat [K⁺]. CV, coefficient of variation; CI, confidence interval; HPLC, ion chromatography using the Dionex ICS-3000; HORIBA, HORIBA B-722 for sweat [Na⁺] and HORIBA B-731 for sweat [K⁺]; ICC, interclass correlation coefficient (based on two-way mixed ANOVA, absolute agreement, average measures); SD, standard deviation; SEE, standard error of the estimate; TEM, typical error of measurement; *P < 0.001.

Source: Baker et al. (2014). Validity and reliability of a field technique for sweat Na⁺ and K⁺ analysis during exercise in a hot-humid environment.

Results And Benefits

To maintain water and electrolyte balance during prolonged exercise or training, it is recommended to drink water and/or sports drink to replace the water and Na⁺ loss from profuse sweating. Thus, having a rapid, low-cost method and user-friendly, portable instrument to measure athlete's sweat in the field could assist health professionals in tracking changes in sweat [Na⁺] and planning water and electrolyte replacement strategies.

Baker et al. (2014) conducted a study comparing a field versus reference laboratory method for extracting (syringe vs. centrifuge) and analysing sweat [Na⁺] and [K⁺] (LAQUAtwin vs. HPLC) collected with regional absorbent patches during exercise in a hot-humid environment. They found that the sweat [Na⁺] and [K⁺] obtained with the syringe-LAQUAtwin field method were significantly correlated to those of centrifuge-HPLC laboratory method (See Table 1 for the results). The LAQUAtwin Na-11 and K-11 pocket meters (superseded the B-722 and B-731 models used in the study) have been proven practical and useful tools in delivering rapid, cost-effective, and highly reliable measurements of athletes' sweat [Na⁺] and [K⁺], respectively, in field studies.

Sweat [Na⁺] determined from anatomical sites can be used to predict whole-body sweat [Na⁺] with regression equations. Sweat [Na⁺] can vary considerably among individuals and typically ranges from approximately 10 to 90 mmol/L. Unlike [Na⁺], sweat [K⁺] is considerably lower and less variable despite changes in sweating rate. For this reason, sweat [K⁺] can serve as quality control check in sweat electrolyte testing. If the sweat [K⁺] is > 10 mmol/L, the potential issues are sample evaporation, contamination, or leaching of electrolytes from skin. Sweat samples that do not fall within these normal ranges: [Na⁺] = 10 – 90 mmol/L, [K⁺] = 2 – 10 mmol/L should be flagged. Initial sweat may have high concentrations due to minerals trapped in sweat pore. To avoid this, clean skin surface and collect sample after 10 minutes of training or exercise or when steady-state sweating is achieved.

To convert ppm or mg/L reading to mEq/L or mmol/L, divide the reading by the molar mass of the ion (Na⁺ = 22.989, K⁺ = 39.098). Alternatively, refer to **Technical Tip 7: Procedure for Setting mmol/L Unit in LAQUAtwin Ion Pocket Meters** to set the meter to display the reading in mmol/L unit. Calibration in mmol/L unit can also be performed on the LAQUAtwin ion pocket meters.

References And Suggested Readings

1. Perspiration. Wikipedia <https://en.wikipedia.org/wiki/Perspiration>
2. Baker, L., Ungaro, C., Barnes, K., Nuccio, R., Reimel, A., & Stofan, R. (2014). Validity and reliability of a field technique for sweat Na⁺ and K⁺ analysis during exercise in a hot-humid environment. *Physiological Reports*. Volume 2, Issue 5.
3. Baker, L. (2017). Sweating Rate and Sweat Sodium Concentration in Athletes: A Review of Methodology and Intra/Interindividual Variability. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5371639/> on 29 August 2017.

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LAQUAtwin Pocket Meters Lineup



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