OPEN ACCESS

ISSN: 2835-9496

Kotchetkov, M (2025): 860
Ameri J Clin Med Re, 2025; 5(3): 100197
DOI: 10.71010/AJCMR.2025-e197

Research Article

American Journal of Clinical and Medical Research

PRIME Time to Lyte up Exercising

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Abstract

Background: Electrolyte replacement is commonly used by athletes. There are multiple commercially available electrolyte drinks. However, it is not known whether the consumption of electrolyte drinks before exercises actually replaces electrolytes or causes their excretion through urine. We assessed whether the consumption of electrolyte drinks before regular exercise and or intensive sweating replaces electrolytes, or they are excreted via urine.

Methods: Electrolyte concentrations in drinks and urine were measured by multimeter and home-made conductance sensors. Urinalysis was performed using 10-parameters commercial urine test strips. Experiments were conducted with water (control) and Prime at baseline and hourly after up to 4 hours in 3 different settings: “no exercise”, “exercise only” and “exercise and sauna”. Urine samples were collected before and at different time points after consumption of 500mL water or Prime.

Results: Among electrolyte drinks, PRIME had the highest electrolytes content. Thus, it was selected for further experiments. In all settings, the consumption of water caused a decrease in urine electrolytes, specific gravity and pH. Those changes were most prominent after exercise and sauna. PRIME lessened the drop-in urine electrolytes, specific gravity and maintained urine pH after exercise and sauna. In the "no exercise" setting, PRIME caused an increase in urine electrolytes due to excess excretion. With exercise and sauna water did not prevent a decrease in urine electrolytes, despite the significant drop in specific gravity. Urine pH became acidic. PRIME, however, maintained the urine electrolytes concentration and pH and prevented urine acidification.

Conclusion: PRIME consumption before exercise/sauna replaces the body’s electrolytes, prevents urine acidification, and does not negatively affect urinalysis.

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Citation: Kotchetkov M, Kotchetkov D, Krishnan M (2025) PRIME Time to Lyte up Exercising. Ameri J Clin Med Re: AJCMR-197.

Received Date: 23 February, 2025; **Accepted Date:** 03 March, 2025; **Published Date:** 07 March, 2025

Keywords: electrolyte, urine, perspiration, exercise, water, PRIME.

Introduction

The human body contains a variety of electrolytes, including sodium, potassium, magnesium, calcium, copper, zinc, iron, chloride, bicarbonate, phosphate, manganese, and chromium. Six electrolytes are most important for body functioning: sodium, potassium, chloride, bicarbonate, calcium, and phosphate. They are essential to maintain proper nerve excitability, endocrine secretion, membrane permeability, buffering body fluids, and controlling the movement of fluids between compartments [1]. Sodium, the principal cation of extracellular fluid, is the primary regulator of extracellular fluid volume. These ions enter the body through the gastrointestinal tract with food and drinks. Excretion of electrolytes occurs mainly via the kidneys, with lesser amounts through the skin with perspirations and GI tract with feces. The body may be depleted of electrolytes, in particular sodium, with heavy or persistent sweating, trauma, diarrhea, or renal disease [2,3].

Restoration and maintenance of fluids and electrolyte balance after exercise-induced dehydration is necessary to promote effective recovery and avoid detrimental effects on subsequent exercise sessions [4]. Ingestion of plain water is not effective at maintaining fluid balance during recovery, as this results in large reductions in plasma sodium concentration and osmolality [5], which lead to diuresis. It is well-accepted that electrolyte replenishment is of importance both during and following exercise, to aid in rehydration for subsequent exercise bouts [4,6].

Practicing to drink regularly during training was suggested to prevent dehydration and electrolyte loss possibly due to increased intestinal absorption capacity [7]. However, it is not known whether the consumption of electrolyte drinks before initiation of exercises actually replaces electrolytes or cause their excretion with the urine.

We assessed electrolyte contents in marketed electrolyte drinks (Bio Steel, Gatorade, Powerade, Prime), and beverages (fruit juices, chocolate milk, soy milk, almond milk, coconut water). Then we compared PRIME, one of the common electrolyte drinks, with drinking water on electrolyte urine excretion to assess whether the consumption of PRIME before exercise helps to maintain electrolyte balance after regular exercise, or intensive sweating, or if electrolytes are rather excreted via urine.

Methods

This study was a low-risk project involving human participation. Ethics approval was in full compliance with Policy 4.1.1 Participation of Humans in Research - Low Risk, Youth Science Canada. The study was performed using healthy volunteers, who provided written informed consent before participation. We assessed commercially available common electrolyte drinks: Bio Steel, Gatorade, Powerade, Prime and common beverages: Almond milk (Kirkland, Silk, Earth), Coconut water (Vita), Soy chocolate (Silk), Chocolate milk, Mango juice, Guava juice, and

Pineapple juice. Total electrolyte contents and individual components were calculated using information on food labels.

Electrolyte concentrations were measured by using the Klein 325 MM multimeter and home-made conductance sensors (two 12 cm copper wires, one 5 cm piece of straw). This method measures the conductivity of the liquids, which is directly proportional to the electrolyte content as shown previously [8]. All measurements were performed in standard conditions, with 3 seconds exposure time, 100 mL of urine samples, same distance between sensor electrodes. Three measurements were conducted, mean value selected.

Measurement of pH of drinks and beverages was performed by using pH test strips as described previously [9]. Urinalysis was performed using 10-parameters commercial urine test strips, which contain specific indicators reagents and buffers for the determination of pH, specific gravity, leukocytes, nitrites, protein, glucose, ketones, urobilinogen, bilirubin, blood. The strip will change color according to the substances present in the urine and will be read at the time indicated by comparing it with the color chart provided by the manufacturer. Midstream urine samples were collected in a clean dry container. Test strips were dipped in urine samples for 3 seconds, then incubated for 30 seconds before readings.

Experiments were carried out with water (control) and PRIME at baseline and hourly after up to 4 hours. They were sorted into 3 different settings: 1) no exercise, 2) standard aerobic exercise only for 90 minutes, 3) same exercise (90 minutes) and sauna (2 rounds for 10 minutes at 90°C with 10 min break) to produce intense sweating. Initially measurements in setting A were performed hourly for a 5-hour total duration; after that, timeframes for settings B and C were set for 4 hours as no significant differences were observed after 4 hours. All participants consumed water or PRIME 15 minutes before starting exercising.

Urine samples were collected before and after 500mL of either water or Prime were consumed at different time points. Results were analyzed by Prisma Plot software and presented as mean ± standard deviation. Significance was assessed by p-value (<0.05)

Results

First, the total electrolyte content and individual components in commercially available sport drinks (per 500 mL) and common beverages were calculated as mg in 500 mL. Total electrolyte contents were the lowest in fruit juices (range: 220-330mg), followed by marketed electrolyte drinks (range: 302-705 mg). Surprisingly, the highest electrolyte content drinks were almond and soy milk, both regular or chocolate, chocolate milk, and coconut water (range: 1012-1621 mg). Next, pH of the same drinks and beverages were measured. The pH of all drinks tested were in acidic range. Fruit juices had the lowest pH (around 4), chocolate milk, soy milk, almond beverages had the highest pH (between 5 and 7), marketed electrolyte drinks had pH between: 4 and 5. Electrolyte contents and pH values for marketed electrolyte drinks beverages are summarized in Table 1. Electrolyte contents were the same in different PRIME flavors, based on product labels. After testing multiple electrolyte drinks (PRIME, Gatorade, Powerade), PRIME was found to have the highest electrolyte content. In addition, the readings were also consistent. (Figure 1). Therefore, for further experiments PRIME was selected.

Table 1: Electrolyte contents (mg) and pH in marketed electrolyte drinks and commercial beverages (500mL each).

Drinks	Sodium	Potassium	Calcium	Iron	Magnesium	Zinc	Total	pH
Electrolyte Drinks								
Bio Steel	230	225	50	0.1	25	0	530.1	5
Prime (Ice Pop)	5	700	0	0.4	0	0	705.4	4
Powerade Orange	338	106	7	0	3	0	454	4
Gatorade Fit Tropical Mango	230	75	0	0.1	0	0	305.1	5
Gatorade Cool Blue	232	70	0	0	0	0	302	5
Milk, Soy, Almond Beverages								
Almond milk (Kirkland)	200	450	600	0	30	2	1282	7
Almond milk (Silk)	360	60	600	0.8	0	2	1022.8	7
Almond milk (Earth)	300	80	600	0.8	30	2	1012.8	7
Coconut Water (Vita)	76	985	76	0	38	0	1175	5
Soy Chocolate (Silk)	170	800	600	6	0	2	1578	7
Chocolate milk	320	800	500	1.5	0	0	1621.5	6
Fruit juices								
Mango (Del Monte)	30	150	40	0.6	0	0	220.6	4
Guava (Del Monte)	40	250	40	0.6	0	0	330.6	4
Pineapple (Del Monte)	30	200	60	1	0	0	291	4

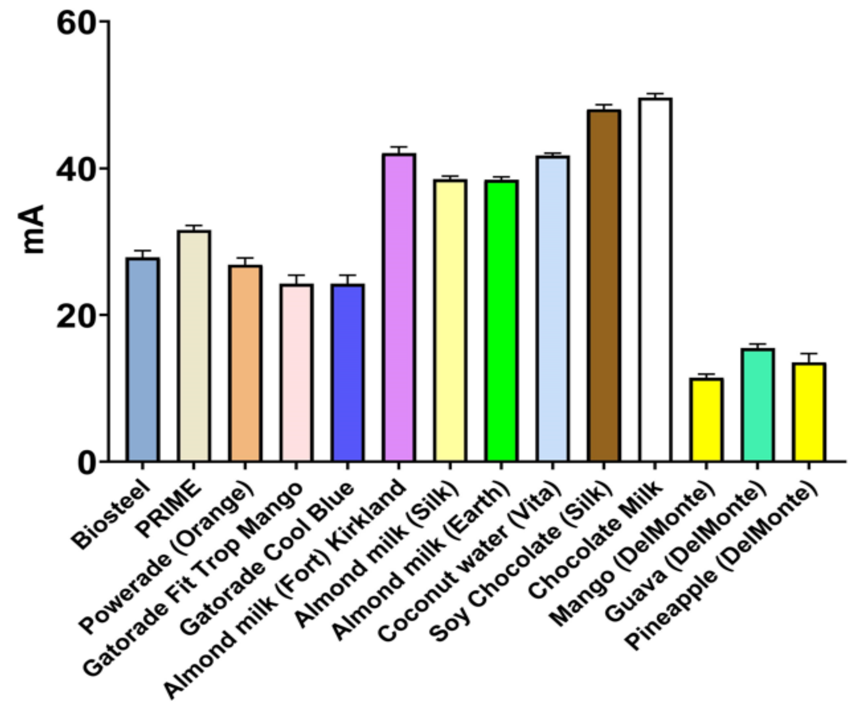

Figure 1: Measurement of conductivity (electrolyte content) in marketed electrolyte drinks and commercially available beverages.

Then experiments were carried out with water and PRIME. In the no exercise setting (Figure 2, Panel A) consumption of water caused a decrease in urine electrolytes, specific gravity (SG) and in a lesser degree pH. PRIME consumption (Panel B) caused a statistically significant increase in urine electrolytes at 1, 2, 3 and 4h time points ($p < 0.05$) in parallel with an increase in SG at 2, 3, and 4h points ($p < 0.05$) and pH at 3h and 4 h points only, ($p < 0.05$), likely due to excess excretion.

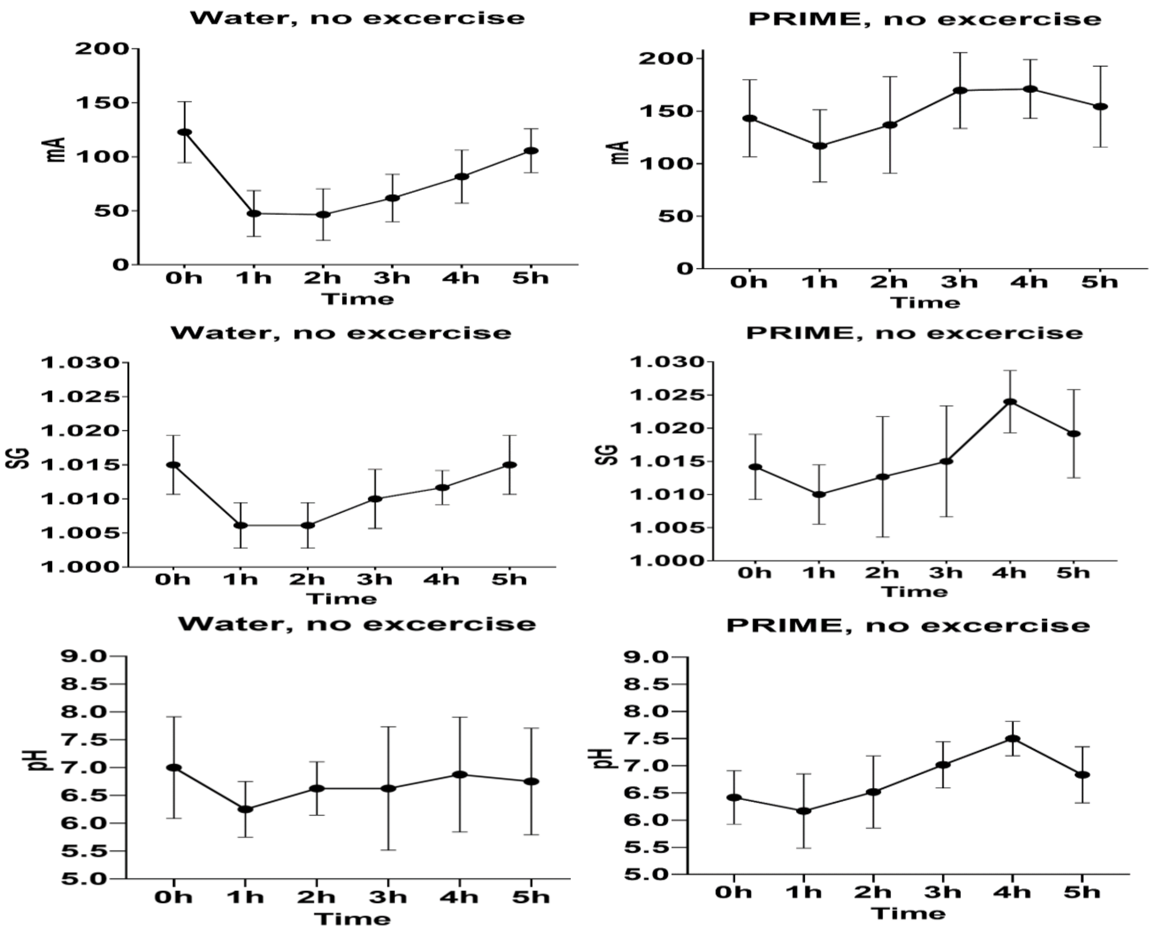

Figure 2: Setting 1 (no exercise). Consumption of water (left panel) decreased urine electrolytes and SG significantly, returning to the baseline by 4 hours. pH was mildly affected. PRIME (right panel) was mainly excreted by urine, however it caused urine alkalization (pH increase).

Similar patterns were seen with water consumption during exercise only as shown in Figure 3 Panel A. PRIME lessened the drop in urine electrolytes at 1, 2, and 3h time points ($p < 0.05$), SG at 1, 2, and 3h time points ($p < 0.05$) and maintained urine pH, mostly at 2, 3, and 4h time points ($p < 0.05$).

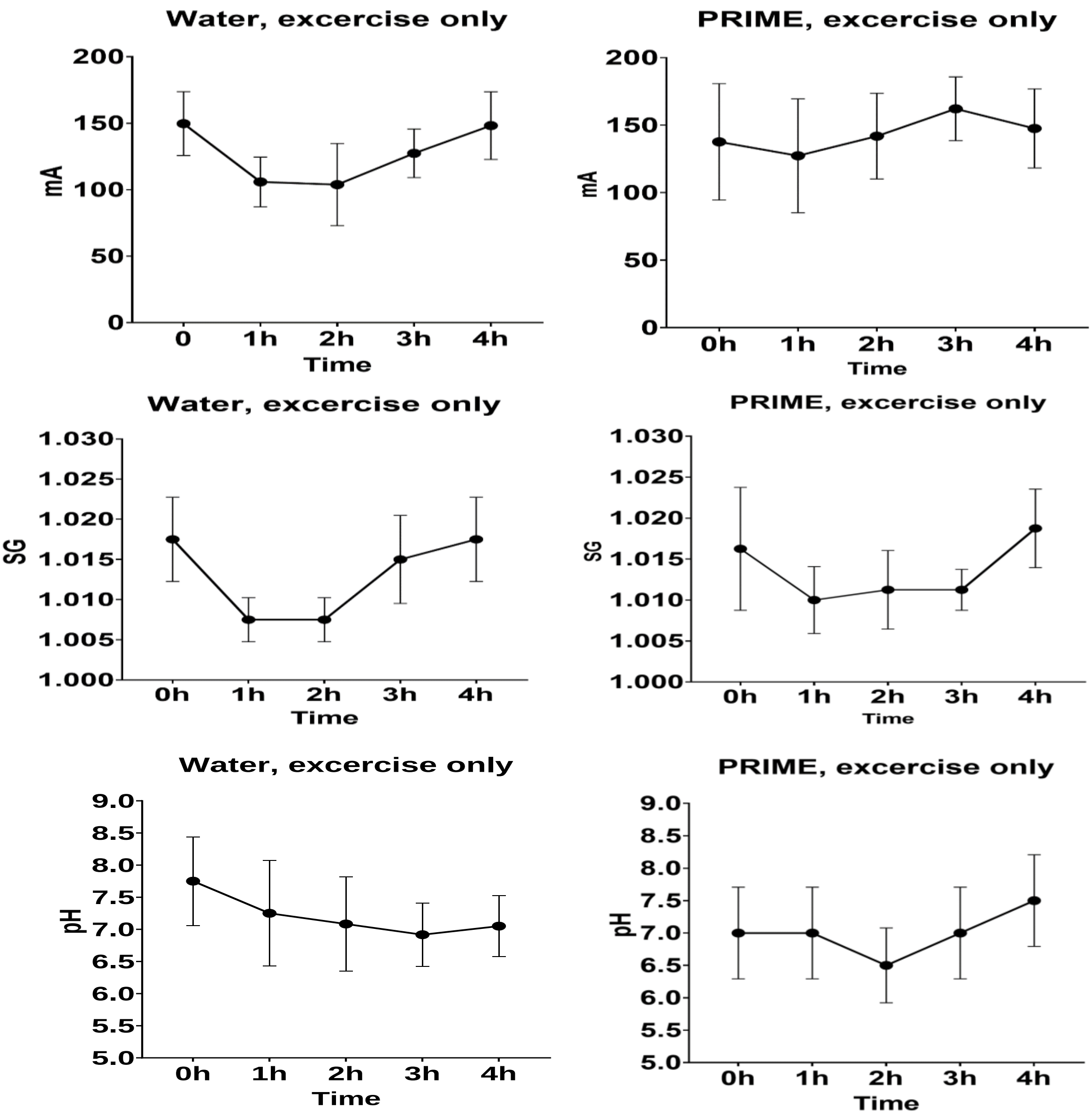

Figure 3: Setting 2 (exercise only). Water consumption (left panel) was associated with lesser drop in urine electrolytes, SG and urine acidification. PRIME (right panel) resulted in decreased urine electrolyte concentration and SG and prevented urine acidification.

Those changes were most prominent in setting 3 (after exercise and sauna), as shown in Figure 4. Water consumption (Panel A) caused a decrease in urine electrolytes; however, the slope was less steep compared to no exercise and exercise only. PRIME consumption (Panel B) resulted in flattening in urine electrolyte curve, statistically different from seen in Panel A at all time points ($p < 0.05$) in parallel with SG ($p < 0.05$ for 1, 2, 3, h time points). Compared to water, PRIME also maintained urine pH; the difference however was statistically significant at 3 and 4 hours' time points.

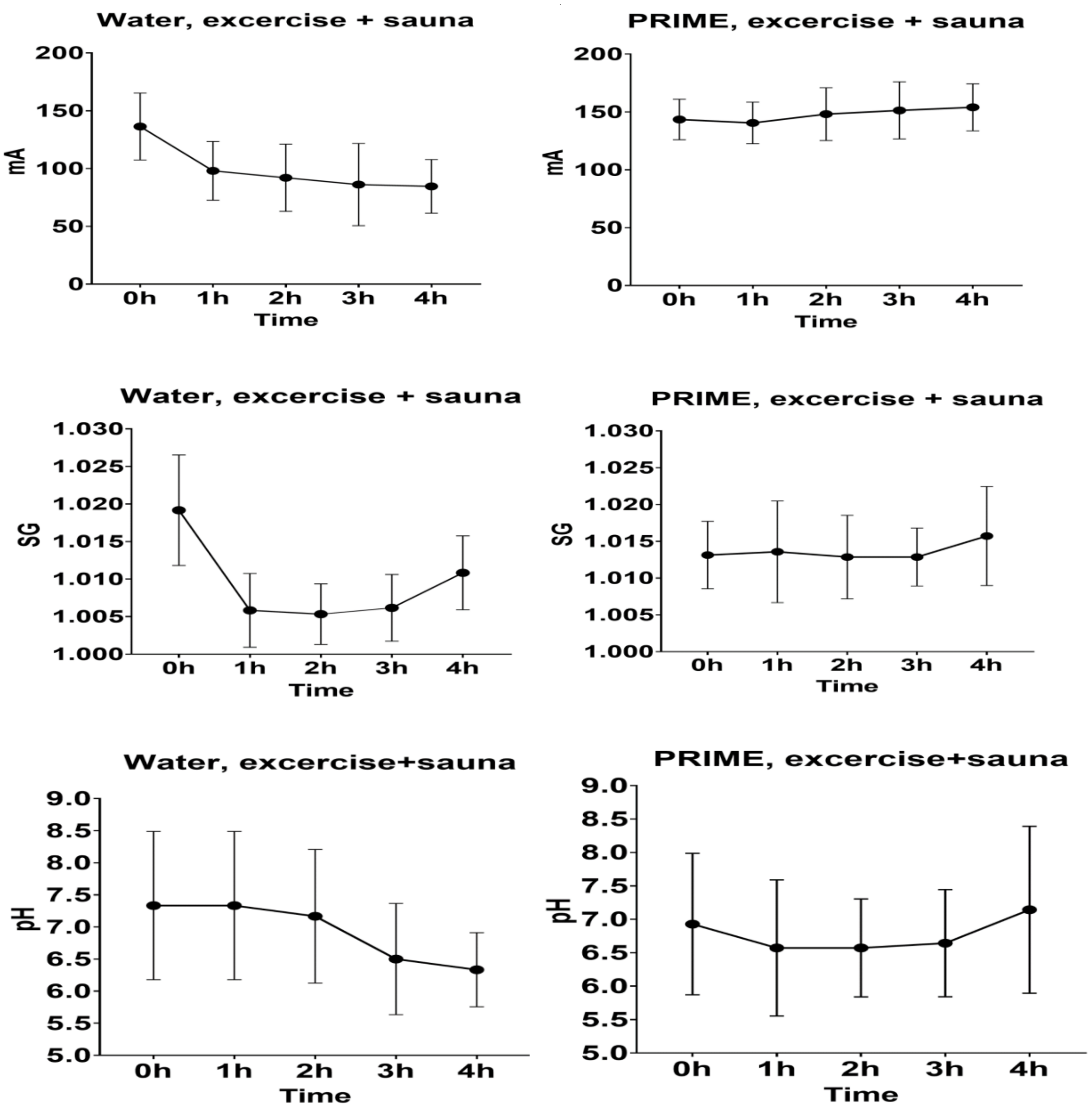

Figure 4: Setting 3 (exercise and sauna). With water alone (left panel) there was a slow but steady decrease in urine electrolytes, in spite of the significant drop in SG. Urine pH became acidic. PRIME consumption (right panel) maintained urine electrolytes concentration, pH and prevented urine acidification.

Neither PRIME nor water caused the appearance of blood, leukocytes, nitrites, bilirubin in urine. About 80% of urine samples turned positive for ketones. All, except one, appeared after exercise/sauna, regardless of water or PRIME consumption. No difference was found in urine ketones between water and PRIME ($p=0.4$).

Discussion

Exercise performance can be compromised by body water and electrolytes deficit. It is commonly recommended that during prolonged exercise, usually lasting longer than 90 minutes, carbohydrate electrolyte beverages should be considered to sustain endurance performance [10].

In this study, we compared water and PRIME on urine electrolyte concentration, SG, and pH. Without exercises, drinking plain water, as expected, caused changes consistent with urine dilution. In contrast, consumption of PRIME caused an increase in urine electrolytes, consistent with increased electrolytes excretion. With exercises, the decrease in urine electrolyte, SG and pH were still observed, however, consumption of PRIME ameliorated decrease in urine electrolyte concentration, SG and pH. With exercise and sauna, hydration with water did not prevent a decrease in urine electrolytes, in spite of the significant drop in SG. Urine pH became acidic. PRIME, however, maintained urine electrolytes concentration and pH, prevented urine acidification. We showed that the consumption of PRIME before exercise and sauna replaces body electrolytes, and they do not excrete with urine.

The difference was the most prominent in the exercise and perspiration setting. PRIME resulted in flattening of electrolyte urine concentration and SG and prevented urine acidification. We suggested that consuming PRIME without exercises was not beneficial, however it had a positive effect on electrolyte replacement with exercises. This effect was the most prominent with both exercise and extensive sweating. The results underscore the importance of both hydration and electrolyte replacement before, but not after exercises to maintain adequate electrolyte balance.

Our results are in agreement with previously shown: one study compared an anti-dehydration schedule with either water or experimental sport drink, initiated before and continued throughout exercises. Compared to water, minimal plasma electrolyte changes were associated with electrolyte drink consumption [11]. In another study, commercial beverages with different mineral waters were compared in relation to mineral concentration and carbohydrate content. The authors concluded that the replacement was equally effective, by ingesting mineral water, confirming importance of electrolyte replacement, both in mineral water and currently marketed beverages [12]. Another study showed that the effects on performance of an uncorrected fluid deficit should persuade all athletes to attempt to remain fully hydrated at all times, and the aim should be to start each bout of exercise in a fluid replete state. This will only be achieved if a volume of fluid in excess of the sweat loss is ingested together with sufficient electrolytes [13].

Exercise has long been known to increase ketone production; however, PRIME has no effect on appearance of ketones in urine after exercise. It is important to mention that no safety concerns were detected on urinalysis with PRIME and water. All urinalysis results collected were normal. It is important that PRIME decreases urine acidification and does not negatively affect urinalysis. Overall, our results support the American College of Sports Medicine recommendation #5: Addition of proper amounts of carbohydrates and electrolytes to a fluid replacement solution is recommended for exercise events of duration greater than 1 hour [14].

Our study has several limitations. The method used can only measure total electrolyte contents using voltage but not the exact amount of each electrolyte. No direct measurement of total and individual electrolytes was done. In addition, the use of a multimeter in measuring electrical voltage in solutions is very sensitive to multiple factors: depth of electrodes in solution, wire length of electrode design, repeated use of electrodes, solution temperature. Changing any of those parameters can result in different voltage (mA) readings. For more accurate results, we standardized the electrode design, focusing on maintaining equal wire length, measuring the same depth and time as well as keeping all solutions at strictly room temperature. In addition, we found that electrolyte excretion depends on different types and amounts of food consumed. We therefore maintained a similar diet including food and beverages for all subjects in all experiments, however we could not completely exclude food factor influence. In addition, the number of subjects included in the experiment was low, making it more difficult to determine the true effect. And finally, antidiuretic hormone (ADH) plays an essential role in the control of the body’s osmotic balance, blood pressure regulation, sodium homeostasis, and kidney functioning, including electrolytes [15]. It primarily affects the ability of the kidney to reabsorb water. The differences in urine electrolyte concentration observed in our study may be due to individual subjects’ variation in the extent of ADH release as well as different variations of ADH actions in their bodies. Those factors may explain high standard deviation in the measurements obtained during the study.

Conclusion

In conclusion, PRIME consumption before exercise and sauna replaces body electrolytes, prevents urine acidification, and does not negatively affect urinalysis.

Acknowledgement: We sincerely thank all participants for taking the time to complete the study.

Conflict of Interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors contributions: M. Kotchetkov: conceptualization of the study and performing experiments, writing original draft, review and editing. D. Kotchetkov: perform experiments, writing original draft, review and editing. M. Krishnan: supervision, review and editing.

Source of funding if the project was funded: This research received no external funding.

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