

SWEAT RATE AND SWEAT-ELECTROLYTE COMPOSITION IN ATHLETES EXPERIENCING RECURRENT MUSCLE CRAMPS VERSUS MATCHED CONTROLS

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BACKGROUND AND PURPOSE

- Exercise-associated muscle cramps are intense, painful contractions of skeletal muscles that occur during or immediately following physical exertion
- There are 2 prevailing theories to explain the etiology of exercise-associated muscle cramps²
 - 1) Overuse, or neuromuscular fatigue²
 - 2) Dehydration and/or abnormal electrolyte concentrations²
- Depletion of electrolytes sodium (Na⁺) and chloride (Cl⁻) are associated with muscle cramps¹
- Muscle cramps and electrolyte depletion can be managed through proper fluid replacement⁴
- The purpose of this study was to compare sweat rate (SR) and sweat electrolyte concentrations between cramp-prone (CP) to matched-control (MC) athletes

PARTICIPANT CHARACTERISTICS

- Twenty-four (12 CP; 12 MC) competitive and recreational male athletes participated
 - High school football (n=14), college football (n=6), cross-country (n=2), cycling (n=2)
- CP defined as athletes who had experienced recurrent cramps over the previous 12 months
- Available MC athletes matched as closely as possible to CP athletes
 - Age, body mass, % body fat, gender, sport, position, and heat-acclimatization status

| | CP | | MC | |
|----------------|------|------|------|------|
| Age (years) | 21 | 8 | 21 | 8 |
| % Body Fat | 13.5 | 3.5 | 13.9 | 3.6 |
| Body Mass (kg) | 94.7 | 20.5 | 96.8 | 19.7 |

Table 1. Participant Characteristics



Figure 1. Sweat patch

METHODS

- Testing performed in climate-controlled location or at assigned practice facility
 - Pre-exercise body mass assessed using a standard scale (Tanita Arlington Heights, IL)
 - Right proximal forearm cleaned using 70% isopropyl alcohol and allowed to dry
 - Sterile gauze pad placed on forearm and covered with transparent dressing (Figure 1)
 - Subjects then exercised for a minimum of 45 minutes (sport-specific activities)
 - Exercise regimen identical for each matched pair of athletes for a given session
 - Post-exercise body mass measured
- $SR = (\text{pre-exercise body mass} - \text{post-exercise mass} + \text{fluid consumed}) / \text{exercise duration}$
- Following exercise, gauze removed and centrifuged to extract sweat
- Sweat-electrolyte concentrations (mEq·L⁻¹) determined using ion-specific electrode analysis
 - EasyLyte Plus Na/K/Cl Analyzer (Medica Corporation, Bedford, MA)
- Data analyzed by independent t-tests ($\alpha = .05$), receiver operating characteristic (ROC) analysis, Fisher's exact test, sensitivity (Sn), specificity (Sp), and odds ratio (OR)

RESULTS

- One CP and one MC removed due to MC outlier sweat [Na⁺] (>2 SD above group mean)
- Independent t-test results:
 - No significant difference between groups for SR ($p=.398$) or sweat [K⁺] ($p=.142$)
 - CP significantly greater than MC in terms of sweat [Na⁺] ($p=.025$) and sweat [Cl⁻] ($p=.040$)
- Dichotomized univariable analysis results:
 - Group membership (CP vs. MC) associated with SR, sweat [Na⁺], and sweat [Cl⁻]
 - CP approximately 8 X more likely than MC to have $SR \geq 1.23 \text{ L}\cdot\text{h}^{-1}$
 - CP 15 X more likely than MC to have a sweat [Na⁺] $\geq 29.38 \text{ mEq}\cdot\text{L}^{-1}$
 - CP 15 X more likely than MC to have a sweat [Cl⁻] $\geq 24.13 \text{ mEq}\cdot\text{L}^{-1}$

| Group | SR (L·h ⁻¹) | Na ⁺ (mEq·L ⁻¹) | Cl ⁻ (mEq·L ⁻¹) | K ⁺ (mEq·L ⁻¹) |
|-------|-------------------------|--|--|---------------------------------------|
| CP | 2.13 0.99 | 48.03 27.69 | 38.65 25.03 | 5.74 0.84 |
| MC | 1.82 0.80 | 26.09 15.28 | 20.48 14.32 | 6.49 1.40 |

Table 2. Means and Standard Deviations

| Variable | Cut-point | Sn | Sp | OR | OR 90% CI |
|--|-----------|-------|-------|-------|--------------|
| SR (L·h ⁻¹) | 1.23 | 90.7% | 41.7% | 7.86 | 1.10 – 56.32 |
| Na ⁺ (mEq·L ⁻¹) | 29.38 | 75.0% | 83.3% | 15.00 | 2.79 – 80.57 |
| Cl ⁻ (mEq·L ⁻¹) | 24.13 | 75.0% | 83.3% | 15.00 | 2.79 – 80.57 |

Table 3. Results of Univariable Analyses

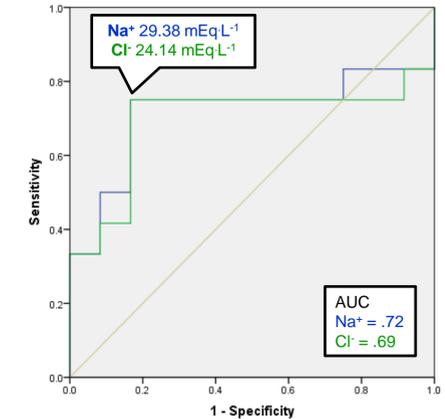


Figure 2. ROC Curve

CONCLUSIONS

- The results suggest that increased sweat [Na⁺] and sweat [Cl⁻] predispose athletes to cramps
- Sweat-electrolyte concentration strongly discriminates CP athletes from MC athletes
- SR appears to have less predictive power for identification of recurrent muscle crampers
- NaCl supplementation may attenuate recurrent exercise-associated muscle cramps

REFERENCES

1. Schweltnus MP, Derman EW, Noakes TD. Aetiology of skeletal muscle "cramps" during exercise: a novel hypothesis. *J Sports Sci.* 1997;15:277-285.
2. Bergeron MF. Muscle cramps during exercise – Is it fatigue or electrolyte deficit? *Curr Sports Med Rep.* 2008;7:50-55.
3. Eichner RE. Heat cramps in sports. *Sports Med Pearls Pitfalls.* 2008;7:178-179.
4. Stofan JR, Zachwieja JJ, Horswill CA. Sweat and sodium losses in NCAA football players: a precursor to heat cramps? *Int J Sport Nutr Exerc Metab.* 2005;15:641-652.