4-21-2016

Hydration status, habits, and knowledge of collegiate cross country runners

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HYDRATION STATUS, HABITS, AND KNOWLEDGE OF COLLEGIATE CROSS COUNTRY RUNNERS

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Abstract

Dehydration exceeding 2% loss of body mass can cause decreased cognitive and physical performance in endurance athletes.[1] While many runners carry water bottles with them, most do not know their sweat rate or fluid recommendations, increasing the risk for heat-related illnesses such as heat stroke.[2] **Purpose**: To assess hydration status, habits, and knowledge of collegiate cross country runners. **Methods**: Institutional Review Board approval was obtained and subjects completed informed consents. Thirty-three female and twenty-five male Division III collegiate runners participated in the study. Hydration status was assessed measuring the specific gravity of three urine samples one each before a race, recovery run, and workout run. Participants completed questionnaires regarding hydration knowledge and habits. Sweat rates were calculated for each runner to estimate fluid losses. Water bottles were swabbed with a 3M quick swab around the lid and areas that touch the mouth and cultured using 3M aerobic petrifilms to assess cleanliness. ANOVA and T-tests were used for statistical analysis using SPSS. **Results:** There were no significant differences in the average urine specific gravity, however there was a bi-modal distribution and 50% of runners began the race dehydrated compared to 32.8% before the workout and 36.2% before the recovery run. Fluid consumption was significantly lower before the race compared to the other types of runs (Race: 443.4. ± 375mL, Workout: 1206.3 ± 552.6mL, Recovery: 1287 ± 792mL; p=0.002). Fluid consumption was similar between males and females before the workout and recovery run (Workout: males 1153.8 ± 459mL, females: 1235.4 ± 600.9mL, p=0.578; Recovery: males 1240.5 ± 664.8mL, females: 1209.6 ± 663.9mL, p=0.499). However, males did consume more fluid before the race (Males: 661.68 ± 471.6mL, Females: 324.6 ± 244.8mL; p=0.09) Sweat rates were higher in males (Males: 1377.6 ± 335.1mL/hr, Females: 1128.6 ± 320.7mL/h; p=0.005) and males ran more miles per week (males: 65.77 ± 12.6, females: 47.64 ± 10.17; p=.000). The average knowledge score was 58% for males and 61% for females. The majority (64.9%) of water bottles cultured had bacteria *too numerous to count*. **Conclusions:** Twenty-one percent of all participants (8 males, 4 females) were severely dehydrated prior to competition. Sweat rates (mL/hr) of males were 18% higher, and males ran on average 18 more miles per week, yet consumed approximately the same amount of fluid as females before the recovery and workout runs. Males consumed more fluid before the race, but 57% of males were dehydrated compared to 45% of females. Water bottle cleanliness should be addressed by runners. Total aerobic plate count only assesses the amount of bacteria and future research is needed to determine whether the bacteria is pathogenic.

1. Thomas, D.T., Erdman, K.A., & Burke, L.M. (2016). Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance*. Journal of the Academy of Nutrition and Dietetics,* 116(3), 501-28. doi: 10.1016/j.jand.2015.12.006.
2. Brown, S., Chiampas, G, Jaworski, C., & Passe, D. (2011). Lack of awareness of fluid needs among participants at a Midwest marathon. *Sports Health, 3(5),* 451-4.

Introduction

Dehydration exceeding 2% loss of body mass can cause decreased cognitive and physical performance in endurance athletes by increasing core body temperature, increasing cardiovascular strain, increasing glycogen utilization, and altering metabolic function (1). Runners only replace approximately 70% of sweat losses when drinking ad libitum (2). Beginning an exercise-training session without full rehydration from the previous session can have detrimental performance consequences (1). Runners are likely to consume inadequate fluid even when water or sports drinks are readily available in races (3). Runners may know the negative impacts of dehydration, but their behaviors do not always reflect their knowledge on hydration (4).

Many surveyed runners (80%) failed to monitor their hydration status (5). Urine color was the most common method for monitoring hydration status and only 2% of participants relied on weight changes, which is the most accurate method to assess hydration status (5). Similarly, 88.7% of runners in another study did not know their sweat rate (6). Sweat rate should be understood in order to properly rehydrate and maintain adequate hydration status (3).

Runners carry personal water bottles but do not maintain adequate hydration status, increasing their risk for heat-related illnesses such as heat stroke (5). Collegiate runners tend to run every day at the same time and must fully rehydrate between practices to prevent decreases in performance (1). There is also insufficient research on differences in hydration status between practices and races in collegiate runners. The purpose of this study is to assess hydration status, habits, and knowledge of collegiate cross country runners.

Methods

Institutional Review Board (IRB) approval was obtained and all participants completed informed consent (Appendix 1,2). Eligibility for participation included any member of the women's and men's cross country team. There were a total of fifty-eight participants; thirty-three females, twenty-five males. Subjects were between the ages of 18 and 22.

Hydration status was assessed with the specific gravity of three urine samples. Subjects completed questionnaires regarding knowledge and hydration habits. An educational lecture was included after urine collections. A follow-up urine collection assessed differences in hydration status after the educational lecture. Many runners also carry personal water bottles on a daily basis to maintain hydration and cleanliness of the bottles was tested.

Subjects were recruited before a cross country practice. Subjects attended a short presentation and completed informed consent. The hydration habits questionnaire (appendix 3) asked general questions about subject's typical hydration practices and subjects completed the questionnaire before any urine collections were taken. Urine collections were taken before a race, workout run (intervals, tempo, hills, etc.) and recovery run (slower pace). Subjects were not warned when urine collections would occur. Three questions were asked with every urine collection (appendix 4) including how much fluid was consumed during the day and a prediction of hydration status. Beakers were coded with the last four digits of the subject's student ID. Participants placed the filled beakers in a cooler in the bathroom. Hydration status was assessed by urine specific gravity using a Palm Abbe-digital refractometer, a reliable method to assess hydration (7). Dehydration was defined as a USG >1.020 and severely dehydrated was defined as USG >1.025 (1, 8).

Sweat rate was calculated for each participant. Dry body weight was measured before and after exercise. Subjects towel-dried off before the post-weight measurement was taken. Subjects were told not to drink fluid or go to the bathroom between weight measurements. Sweat rate was calculated as (pre-exercise body weight) – (post-exercise body weight)/ (exercise duration). The difference in body weight was converted to ounces (1 lb. = 16 oz.) and exercise duration was recorded in hours (40 min = .66 hr). Subjects completed a hydration

knowledge questionnaire after sweat rate was calculated and all three urine collections were completed (appendix 5).

A hydration educational lecture customized to the topics subjects marked incorrectly on in the knowledge questionnaire was presented. Subjects received a handout on hydration with a urine collection chart, feedback on their hydration status, and their sweat rate. Participants were taught how to use their sweat rate to rehydrate properly. A follow-up urine sample was taken a week later to assess if the educational lecture improved hydration status.

A separate informed consent was completed for testing water bottles. Participants did not know when the bottles would be swabbed. Participants completed a water bottle questionnaire before the bottles were swabbed (appendix 6), which included questions about how often subjects cleaned their bottles and the types of fluid put into the bottles. The water bottles were swabbed with 3M quick swabs around the lid and areas that the mouth touches and the contents of the swab were poured onto a 3M total aerobic petrifilm and incubated for 24 hours. Total aerobic plate count was used for testing all participants' water bottles. The recommendation for total aerobic plate count is <500cfu/ml (9). The female's bottles were swabbed first and many samples were *too numerous to count*. Total aerobic plate count only determines total bacteria and does not differentiate the type of bacteria. An E.coli plate count and total aerobic plate count was used for the males' bottles to determine if any of the bacteria came from fecal contamination.

SPSS was used for statistical analysis. A one way ANOVA was used to compare the mean USG of the different runs, differences in gender and USG, and differences in knowledge scores and USG. A paired T-test was used to compare results of the pre- hydration lecture USG and the post- lecture USG. Results are in mean ± standard deviation form and $P<0.05$ indicated significance.

Results

There were no significant differences in the average urine specific gravity (Race: 1.0158 ± 0.0093, Workout: 1.0149 ± 0.0078, Recovery: 1.0156 ± 0.0076; p=0.57) (Figure 1), however there was a bi-modal distribution and 50% of runners began the race dehydrated compared to 32.8% before the workout and 36.2% before the recovery run (Figure 2, Table 1).

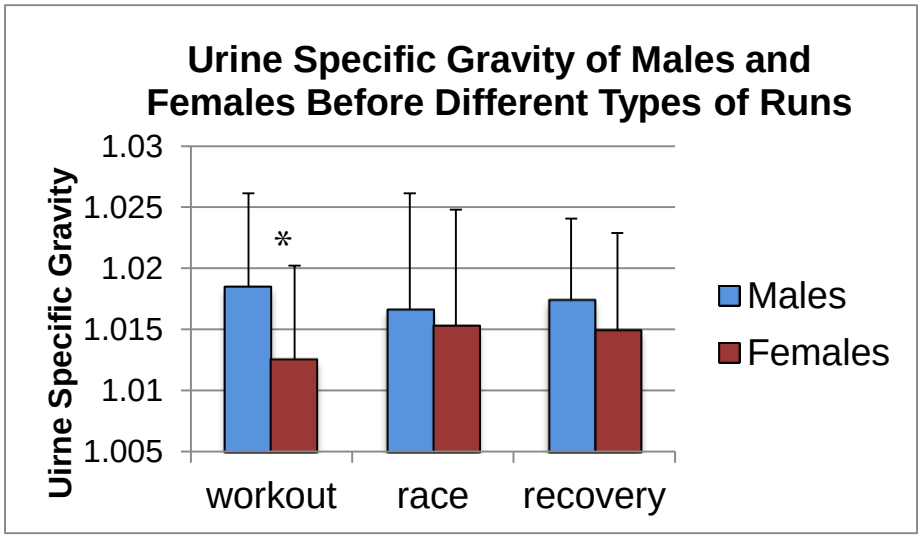

Figure 1. Urine specific gravity before different types of runs. No significant differences between the types of runs (p=0.57). Urine specific gravity was significantly higher for males before the workout (57 df, t=-3.363, p=0.001). There were no significant differences between gender before the race and recovery run.

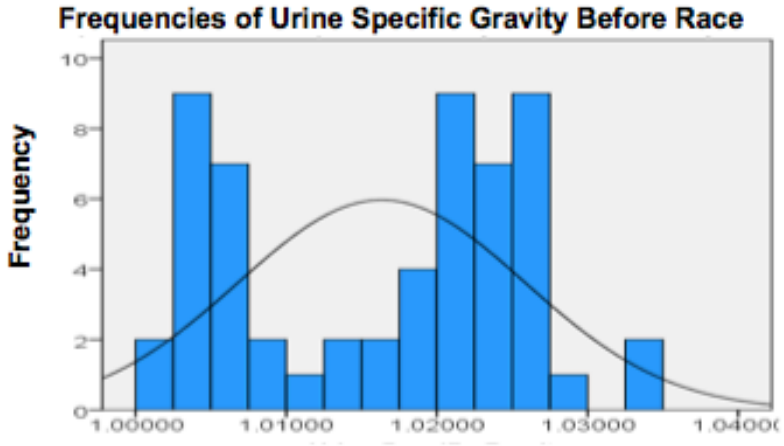

Figure 2: Frequencies of urine specific gravity before a race. USG>1.0200 represents dehydration and 50% of participants were dehydrated prior to competition.

Table 1. Percentages of participants dehydrated before different types of runs.

	Race	Workout	Recovery
Males	57%	42%	46%
Females	45%	32%	24%
Total	50%	36%	33%

Fluid consumption was significantly lower before the race compared to the other types of runs (Race: 443.4. ± 375mL, Workout: 1206.3 ± 552.6mL, Recovery: 1287 ± 792mL; p=0.002). (Figure 3).

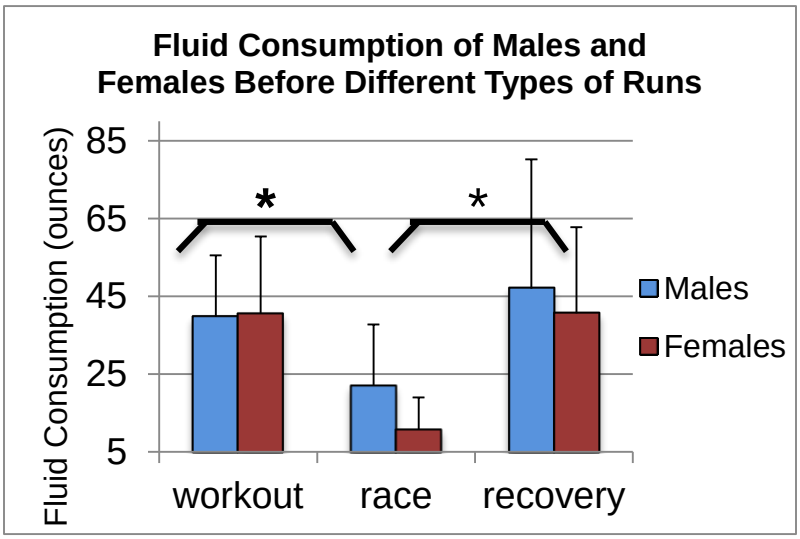

Figure 3. Fluid consumption between males and females before different types of runs. Runners consumed significantly less fluid before the race (p=0.002). There were no significant differences in fluid consumption between males and females before the workout run (56 df, t=0.559, p=0.578), recovery run (57 df, t=-0.68, p=0.522) race (t=-3.25, p=0.009).

Males were significantly more dehydration before the workout run compared to females (males: 1.0189 ± 0.0068, females: 1.0124 ± 0.0076; p=0.001); however, there were no differences before the recovery run and race (Figure 1). The percentage of males dehydrated was higher for every type of run compared to females (Table 1). Fluid consumption was not significantly different between males and females for each type of run (Workout: males 1153.8 ± 459mL, females: 1235.4 ± 600.9mL, p=0.578; Recovery: males 1240.5 ± 664.8mL, females: 1209.6 ±663.9mL, p=0.499, Race: males: 661.68 ± 471.6mL, females: 324.6 ± 244.8mL; p=0.009) (Figure 3), yet sweat rate was higher in males (Males: 1377.6 ± 335.1mL/hr, Females: 1128.6 ±320.7mL/h; p=0.005) and males also ran more miles per week (males: 65.77 ± 12.6, females: 47.64 ± 10.17; p=.000).

Learning about hydration status and sweat rate did not improve hydration status. There were no differences in urine specific gravity (pre: 1.0152 ± .0076, post: 1.0154 ± 0.0077; p=0.903) or fluid intake (pre: 1287 ± 792mL, post: 1401.9 ± 655.5mL; p=0.542) before and after the educational lecture (Table 2).

Table 2. Comparison of urine specific gravity (Paired t-test, 55, df, t=0.122, p=0.903.) and fluid consumption (Paired t-test, 55 df, t=-0.614, p=0.542.) before and after an educational lecture.

	Urine Specific Gravity	Fluid Consumption (mL)
Before	1.0152	1287
After	1.0154	1402
P Value	p=0.903.	p=0.542.

On the hydration habits questionnaire, most participants monitored their hydration status by urine color (N=53, 88.3%) and thirst (N=52, 86.7%). Only one participant reported using changes in body weight (1.7%) and two reported not monitoring their hydration status (3.3%) (Figure 4).

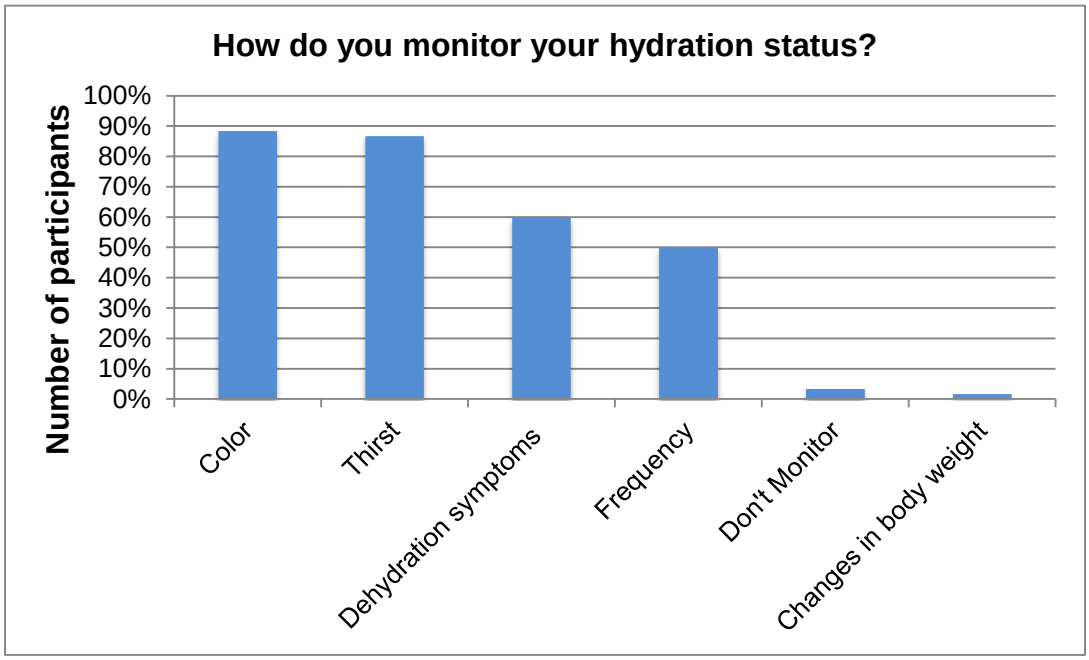

Figure 4. Responses on the hydration habits questionnaire to the question “how do you monitor hydration status?”

Participants learned about hydration mostly from coaches (N=52, 86.7%), personal trial and error (N=41, 68.3%), and other runners (N=38, 63.3%) (Figure 5).

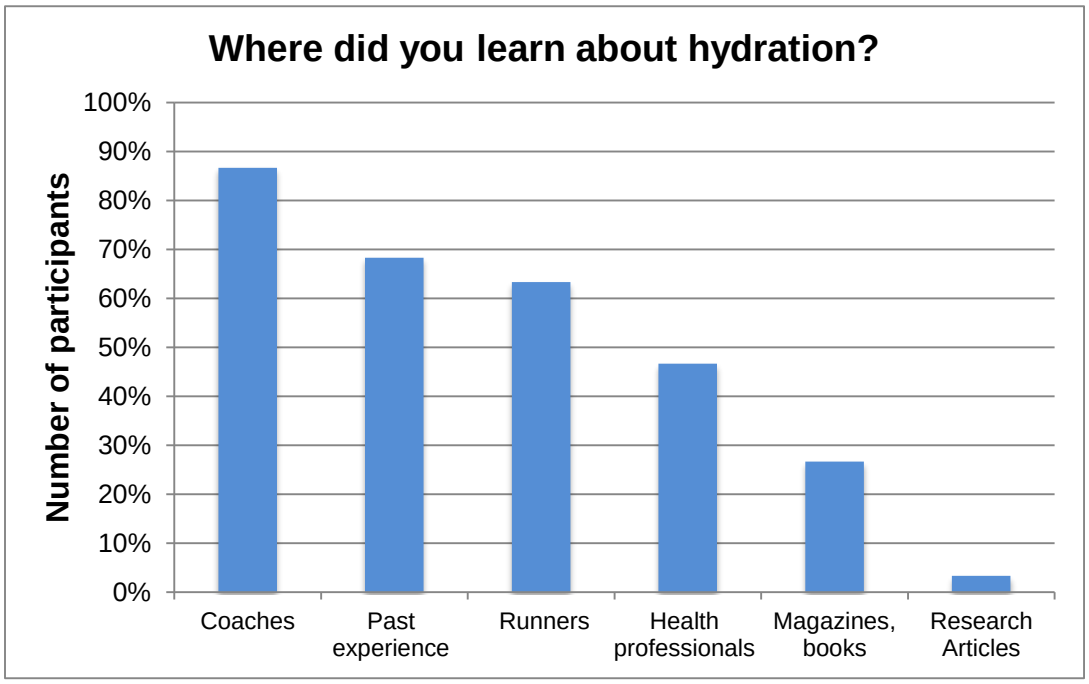

Figure 5. Responses on the hydration habits questionnaire to the question “where did you learn about hydration?”

The top three reasons for drinking fluid included hotter weather (N=46, 76.7%), exercising (N=44, 73.3%), and thirst (N=25, 41.7%) (Figure 6).

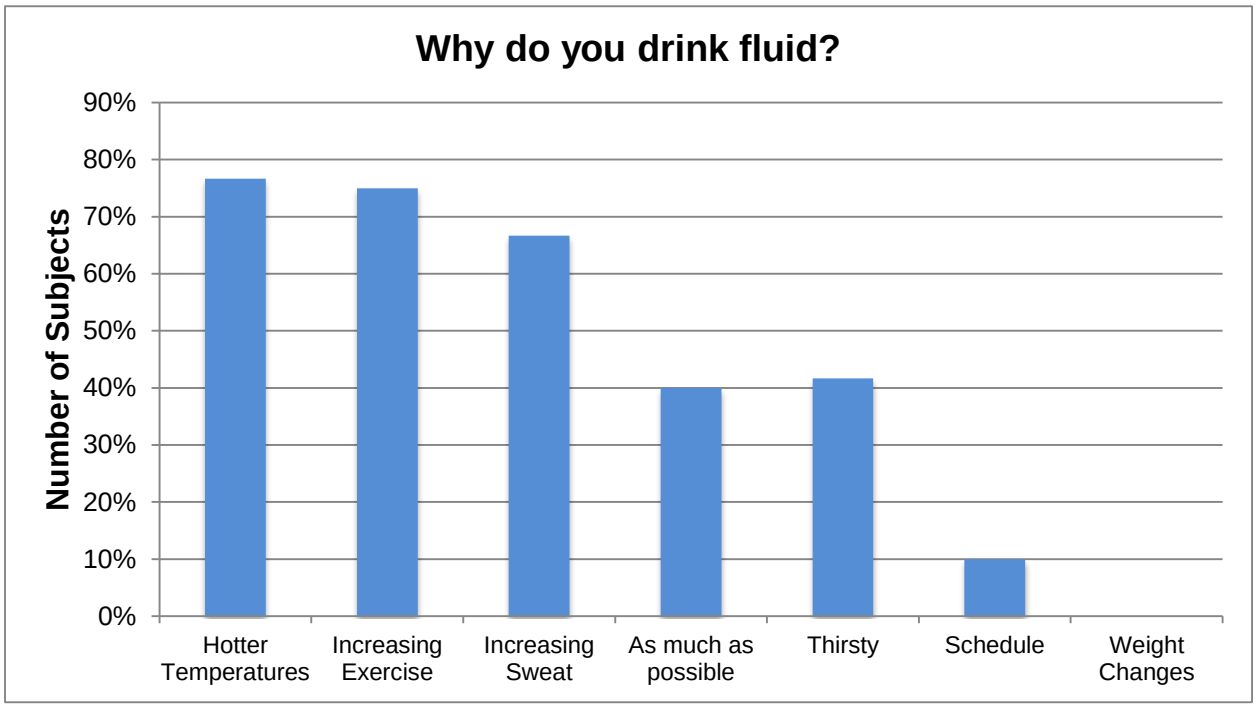

Figure 6. Responses on the hydration habits questionnaire to the question “why do you drink fluid?”

Average knowledge scores were 59.6% ± 7.06%. There were no differences in scores between males (58.36% ± 5.53%) and females (61.46% ±7.93%) (p=0.14).

A total of 37 water bottles were swabbed. The majority (64.9%) of water bottles cultured bacteria *too numerous to count* (Figure 7). Fortunately, all of the E.coli plate counts had zero bacteria growth (Figure 8). Many subjects (43%) reported never cleaning their water bottles. Only one participant cleaned their bottle weekly, and no participants cleaned their bottles daily.

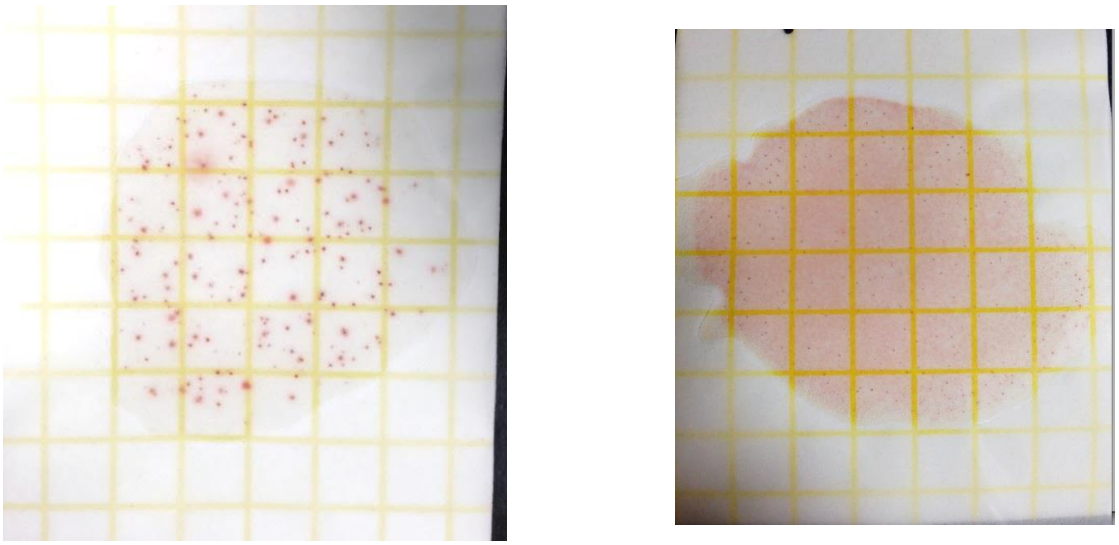

Figure 7. Total Aerobic Plate Counts. The left picture has 380cfu/ml. The right picture *too numerous too count* as indicated by the red background.

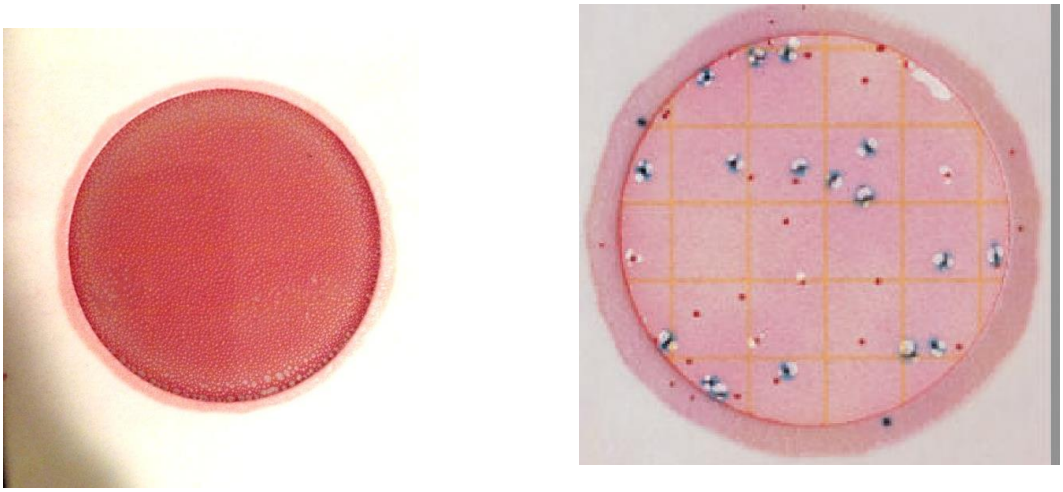

Figure 8. E.coli plate counts. The left picture has no bacteria growth. The right picture demonstrates what E.coli (blue) would look like if it grew on the samples. No water bottle samples grew E.coli.

Discussion

Dehydration causes decreased cognitive and physical performance in endurance athletes (1). Most runners were either dehydrated or well hydrated as urine specific gravity

frequencies demonstrated a bi-model distribution. Surprisingly fluid consumption was significantly less before the race (Race: 14.78 ± 12.5oz, Workout: 40.21 ± 18.42oz, Recovery: 42.9 ± 26.4oz; p=0.002) resulting in the highest number of participants dehydrated (race: 50%, workout: 32.8%, recovery: 36.2%, p=0.736). Seven subjects (13%) did not consume any fluid within the seven hours prior to competition. Subjects who were severely dehydrated before the start of the race are at the greatest risk of heat-related illnesses.

Races may pose a challenge for adequate fluid consumption. First, the race was early in the morning and participants may not have had time to drink sufficient amounts of fluid. Practices are in the late afternoon, allowing for more time to drink fluid. Second, some runners may consume little fluid in order to avoid gastrointestinal distress. Surveyed runners (71.5%) indicated avoiding over-hydration to prevent stomach pain and GI distress (2). Runners may also fail to increase fluid consumption as sweat rate increases. For example, football players do not change fluid consumption between practices and competition (P>0.05), even though sweat rates were significantly higher in games (1.30±0.57 L/h) compared to practices (0.65 ± 0.35 L/h) (P=0.002) (4). Subjects adequately rehydrated during practices, but not during games (4).

Fluid consumption was similar between males and females before the workout and recovery run. Sweat rates of males were 18% higher and males also ran 18 more miles per week than females. Males did consume more fluid compared to females before the race, but there was still a higher percentage of males dehydrated (57%) compared to females (45%). Males being more dehydrated than females is a pattern in published studies. Urine specific gravity was higher at twelve hours post run for men (1.025±0.007) compared to women (1.014 ±0.007) after a one-hour self paced run (10). Men also consumed 171% ± 40% of sweat loss and women consumed 268% ± 88% of sweat loss, suggesting females rehydrate more aggressively than males (10). Basal fluid needs per day is 3.7L for males and 2.7L for females, however males reported drinking an average of 2.4L and females reported 1.9L, both under the basal intake levels.

Most subjects monitored their hydration status by urine color (88.3%) and thirst (86.7%). Only 3.3% of subjects reported not monitoring their hydration status. Less than a quarter (20%) of runners monitored their hydration status in other studies; however, urine color was also the most common method (5). Measuring changes in body weight is the most accurate way to monitor hydration status and only one participant reported monitoring weight changes.

None of the participants knew their sweat rate at the start of the study similar to 89% of runners in another study (6). Consequently, it is impossible to know how much fluid to consume to accurately rehydrate if the runner does not know how much fluid was lost. Participants' average knowledge scores were 60% indicating a lack of knowledge about hydration. These results are similar to other findings. Many runners surveyed (67%) responded incorrectly that dehydration was the most common cause of collapse after a race and only 2.8% responded correctly (2). Also, 5.6% of participants believe that drinking more fluid than planned would decrease the probability of hyponatremia, when drinking more fluid is one of the causes of hyponatremia (2). There was a severe knowledge deficit in the runners surveyed and only 28.5% of subjects reported paying attention to hydration guidelines from the national sport science organizations (2). Only 3.3% of subjects indicated learning about hydration from research articles in this study.

An education session providing personal feedback regarding hydration status and sweat rates did not improve hydration status in this population. A surprise follow-up urine collection did not result in any improvements in urine specific gravity or fluid intake. Runners were provided with information on the negative impacts of dehydration and methods for hydrating properly. Hydration education was beneficial for athletes such as volleyball and basketball players. Hydration status improved significantly in the group that received an educational intervention (USG: pre= 1.031± 0.09, post= 1.023 ±0.012, P<0.05), while there was no significant difference in the control group (USG: pre= 1.033±0.011, post= 1.032±0.013, P>0.05) (7). Performance in a

600-meter race also significantly improved in the intervention group (pre=189±5s, post=167±4s, P<0.05), but not the control group (7). Runners may benefit from more frequent education lectures and coaches enforcing the importance of hydration.

Water bottle cleanliness can influence the health of runners. An alarming number of water bottles (65%) cultured bacteria *too numerous to count* on a 3M aerobic plate count, exceeding the recommendation of less than 500cfu/mL. Fortunately, all E.coli plate counts did not culture any bacteria. Many subjects (43%) reported never cleaning their water bottles. Most (64.4%) of elementary students' water bottles were over the recommendation (9). Also, some samples contained fecal coliforms (8.9%) greater than the recommended amount of 1cfu/100ml (9). Samples of water from the drinking fountains in the school were all under the limits for coliforms and heterotrophs, which suggests the contamination came from the environment, not the water source (9).

Limitations to the study include there was only one urine collection before each type of run. Multiple urine collections before each type of run may be beneficial to determine trends in hydration status and whether runners consistently consume less fluid before races. Another limitation to the study is the females' water bottles were not cultured for E.coli. None of the male's bottles cultured bacteria on the E.coli plate counts, however the females' bottles may have produced different results.

Future research should examine pre- and post race hydration status to determine the degree of dehydration that occurs during the race. Nearly 21% of runners started the race severely dehydrated but hydration status was not measured at the end of the race, so the number of runners who ended the race severely dehydrated was not known. Future research is also required to determine the types of bacteria growing and if the bacteria is pathogenic and harmful to health. Runners may benefit from frequent reminders to wash their bottles.

Conclusions

Half of subjects were dehydrated before the race. It is essential runners consume fluid immediately after waking up or while traveling to competition. Drinking fluid well before the start of competition can decrease gastrointestinal distress. None of the runners knew their sweat rates before the study and sweat loss should be understood to develop an individualized drinking strategy. Water bottle cleanliness should be addressed by runners. Total aerobic plate count only assesses the amount of bacteria and future research is needed to determine whether the bacteria is pathogenic.

Acknowledgments

Thank you Emily Heying, PhD, and Richard Wielkiewicz, PhD for helping with statistics. Thank you coaches Robin Balder-Lanoue and Tim Miles for allowing research to be done on the cross country teams and supporting the study.

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Appendix 1

COLLEGE OF ST. BENEDICT/ST. JOHN'S UNIVERSITY
Hydration status, habits, and knowledge of collegiate cross county runners

INTRODUCTION

You are invited to be in a research study about the hydration status, habits, and knowledge of cross country runners. This study is being conducted by: Laura Comee (Nutrition Major) and Amy Olson (Faculty, Nutrition CSB-SJU). You were selected as a possible participant because you are a member of the College of Saint Benedict/Saint John's University cross country team. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

BACKGROUND

Dehydration can cause decreases in performance in long-distance running. The purpose of this study is to understand if collegiate runners have adequate hydration status and knowledge. The study will investigate how runners develop their hydration strategy and how well hydrated collegiate runners are before practices and races. Hydration status will be assessed and educational feedback will be provided. A follow up assessment will determine whether hydration status improved.

PROCEDURES

If you agree to be in this study, we would ask you to do the following things.

- Fill out questionnaire about hydration habits (≈10 minutes)
- Provide urine samples before practices or races on three occasions (≈5 minutes each)

    - Random schedule
- Fill out questionnaire about hydration knowledge (≈10 minutes)
- Allow sweat rate to be calculated (≈5 minutes before and after a run)
    - Includes dry body weight measurements before and after run
- Attend a feedback presentation on hydration status (≈15 minutes)
- Provide urine samples before practices or races for follow-up on three occasions (≈5 minutes each)

RISKS/BENEFITS
This study has no known risks.
The benefits of participation are that individuals will learn:

- Personal hydration status
- Importance of hydration
- Hydration recommendations
- Personal sweat rate

CONFIDENTIALITY
Names or other identifying information will not be collected for the study. The last 4-digits of the individual's student ID will be used to code urine samples and questionnaires. If you choose you can share your data with your coach Robin Balder-Lanoue or Tim Miles. The records of this study will be kept private. Research records will be kept in a password protected excel file; only the researchers will have access to the records. In any reports or public presentations, no information will be included that would make it possible to identify a participant.

VOLUNTARY NATURE OF THE STUDY
Your participation in this research study is completely voluntary. You may stop participating at any time without penalty or costs of any kind. Your decision whether or not to participate will not affect your current or future relationships with the College of Saint Benedict or Saint John's University or your relationships with the coach.

FUNDING SOURCES
Undergraduate Research Grant

CONTACTS AND QUESTIONS
The researchers conducting this study are Amy Olson and Laura Comee. You may ask any questions you have now. If you have questions later, you may contact Laura at ljcomee@csbsju.edu or 952-693-3406 or Amy at aolson@csbsju.edu. If you have additional questions you may also contact the CSB/SJU Institutional Review Board chair at *irb@csbsju.edu*.

A copy of this form will be emailed to you to keep for your records if you wish.

STATEMENT OF CONSENT

- I have read the above information. I have asked questions and have received answers. I consent to participate in the research
- I know I can stop taking part at any time

- I am satisfied the results will be stored securely
- I am at least 18 years of age
- I have had a recent physical examination and a physician's approval to participate in sports
- I know the results may be published, but they will not be linked to me
- I agree to inform the researcher if I am in pain, or if I feel uncomfortable

Robin Balder-Lanoue and Tim Miles keep records to help identify patterns and effectiveness of training program schedules. They are interesting in helping individuals enhance their performance and will use shared data to ultimately benefit runners. Your personal data will not be revealed to others should you choose to share your results with the coach.
_____I want the coach to have my results
_____I do not want data shared with my coach

Signature _____ Date _____

Printed name _____

Email Address_____

Last 4-digits of student ID_____

Appendix 2

COLLEGE OF ST. BENEDICT/ST. JOHN'S UNIVERSITY
Hydration status, habits, and knowledge of collegiate cross county runners

INTRODUCTION
You are invited to be in a research study about the hydration status, habits, and knowledge of cross country runners. This study is being conducted by: Laura Comee (Nutrition Major) and Amy Olson (Faculty, Nutrition CSB-SJU). You were selected as a possible participant because you are a member of the College of Saint Benedict/Saint John's University cross country team. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

BACKGROUND
Many runners carry personal water bottles with them to maintain proper hydration. Cleanliness of the bottles can affect how much fluid runners drink and their health. The purpose of this study is to assess the cleanliness of runners' personal water bottles. The study will investigate how runners' clean their water bottles and how different types of fluid affect cleanliness.

PROCEDURES
If you agree to be in this study, we would ask you to do the following things.
- Provide personal water bottles to be swabbed (≈1 minute)
- Fill out questionnaire about water bottles maintenance (≈10 minutes)

RISKS/BENEFITS
This study has no known risks.
The benefits of participation are that individuals will learn:

- Cleanliness of personal water bottles
- Proper procedures to sanitize water bottles

CONFIDENTIALITY
Names or other identifying information will not be collected for the study. The last 4-digits of the individual's student ID will be used to code the water bottle and questionnaire. If you choose you can share your data with your coach Robin Balder-Lanoue or Tim Miles. The records of this study will be kept private. Research records will be kept in a password protected excel file; only the researchers will have access to the records. In any reports or public presentations, no information will be included that would make it possible to identify a participant.

VOLUNTARY NATURE OF THE STUDY
Your participation in this research study is completely voluntary. You may stop participating at any time without penalty or costs of any kind. Your decision whether or not to participate will not affect your current or future relationships with the College of Saint Benedict or Saint John's University or your relationships with the coach.

FUNDING SOURCES
Undergraduate Research Grant

CONTACTS AND QUESTIONS
The researchers conducting this study are Amy Olson and Laura Comee. You may ask any questions you have now. If you have questions later, you may contact Laura at ljcomee@csbsju.edu or 952-693-3406 or Amy at aolson@csbsju.edu. If you have additional questions you may also contact the CSB/SJU Institutional Review Board chair at *irb@csbsju.edu*.

A copy of this form will be emailed to you to keep for your records if you wish.

STATEMENT OF CONSENT

- I have read the above information. I have asked questions and have received answers. I consent to participate in the research
- I know I can stop taking part at any time
- I am satisfied the results will be stored securely
- I am at least 18 years of age
- I have had a recent physical examination and a physician's approval to participate in sports
- I know the results may be published, but they will not be linked to me
- I agree to inform the researcher if I am in pain, or if I feel uncomfortable

Robin Balder-Lanoue and Tim Miles keep records to help identify patterns and effectiveness of training program schedules. They are interesting in helping individuals enhance their

performance and will use shared data to ultimately benefit runners. Your personal data will not be revealed to others should you choose to share your results with the coach.
_____I want the coach to have my results
_____I do not want data shared with my coach

Signature _____ Date _____

Printed name _____

Email Address_____

Last 4-digits of student ID_____

Appendix 3

Hydration Habits Questionnaire
Last four digits of student ID:
Gender:
Circle all that apply/Open ended

1. How much fluid *do you* drink on an average day?_____
2. How often do you drink throughout the day?
    a. At meals
    b. After practice
    c. While studying
    d. At work
    e. During class
    f. Never
    g. Other, Explain____
3. When do you drink fluid?
    a. I drink only when thirsty
    b. I drink according to a schedule
    c. I drink when I know I will be exercising a lot
    d. I drink according to how much weigh I lost while exercising
    e. I drink more when it is hotter out
    f. I drink more after I sweat a lot
    g. I drink as much as I can when I have access to fluid
    h. Other, Explain____
4. How do you monitor your hydration status?
    a. Urine color
    b. Urine frequency
    c. Changes in body weight
    d. Dehydration symptoms i.e. headache
    e. Thirst
    f. I don't monitor my hydration status
    g. Other, explain____
5. Where or from whom did you learn about hydration?
    a. Other runners
    b. Coaches
    c. Health professionals such as doctors or athletic trainers

d. Magazines, books, newspaper
e. Peer-reviewed journal articles
f. Past experience (trial/error)
g. Other, explain____

Choose one answer

6. How often do you weigh yourself before and after a run?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
7. How often do you drink while running?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
8. How often do you carry fluid during the day?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
9. How often do you carry fluids with you while running?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
10. How often are you dehydrated before practice?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
11. On a typical day how well hydrated are you?
    a. Well hydrated
    b. Hydrated
    c. Slightly dehydrated
    d. Dehydrated
    e. Extremely dehydrated
12. Do you drink sport's drinks? If so, Why?
    a. I don't drink sports drink
    b. Taste
    c. Electrolyte content
    d. Carbohydrate content

    e. Other, Explain____
13. Do you know what your sweat rate is?
    a. No
    b. Yes, if so what is it?____
14. Has dehydration ever affected your performance negatively?
    a. No
    b. Yes, if so how many times____
15. How many miles is your peak week?_____

Appendix 4

Before each urine sample

Last four digits of student ID:

1. How hydrated do you think you are today?
    a. Well hydrated
    b. Hydrated
    c. Slightly dehydrated
    d. Dehydrated
    e. Extremely dehydrated
2. When did you last drink fluid? ____
3. How much did you drink today?____

Appendix 5

Knowledge questionnaire

Last four digits of student ID:

1. Which of the follow increases sweat rate?
    a. Humidity
    b. Drinking more water
    c. Increase in temperature
    d. Increase in intensity
    e. Run longer amount of time
    f. Wearing less clothes
    g. Female
    h. I don't know
2. Dehydration can cause:
    a. Increased heart rate
    b. Weight loss
    c. Increase in performance
    d. Increase in perceived effort
    e. Decrease in anaerobic performance
    f. Decrease in cognition
    g. I don't know
3. Over-hydration can lead to which of the following?
    a. Death
    b. Coma
    c. Seizures
    d. Confusion
    e. Muscle cramps

    f. Diarrhea
    g. Weight gain
    h. I don't Know
4. What is the best way to rehydrate?
    a. Pouring water on head
    b. Drinking as much as possible as fast as possible
    c. Drinking only when thirsty
    d. Drinking 150-200% of weight lost during exercise
    e. Drinking 2 cups per pound loss
    f. According to a planned schedule
    g. I don't know
5. What is the number one cause of collapse at the end of a race?
    a. Dehydration
    b. Muscle fatigue
    c. Postural hypotension (drop in blood pressure)
    d. Over hydrating
    e. I don't know
6. What is true about sports drinks, such as Gatorade?
    a. Increases fluid retention
    b. Does not contribute to hydration because it is not water
    c. Provides carbohydrates
    d. Provides protein
    e. Contains potassium and sodium
    f. Causes saltier sweat
    g. I don't know
7. Heat acclimation results in?
    a. More sodium loss in sweat
    b. Decrease in heart rate
    c. Decrease in sweating
    d. Increase in blood volume
    e. I don't know
8. Hyponatremia is occurs more often in?
    a. Men
    b. Experienced runners
    c. Slow runners
    d. Salty sweaters
    e. Runners using NSAIDS (anti-inflammatory drugs, i.e. Ibuprofen)
    f. I don't know
9. What is the baseline (without exercise) recommendation for fluid intake for males?
    a. 15 cups
    b. 11 cups
    c. 8 cups
    d. 6 cups
10. What is the baseline (without exercise) recommendation for fluid intake for females?
    a. 15 cups
    b. 11 cups

c. 8 cups
d. 6 cups

Appendix 6

Questions before swabbing water bottles

Last four digits of student ID:

1. What do you put into your water bottle?
    a. Water
    b. Sport drink
    c. Milk
    d. Fruit juice
    e. Other, explain____
2. Do you fully empty your water bottle before refilling it? (drinking it all or dumping it out? Yes/No
3. How do you clean your water bottle?
    a. Soap
    b. Water
    c. Vinegar
    d. Dishwasher
    e. Other, Explain
    f. I don't clean it because I only put water in it
    g. I don't clean it
4. How often do you clean your water bottle?
    a. Every day
    b. 2-3 per week
    c. 4-6 per week
    d. Once a week
    e. Once every two weeks
    f. Once a month
    g. Never
    h. Other, explain____

Raw Data: Workout

Prediction Females:	Last Drank (minutes)	How Much? (ounces)	USG
hydrated	20	20	1.0102
hydrated	2	56	1.0123
hydrated	135	30	1.0207
hydrated	150	48	1.0093
Slightly Dehydrated	165	48	1.0219
Slightly Dehydrated	20	40	1.0293
dehydrated	2	56	1.0127
hydrated	1	55	1.0073
hydrated	10	20	1.0073
hydrated	10	35	1.0069
Slightly Dehydrated	1	20	1.0296
hydrated	10	40	1.009
Well Hydrated	30	112	1.003
Well Hydrated	1	20	1.0114
Slightly Dehydrated	1	20	1.0228
hydrated	1	84	1.0043
hydrated	75	60	1.011
Slightly Dehydrated	60	25	1.0125
Slightly Dehydrated	5	32	1.0151
Slightly Dehydrated	60	40	1.0077
hydrated	5	60	1.0114
hydrated	60	48	1.0162
Slightly Dehydrated	20	32	1.02
Slightly Dehydrated	30	32	1.0061
Slightly Dehydrated	60	40	1.0219
hydrated	60	32	1.0037
hydrated	30	40	1.0093
hydrated	20	48	1.0029
hydrated	135	36	1.0042
extremely dehydrated	2	8	1.0261
Slightly Dehydrated	20	35	1.0165

Slightly Dehydrated	20	32	1.0037
hydrated	2	64	1.0078
hydrated	10	32	1.0072
Males:			
Slightly dehydrated	30	40	1.0245
Hydrated	1	35	1.0206
Hydrated	120	32	1.0296
Well-hydrated	2	48	1.0102
Hydrated	30	80	1.0024
	30	56	1.0162
Hydrated	1	48	1.0155
Dehydrated	10	30	1.0154
Slightly dehydrated	110	32	1.0168
Slightly dehydrated	135	16	1.0242
Hydrated	120	60	1.0186
Slightly dehydrated	30	40	1.0217
Hydrated	10	28	1.0202
Slightly dehydrated	90	35	1.0159
Slightly dehydrated	30	20	1.0122
Slightly dehydrated	120	32	1.0159
Hydrated	10	40	1.0186
Slightly dehydrated	5	48	1.0182
Dehydrated	420	16	1.0231
Slightly dehydrated	195	16	1.0273
			1.0062
Slightly dehydrated	60	40	1.0228
Slightly dehydrated	60	30	1.0272
Hydrated	30	45	1.0171
Slightly dehydrated	165	56	1.031

Raw Data: Race

Prediction Females:	**Last Drank (minutes)**	**How Much? (ounces)**	**USG**
Slightly dehydrated	15	8	1.0047
Dehydrated	20	4	1.0259
Slightly dehydrated	30	8	1.0181
Slightly dehydrated	20	16	1.0025
Hydrated	15	10	1.0066
Slightly dehydrated	600	0	1.0203
Slightly dehydrated	5	16	1.0015
Slightly dehydrated	20	4	1.0224
Slightly dehydrated	10	8	1.0211

Hydrated		1	16	1.0033
Slightly dehydrated		2	4	1.0261
Slightly dehydrated		720	0	1.0166
Slightly dehydrated		600	1	1.019
Slightly dehydrated		10	10	1.0208
Slightly dehydrated		30	8	1.0216
Slightly dehydrated		15	24	1.0049
Slightly dehydrated		40	8	1.0039
Slightly dehydrated		600	0	1.0226
Dehydrated		5	4	1.0223
Hydrated		15	16	1.0074
Dehydrated		45	11	1.0111
Hydrated		60	5	1.0227
Slightly dehydrated		210	24	1.0348
Slightly dehydrated		5	32	1.023
Hydrated		10	20	1.0054
Slightly dehydrated		20	16	1.0253
Hydrated		60	10	1.0052
Hydrated	Today		8	1.006
Slightly dehydrated		600	8	1.0131
Dehydrated		15	8	1.0249
Dehydrated		20	24	1.0175
Dehydrated		20	3	1.0205
Males:				
Hydrated		30	23	1.0028
Hydrated		2	8	1.0235
				1.0055
Hydrated		2	16	1.0187
Well hydrated		60	24	1.0257
Slightly dehydrated		5	72	1.0272
Hydrated		20	20	1.0131
Well hydrated		1	32	1.0068
Well hydrated		5	17	1.0046
Well hydrated		60	16	1.0076
Slightly dehydrated		420	0	1.0268
Slightly dehydrated		600	0	1.0248
Hydrated		10	30	1.0267
Slightly dehydrated		20	12	1.0292
Hydrated		30	8	1.0223
				1.003

Slightly dehydrated	60	6	1.0257
Slightly dehydrated	60	24	1.0272
Slightly dehydrated	240	16	1.0211
Slightly dehydrated	60	16	1.0095
Well hydrated	30	60	1.0021
Hydrated	1	30	1.0027
			1.0232
Slightly dehydrated	30	30	1.0174
Slightly dehydrated	60	32	1.0326

Raw Data: Recovery

Prediction Females:	Last Drank (minutes)	How Much? (ounces)	USG
Hydrated	20	30	1.0057
Hydrated	20	80	1.0097
Hydrated	1	25	1.0247
Slightly Dehydrated	225	16	1.017
Hydrated	30	60	1.01
Slightly Dehydrated	5	50	1.0186
Slightly Dehydrated	60	48	1.0146
Hydrated	20	50	1.0077
Slightly Dehydrated	10	10	1.0082
Slightly Dehydrated	1	32	1.003
Slightly Dehydrated	240	20	1.0233
Hydrated	10	50	1.0322
Well Hydrated	30	108	1.004
Hydrated	3	40	1.0192
Slightly Dehydrated	240	20	1.0228
Slightly Dehydrated	120	80	1.008
Hydrated	20	50	1.0064
Hydrated	60	33	1.0269
Hydrated	5	32	1.0216
Hydrated	10	32	1.0072
Slightly Dehydrated	15	60	1.0218
Slightly Dehydrated	30	24	1.0232
Slightly Dehydrated	120	16	1.0201
Hydrated	10	32	1.0083
Hydrated	30	40	1.0083
Slightly Dehydrated	75	24	1.0068
Slightly Dehydrated	120	32	1.0142
Slightly Dehydrated	30	48	1.0164
Extremly Dehydrated	195	24	1.0054
Dehydrated	180	16	1.0256
Hydrated	5	40	1.0112

Slightly Dehydrated	60	40	1.0186
Dehydrated	60	64	1.0209
Well Hydrated	10	80	1.0027
Males:			
hydrated	30	32	1.0177
Slightly Dehydrated	5	20	1.0129
hydrated	195	40	1.024
Well hydrated	20	48	1.015
Dehydrated	975	0	1.024
hydrated	4	70	1.0123
hydrated	15	64	1.0044
Slightly Dehydrated	20	30	1.0083
Slightly Dehydrated	60	32	1.0249
Slightly Dehydrated	195		1.021
Well hydrated	120	24	1.0182
hydrated	5	30	1.0222
hydrated	60	32	1.0249
Slightly Dehydrated	60	30	1.0176
hydrated	120	100	1.0047
hydrated	20	56	1.0228
Slightly Dehydrated	1	40	1.0193
Well hydrated	30	70	1.007
Slightly Dehydrated	10	56	1.0271
hydrated	30	32	1.0231
Well hydrated	120	32	1.0119
hydrated	105	60	1.0107
Dehydrated	240	32	1.0118
Slightly Dehydrated	120	32	1.0142
Slightly Dehydrated	30	30	1.0227
Well hydrated	10	160	

Raw Data: Post

Prediction Females:	Last Drank (minutes)	How Much? (ounces)	Number
Hydrated	45	40	1.012
Hydrated	20	40	1.0099
Slightly Dehydrated	105	38	1.0155
Well Hydrated	20	48	1.0101
Hydrated	45	48	1.0069
Dehydrated	255	24	1.02
Hydrated	20	64	1.0186
Hydrated	1	64	1.0099
Slightly Dehydrated	10	48	1.0055
Slightly Dehydrated	60	45	1.0044

Slightly Dehydrated	60	40	1.0303
Slightly Dehydrated	1	10	1.0108
Well Hydrated	30	112	1.0033
Hydrated	5	60	1.0064
Slightly Dehydrated	1	40	1.0219
Slightly Dehydrated	60	64	1.0082
Slightly Dehydrated	120	60	1.0094
Quit			
extremely dehydrated	1440	0	1.028
Hydrated	10	45	1.008
Hydrated	30	50	1.0063
Slightly Dehydrated	60	48	1.0182
Well Hydrated	10	32	1.0138
Slightly Dehydrated	1	32	1.0158
Slightly Dehydrated	10	32	1.0073
Dehydrated	30	32	1.0193
Slightly Dehydrated	30	36	1.0125
Hydrated	135	32	1.0072
Hydrated	5	40	1.0214
Slightly Dehydrated	5	32	1.0262
Hydrated	20	40	1.009
Slightly Dehydrated	20	48	1.0222
Hydrated	10	80	1.009
Males:			
Hydrated	2	40	1.0149
Slightly Dehydrated	1	24	1.0199
Slightly Dehydrated	90	48	1.0251
Well hydrated	10	38	1.0155
Slightly Dehydrated	60	72	1.0056
Hydrated	5	96	1.0206
Hydrated	1	64	1.0115
Slightly Dehydrated	15	48	1.0251
Hydrated	120	48	1.01
Slightly Dehydrated	10	16	1.0264
Dehydrated	120	32	1.0225
Hydrated	10	84	1.01
Slightly Dehydrated	60	30	1.0301
Slightly Dehydrated	1	48	1.0068
Hydrated	30	64	1.0053
Hydrated	60	96	1.0227
Slightly Dehydrated	30	25	1.0107

Hydrated	10	96	1.0224
Hydrated	60	32	1.0171
Slightly Dehydrated	120	32	1.0208
Hydrated	90	60	1.0118
Slightly Dehydrated	60	32	1.0268
Dehydrated	30	12	1.0263
Hydrated	20	32	1.0244
Extremely Dehydrated	195	40	1.0246

Water Bottles

Gender	What do you put into your water bottle?	How do you clean?	How Often?	Aerobic Total (cfu/ml)
F	water	soap	2-weeks	TNTC
F	water	soap	monthly	TNTC
F	water	I don’t clean-only water	monthy	TNTC
F	water/fruit juice	soap	weekly	TNTC
F	water	water	not often	TNTC
F	water	I don’t clean-only water	never	TNTC
F	water	I don’t clean-only water	everyday	TNTC
F	water	soap	2-weeks	TNTC
F	water/sports drink	soap/dishwasher	weekly	TNTC
F	water	soap	2-3 per week	TNTC
F	water	water/ I don’t clean-only water	monthly	TNTC
F	water	water/ I don’t clean-only water	monthly	TNTC
F	water	I don’t clean-only water	monthly	TNTC
F	water	soap	monthly	TNTC
F	water	soap/water	2 weeks	TNTC
F	water	soap/water	monthly	480
F	water/sports drink/milk/fruit juice	soap/water	weekly	381
F	water	water	monthly	320
F	water/ protein powder	water	monthly	290
F	water	soap	2-weeks	185
F	water	soap/water	2-3 per week	155
F	water	soap	monthly	76
F	water	soap/water	weekly	16
M	Water	Soap	2-3 per week	TNTC
M	Water, milk	I don't clean it b/c only water	N/A	TNTC
M	Water	I don't clean it b/c only water	N/A	TNTC
M	Water, sports drink	Water	weekly	TNTC
M	Water	I don't clean it	monthly	TNTC
M	Water	I don’t clean it b/c only water	N/A	TNTC
M	Water	I don't clean it	N/A	TNTC
M	Water	Dishwasher	monthly	TNTC
M	Water	I don't clean it	N/A	TNTC

M	Water	Soap	weekly	366
M	Water	I don't clean it	N/A	230
M	Water	I don't clean it b/c only water	N/A	225
M	Water	I don't clean it	monthly	200
M	Water	Soap/Water	1 per 2 months	165