Voluntary Intake of Sports Drinks and Water in Males and Females Running in Hot Environment

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ABSTRACT

PURPOSE: This study compared the palatability and voluntary intake of beverages that have different sensory characteristics, between male and female athletes while running or racewalking in a tropical climate. **METHODS:** Thirty-six athletes (runners n=31; race walkers n=5), 18 males (M; mean age=18.9 ± 3.5 yr) and 18 females (F; mean age=20.1 ± 4.7 yr), were recruited. Subjects completed four 90-minute sessions, running or race walking outdoors (mean distance M=18.0 ± 1.7; F=13.1 ± 2.0 km) at an intensity requiring 80 to 85% of age predicted maximum heart rate in a hot and humid environment (WBGT=30.1 ± 1.1 °C) on separate days. One of 4 commercial beverages was offered on each occasion: unflavored water (W), 6% carbohydrate-electrolyte solution (CES), 6% carbohydrate-electrolyte + preservatives solution (CESP1) or 8% carbohydrate-electrolyte + preservatives + B vitamins solution (CESP2). Beverage order was assigned in a Latin Square, double-blind design. They were served cold in squeeze bottles and subjects drank as desired. Palatability was measured during a one-minute exercise break at 15-minute intervals using visual analog 10-point scales and 9-point category scales. **RESULTS:** There were no differences between conditions (P>0.05) in environmental variables, exercise intensity or sweat rates. The amounts consumed of the four beverages were similar and insufficient to match sweat rates (W = 17.0 ± 4.8; CES=16.9 ± 5.4; CESP1=17.8 ± 5.4; CESP2=17.5 ± 5.2 ml·kg^{-1}, P>0.05). Males showed a higher fluid intake (18.5 ± 5.4 vs. 16.1 ± 4.7 ml·kg^{-1}, P=0.006) but greater level of dehydration (2.6 ± 0.7 vs. 1.5 ± 0.8 % BM, P < 0.001) in all conditions. No differences were found between males and females in overall acceptance, liking of flavor or thirst quenching at any time point. **CONCLUSIONS:** Female athletes replaced more of their sweat losses than males but both groups finished dehydrated, with no differences among beverages. Contrary to a previous report in older individuals, females did not drink more water than males. The reluctance of young athletes to drink while running or racewalking in a hot and humid outdoor environment did not seem to be due to the palatability of these beverages and should be further investigated.

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INTRODUCTION

Studies using laboratory exercise protocols have demonstrated that sensory characteristics of beverages may affect palatability and drink intake during exercise (Passe et al., 2004) and recovery (Wilmore et al., 1997). Sex-related differences in drinking patterns during prolonged exercise have also been documented (Baker et al., 2005; Hew, 2005).

Passe et al. (2004) examined the palatability and fluid intake of 4 beverages: Diluted orange juice, homemade 6% carbohydrate-electrolyte sports beverage, commercially available 6% carbohydrate-electrolyte sports beverage and water in a group of triathletes and runners. They were given brief access to the beverages for 1 minute after 30 min and 60 min of exercise. Results showed that the commercial sports drink scored higher in "overall acceptance" and was consumed in greater quantities. Wilmore et al. (1997) found that during recovery following a 90 minute run at 60% VO_{2max} subjects consumed approximately 50% more fluid when drinking two sports drinks compared with water. Passe et al. (1997) have also shown that the presence of sodium benzoate in a beverage affects fluid intake. Sodium benzoate is a preservative commonly used in carbonated drinks.

Sex-related differences in drinking pattern of marathon runners (Hew, 2005) and older adults (Baker et al., 2005) have been reported. In these studies women drank more water than men in proportion to body size. In addition, Baker et al. (2005) reported that older women rate the "overall acceptance" and the "liking of flavor" of water higher than men.

The present study was designed to simulate training situations in natural outdoor conditions in which athletes have unlimited access over a long period of time to water or beverages that have different sensory characteristics (flavor, carbohydrate, electrolytes, vitamins, preservatives). Our goal was to compare the palatability and voluntary intake of 4 beverages (See Table 1) in male and female athletes who tend to minimize drinking (runners and race walkers), during prolonged exercise outdoors in a hot and humid climate.

Table 1. Composition of commercial beverages offered in the 4 experimental conditions (per 8 oz or 240 ml serving)

Beverage	CHO (g)	Na+ (mg)	K+ (mg)	Preservatives	Vitamins	Osmolality (mosm/L)
Water	0	0	0	none	none	0
CES	14	110	30	none	none	280-300
CESP1	14	110	30	Sodium Hexametaphosphate	none	280-300
CESP2	19	75	50	Potassium Sorbate Sodium Benzoate (< 0.06%)	B12 (0.6 µg) B3 (1.8 mg) B6 (0.25mg)	381

Drink flavors for CES, CESP1, and CESP2: Orange or Fruit Punch

METHODS

Subjects

- Thirty six athletes (runners n=31; racewalkers n=5), 18 males and 18 females completed the study. Nine of each group were adolescents and 9 were adults.

Study Design and Procedures

Measurements before exercise

- A urine sample was obtained; color and specific gravity were determined as indices of hydration status.
- Nude body weight was measured (scale accurate to 20g).
- Taste measurements obtained.

Measurements during exercise

- Subjects completed four 90-minute exercise sessions, running or race walking outdoors at an intensity requiring 80-85% of age predicted maximum heart rate in a hot and humid environment on separate days in the summer months.
- They were instructed to run laps around a marked area of 420 meters for six-15 minute intervals. Total distance covered was calculated and kept constant.
- Subjects wore a heart rate monitor and at the completion of each lap they were asked to report the heart rate to assure they were maintaining the exercise intensity required. Heart rates were stored every 15 seconds and downloaded to a computer program for subsequent calculation of average heart rate sustained during the exercise intervals. Taste measurements were obtained during a 1-min exercise break after each 15 min interval.
- Environmental conditions were measured every 15 min using a WBGT heat stress monitor.

Taste Measurements (Palatability)

- Overall Acceptance, liking of flavor and liking of sweetness were measured using 9 point hedonic category scales.
- Perceived intensity of thirst, sweetness, saltiness, tartness, thirst quenching, palatability and flavor strength were measured using visual analog 10-point scales. We also used this scale to rate the question "Can you drink a lot of this beverage?".
- Perception of exercise difficulty and how hot/overheated subjects felt were measured using a visual analog 10-point scale.

Measurements after exercise

- A urine sample was obtained; color and specific gravity were determined as indices of hydration status.
- Nude body weight was measured (scale accurate to 20g).

Statistical Analysis

- A Student's t-test was used to compare subjects' characteristics between sexes.
- A two-way (condition vs. sex) analysis of variance (ANOVA) was used to compare males and females in body fluid balance and indices of hydration status and in variables measured throughout time such as taste and sensory variables.
- A three-way (condition vs. time vs. sex) repeated measures ANOVA was performed where appropriate.
- The Tukey post hoc test was performed when main effects were found.
- Significance level for all statistical tests was set to alpha=0.05.

RESULTS

Subjects

- Males were taller than females (172.5 ± 7.5 vs. 161.7 ± 4.2 cm) and had a higher body weight (60.1 ± 8.7 vs. 52.8 ± 3.6 kg) and surface area (1.72 ± 0.1 vs. 1.55 ± 0.1 m^2).
- The subjects had been training for an average of 5.3 ± 3.1 yr, 5.7 ± 0.8 days/wk, and 2.6 ± 0.7 hr/day.

Environmental Conditions

- There were no differences between conditions (P > 0.05) in environmental variables.
- The average environmental conditions were hot (31.5 ± 2.0 °C) and humid (67.1 ± 6.2 % RH). The average WBGT Index was 30.1 ± 1.1 °C.

Exercise Intensity and Distance

- There were no differences between males and females (P>0.05) in average heart rate and % maximal heart rate in any condition during the exercise session. Males covered more distance than females in all conditions (P<0.05).

	Water		CES		CESP1		CESP2	
	M	F	M	F	M	F	M	F
Heart rate (beats·min^{-1})	164.2±5.6	162.4±4.3	165.4±5.9	162.4±5.8	164.9±4.9	162.7±6.7	164.3±7.2	163.2±6.9
% Maximal heart rate	82.0±2.4	81.6±2.4	82.5±2.7	81.6±3.1	82.2±2.4	81.7±3.6	82.0±3.2	81.9±3.3
Distance covered (km)	18.1±1.9*	13.0±2.1	18.1±1.8*	12.9±2.0	18.1±1.6*	13.2±2.1	17.9±1.8*	13.1±2.1

Values are means ± SD.
*Higher than females, P<0.05.

RESULTS, continued

Indices of Hydration Status

- Subjects arrived to the exercise sessions in an adequate state of hydration as indicated by the urine specific gravity (W=1.020 ± 0.007; CES=1.021 ± 0.007; CESP1=1.020 ± 0.009; CESP2=1.021 ± 0.007 g/ml). No differences were found between males and females in pre or post exercise urine specific gravity measurements in any condition, P>0.05.

Body Fluid Balance

- The amounts consumed of the four beverages were similar and insufficient to match sweat rates, P>0.05 (Table 2 and Figure 1).
- Males showed a higher fluid intake (Figure 1) but greater level of dehydration (Figure 2) in all conditions.

Taste and Sensory Measurements (Figures 3 to 8)

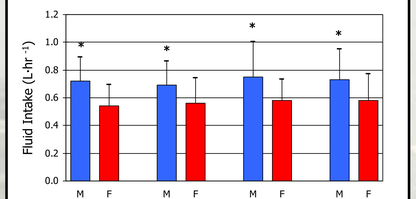
- No differences were found between conditions or between males and females for ratings of overall acceptance, liking of flavor, thirst quenching, palatability, flavor strength, or in ratings of "can you drink a lot of this beverage" in any of the conditions.
- No differences were found between males and females for ratings of saltiness, tartness and sweetness in any of the conditions.
- Males rated the perception of hot/overheated higher than females in the CESP1 (min 15, 30, 45, 75, 90) condition.
- Males rated thirst intensity higher than females in the CES (all time points) and CESP1 (min 30, 45, 60, 75, and 90) conditions.
- Males rated the sweetness of the beverage (pre-exercise, 30, 60, and 90 min) higher than females in the CESP1 condition.

Table 2. Body Fluid Balance

	Water		CES		CESP1		CESP2	
	M	F	M	F	M	F	M	F
Body weight pre (kg)	59.8 ± 8.9*	52.8 ± 3.6	60.1 ± 8.8*	52.7 ± 3.6	59.8 ± 8.9*	52.8 ± 3.7	60.6 ± 9.0*	52.7 ± 3.7
Body weight post (kg)	58.2 ± 8.4*	52.0 ± 3.6	58.4 ± 8.3*	52.0 ± 3.6	58.2 ± 8.4*	52.0 ± 3.6	58.9 ± 8.6*	51.9 ± 3.7
Sweat loss (ml·kg^{-1})	44.0 ± 5.4*	30.4 ± 5.2	44.3 ± 4.8*	30.0 ± 5.8	43.6 ± 6.0*	30.2 ± 5.6	44.7 ± 5.0*	30.5 ± 5.0
Sweat rate (L·h^{-1})	1.8 ± 0.4*	1.1 ± 0.2	1.8 ± 0.3*	1.0 ± 0.2	1.7 ± 0.4*	1.1 ± 0.2	1.8 ± 0.4*	1.1 ± 0.2
Fluid loss (ml·kg^{-1})	45.1 ± 5.6*	31.4 ± 5.1	45.1 ± 4.8*	30.9 ± 6.1	44.8 ± 6.4*	31.3 ± 6.1	45.6 ± 4.8*	31.4 ± 5.1
Fluid intake (ml·kg^{-1})	18.6 ± 4.8	15.5 ± 4.3	17.8 ± 5.4	16.0 ± 5.3	19.1 ± 6.3	16.6 ± 4.2	18.5 ± 5.4	16.5 ± 5.1
Rehydration (%)	42.3 ± 14.4*	51.5 ± 19.5	39.9 ±12.7*	54.2 ± 21.3	42.5 ± 12.2*	55.4 ± 18.1	40.4 ± 10.9*	53.8 ± 19.3

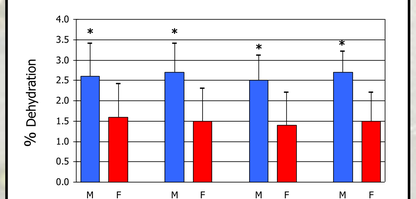
Values are means ± SD. * P < 0.05 males vs females.

Figure 1. Fluid Intake



* Higher than females, P<0.05.

Figure 2. Dehydration



* Higher than females, P<0.05.

Figure 3. Overall Acceptance

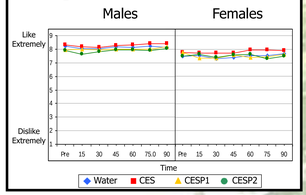


Figure 4. Liking of Flavor

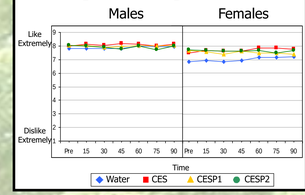


Figure 5. Thirst Quenching

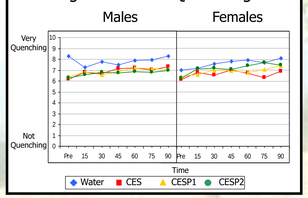


Figure 6. Palatability

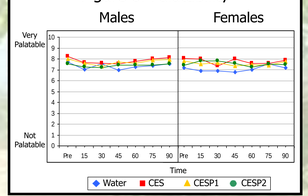
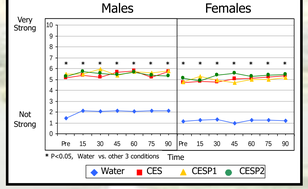
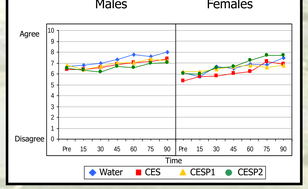


Figure 7. Flavor Strength



* P<0.05, Water vs. other 3 conditions

Figure 8. Can you drink a lot of this beverage?



CONCLUSIONS

- Female athletes replaced more of their sweat losses than males but both groups finished dehydrated, with no differences among beverages.
- Contrary to a previous report in older individuals, females did not drink more water than males.
- The reluctance of young athletes to drink while running or racewalking in a hot and humid outdoor environment did not seem to be due to the palatability of these beverages and should be further investigated.

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