

Study Design and Methodological Details

- **Study Type:** Validation study for the potassium sensor in simulated marching conditions.
- **Power Calculation:** Based on the observed large effect size ($f = 0.6$) of caffeine on physiological performance (e.g., strength). The power analysis was performed using G*Power, indicating that a sample size of 20 participants is sufficient to detect a large effect with a power of 0.8 and $\alpha = 0.05$.
- **Design:** Randomised crossover design to reduce participant variability and improve power efficiency compared to between-groups design.
- **Independent Variable:** Caffeine treatment.
- **Dependent Variables:** All physiological and cognitive measurements in the protocol.
- **Data Normality:** Assessed using Shapiro-Wilks tests. Post-hoc adjustments will be performed using Sidak's correction as needed.
- **Sensor Validation Method:** Bland-Altman analysis to compare potassium levels from the sensor with ELISA-derived blood data (gold standard).

Statistical Analysis Plan

Research Objective 1: Validation of Potassium Measurement

- **Measure:** Potassium in sweat and serum, glucose/lactate from fingertip blood.
- **Data Analysis:**
 - **Potassium in Sweat vs. Serum:** Bland-Altman comparison to evaluate the agreement between potassium levels measured by the sensor and the gold standard (serum).
 - **Glucose/Lactate Analysis:** Two-way mixed ANOVA with independent variables being caffeine/placebo (2 levels) and time (7 levels).

Research Objective 2: Effects of Caffeine on Cognitive and Physiological Performance

- **Measures:** Reaction time and accuracy (Flanker Inhibitory Control), skin conductance, perceived exertion (Borg RPE), gas exchange (VO_2 , VCO_2 , RER, VE, VE/VCO_2), and heart rate.
- **Data Analysis:**
 - **Cognitive Performance:**
 - **Reaction Time and Accuracy:** T-tests comparing caffeine vs. placebo conditions.
 - **Electrodermal Activity (Skin Conductance):** T-tests comparing caffeine vs. placebo.

- **Perceived Exertion:** Two-way mixed ANOVA with independent variables being caffeine/placebo (2 levels) and time (7 levels).
- **Gas Exchange and Heart Rate:** Two-way mixed ANOVA with independent variables being caffeine/placebo (2 levels) and time (3 levels representing the stages of the march).

Research Objective 3: Combined Analysis of Potassium in Sweat and Heart Rate

- **Measures:** Potassium in sweat and heart rate.
- **Data Analysis:**
 - **Two-way MANCOVA:** Independent variables are treatment (caffeine/placebo) and marching protocol/physiological stress (3 levels). Dependent variables include potassium in sweat and heart rate. This analysis will assess if the combined dependent variables differ significantly with changes in the independent variables.
 - **RAG Rating:** The combined MANCOVA results will be used to generate the RAG (Red-Amber-Green) rating for performance.