Changes in Urine Parameters After Desert Exposure: Assessment of Stone Risk in United States Marines Transiently Exposed to a Desert Environment

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Purpose: Living in a desert environment has been associated with a higher incidence of kidney stone formation, likely because of concentrated urine output, higher production of vitamin D and genetic predisposition. We determined the changes in urinary parameters after a group of United States Marines temporarily transitioned from a temperate environment to a desert environment.

Materials and Methods: A total of 50 Marines completed a questionnaire and performed 3, 24-hour urine collections before mobilization to the desert, after 30 days in the desert and 2 weeks after returning from the desert.

Results: Daily urine output decreased 68% to 0.52 L despite marked increased fluid intake (17 L per day). Total daily urinary excretion of calcium, uric acid, sodium, magnesium and potassium in the desert decreased by 70%, 41%, 53%, 22% and 36%, respectively. Urinary pH decreased from 6.1 to 5.6 while in the desert, and citrate and oxalate had minimal changes. After their return from the desert, apart from a decrease of 22% in oxalate, there were no statistically significant differences from baseline. While in the desert, relative supersaturation risks of uric acid and sodium urate were increased 153% and 56%, respectively. Brushite relative supersaturation decreased 24%. After their return there was no statistical difference from baseline.

Conclusions: Our findings suggest that the kidneys preserved water and electrolytes while the Marines were subjected to the desert environment. Despite this conservation, relative saturations indicate increased risk of stones in healthy men exposed to a desert environment with rapid resolution upon return.

Key Words: urolithiasis, desert climate, military personnel

Abbreviations and Acronyms

MRE = meals ready to eat

RS = relative supersaturation

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Populations residing in a desert environment have long been suspected to have a propensity for the formation of urinary stones. It was as early as 1902 when Mr. F. R. S. Milton, an English surgeon stationed in Cairo, Egypt noted a yearly average of 150 stone admissions to the Kasr-el-Ainy Hospital.[1] The lifetime risk of urolithiasis is 10% to 15% in the developed world but can be as high as 20% to 25% in the Middle East.[2] More recently this increased incidence of stone disease was seen in military personnel translocated to a desert environment as described by Evans and Costabile in 2003 regarding Kuwait and Iraq.[3] One presumed cause of this increased stone propensity is diaphoresis and increased urinary concentration.

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This has also been shown to be the case in manual laborers exposed to extreme conditions, such as steel workers.[2]

Sunlight exposure has been studied as a cause of hypercalciuria. Several epidemiological studies involving lifeguards in Israel and English troops deploying to Bahrain have demonstrated this connection. The mechanism is likely due to increased sunlight related vitamin D production leading to solar absorptive hypercalciuria.[4,5]

Genetic causes have been implicated, as demonstrated by Arab populations having a higher prevalence of CA II genetic mutations and Southeast Asian populations having a higher incidence of AE1 genetic mutations. These mutations are both associated with renal tubular acidosis type 1, which is a known risk factor for stone formation.[6]

In this study we assessed the effects of acute environmental change on urinary parameters associated with the stone formation. We studied a group of United States Marines mobilized from a temperate environment to a desert environment for a monthlong period of intense training. To our knowledge, a study of this nature has not been conducted. We hypothesized that this environmental transition would cause an increase in lithogenic factors in a 24-hour urine profile.

MATERIALS AND METHODS

After obtaining institutional review board approval, 50 United States Marines were recruited as volunteers from an Infantry Battalion of 1,000 men. The battalion, stationed in San Diego, was due to conduct a 1-month exercise in the Mojave Desert during the month of July. From a 98-man company 50 were enrolled. Exclusions were based solely on funding and the consent process, and not on past medical history. A baseline 24-hour urine collection called Baseline was performed immediately before deployment, and a second urine collection called Desert was performed after the Marines were in the desert between 3 and 4 weeks. A third collection called Return was performed 2 weeks after the completion of the exercise. The 24-hour urine collection measured volume, pH, and excreted calcium, oxalate, uric acid, citrate, sodium, creatinine, phosphorus, magnesium and potassium. We used UroRisk® kits for all collection analysis. The relative supersaturation risks for sodium urate, brushite and calcium oxalate were also measured. Before the exercise the Marines lived in air-conditioned barracks near the coastline in a temperate climate. During the deployment they were required to abstain from coffee, alcohol and weight lifting supplements. Hydration was encouraged but no set volume was given. The Marines were issued MREs 3 times per day with a daily 20 oz electrolyte beverage (table 1). They also had ready access to water which was not fortified with minerals or electrolytes.

The Marines simulated a combat environment and often wore full battle dress, which consists of body armor, helmets, full-length sleeves and pants, and combat boots. They were encouraged to cover exposed skin with sunblock.

Table 1. *Oral intake*

	Av Amount (range)
Water	17 (12–21) L
Energy	2,645 kcal
Protein	64 gm
Carbohydrate	381 gm
Fat	1.5 gm
Vitamin D[4]	3.5 mcg
Calcium	700 mg
Phosphorus	490 mg
Sodium	3,785–5,185 mg
Potassium	2,240 mg

The Marines consumed a large quantity of water and a balanced diet slightly heavy with sodium while in the desert. These amounts do not reflect salt packets included in MREs.

Information was collected on each volunteer's personal medical history, diet and fluid intake in the desert, as well as family medical history of stones. Weather information for the desert and southern California was recorded as well.[7]

Statistical analysis was performed using QuickCalcs (GraphPad®). Simple statistics were used to calculate patient demographics, and 2-tailed paired t tests were used to compare individual test results, calculate p values and determine 95% CIs with $\alpha = 0.05$. Statistical significance was set at $p \leq 0.05$.

RESULTS

A total of 50 male United States infantry Marines were recruited into the study and completed the initial baseline 24-hour urine collection. Median age was 19 years (range 19 to 25) and median weight was 77.3 kg (range 63.6 to 101.4). Of the subjects 92% (46 of 50) completed the second 24-hour urine collection. Two subjects were medically evacuated for nonheat related injuries and 2 did not provide a sample. The third urine collection was submitted by 72% (36 of 50) of the Marines. The remainder did not provide a sample because they had immediately deployed overseas after returning from the desert. The study questionnaires were completed by 68% (34 of 50) with the remainder not returning the questionnaire before deployment. A family history of kidney stones in a first-degree relative was identified by 6% (2 of 34). No subjects were taking medications. One Marine had a diagnosis of hypertension, and 1 had a history of heat exhaustion as well as a family history of kidney stones.

The average high temperature before deploying to the desert was 78F with 77% humidity. In the desert the average high was 106F with 29% humidity. After returning to base the average high was 73F with 78% humidity.[7] The Marines reported wearing