

Validity and Reliability of a Tool to Assess Beverage Intake in Collegiate Athletes

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ABSTRACT

Hydration status can play a major role in an athlete's physical performance and overall health¹. Athletes may have unique fluid needs that depend, at least in part, on the timing, volume, and type of beverage consumed and the needs required by their training and competition specific to their given sport. Training, travel, and competition can all influence an athlete's fluid needs and separates them from the general public. As such there is a need for valid and reliable tools for assessing beverage intake in this population. The BEVQ-15 is a brief questionnaire that quickly assesses an individual's beverage intake habits over the past 30 days but this survey has not yet been validated in college athletes. Therefore, the purpose of this study is to validate the use of a beverage questionnaire (BEVQ-15) in measuring beverage intake in collegiate NCAA collegiate athletes. To do so, 61 NCAA Division I collegiate athletes were recruited to participate in a cross-sectional, validation study. The participants completed two short BEVQ-15 surveys as well as three 24-hour dietary recall interviews. The results of Bland-Altman suggested acceptable limits of agreement between the two measures with follow up linear regression models indicating no proportional bias. The beverage and food intake from the recalls was analyzed using dietary analysis software (NDSR version 2013, University of Minnesota, Minneapolis, MN), compared using Spearman's rho correlations to the data obtained by the BEVQ-15, and found to have acceptable levels of validity ($R^2 = 0.264$ and 0.262 with $P \leq 0.05$ for total beverage ounces and energy, respectively). The BEVQ-15 questionnaires repeated

on two occasions were found to have acceptable levels of reliability for total beverage ounces ($R^2= 0.641$; $P\leq 0.01$) and for total beverage calories ($R^2= 0.783$; $P\leq 0.01$).

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LAY ABSTRACT

How hydrated an athlete is can play a major role in their physical performance and overall health¹. Athletes may have unique fluid needs that depend, at least in part, on the timing, volume, and type of beverage consumed and the needs required by their training and competition specific to their given sport. Training, travel, and competition can make an athlete's fluid needs different from the general population. As such there is a need for an acceptable tool to determine the beverage intake habits of athletes. This makes a short survey asking about drink consumption desirable for this population. The BEVQ-15 fits this description but has not yet been confirmed for accuracy in college athletes. Therefore the purpose of this study is to prove the accuracy of using drink survey (BEVQ-15) in measuring beverage intake in collegiate NCAA athletes. To do so, this study will look at results from 61 NCAA collegiate athletes recruited from Virginia Tech and Radford Universities. The participants completed two short BEVQ-15 surveys as well as three dietary recall interviews to compare the surveys against. The BEVQ-15 surveys were repeated on two occasions and found to be reliable. The beverage (and food) intake from the recalls was analyzed using dietary analysis software, compared to the data obtained by the BEVQ-15, and found to be a valid tool to assess beverage intake patterns among NCAA Division I collegiate athletes.

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LITERATURE REVIEW

Fluid Compartments

Water comprises the largest fraction of the human body; at birth humans contain between 75-85% water, which decreases throughout the span of an individual's life¹. Adult males are usually 50-70% water by weight². Athletes have higher total body water compared to non-athletes due to their body composition; athletes have more metabolically active cells such as muscle which contains a higher concentration of water compared to fat cells¹.

Physiologic Regulation of Water and Sodium

Water and sodium balance are tightly controlled through thirst and sodium appetite regulation³. Proper renal function also helps maintain homeostasis through excretion or retention of fluid and sodium³. The kidneys are able to handle large electrolyte and water fluctuations, ranging from excessive intake to large losses of either. The kidneys are able to excrete up to 400 mmol per day of excess sodium and up to 10 liters of excess fluid per day via urine³. In times of shortage the kidneys work to preserve the electrolytes and water within the body and mechanisms to prompt intake are utilized³. Healthy adults produce between 1.5-2.0 liters of urine per day, clearing between 900-1200 mOsm each day⁴. When conserving water the kidneys can concentrate urine which in turn decreases urine output to as little as 0.75-1 liter per day while still clearing necessary waste products⁴. In contrast, the kidneys can excrete up to 20 liters of urine per day when water is consumed in excess⁴.

The central nervous system initiates fluid balance corrections by sensing small deviations from homeostasis. Baroreceptors can detect changes in the amount of water

within a cell and relay this information back to the brain⁵. Vasopressin is released when serum osmolality is high or blood volume is low and causes the kidneys to conserve water through urine concentration⁵. Both high serum osmolality and low blood volume stimulate thirst to maintain fluid balance⁵. However, serum osmolality is more sensitive to change as it only takes a 2-3% increase to stimulate thirst⁶. Blood volume can decrease about 10% before fluid intake is stimulated through the thirst mechanism⁷.

Water Balance

Beverage consumption is the main source of water intake among humans, accounting for 70-80% of water consumption⁸. Foods containing water make up the majority of the remaining 20-30% of water intake⁸. The oxidation of substrates during metabolism within the body contributes about 300-400 mL per day³.

Humans lose water through urine, feces, insensible losses through the skin and respiratory tract, and sweat¹. Of these, sweat is the most variable source of water loss and is much greater in active individuals and in those in hot climates¹. Depending on the sport an athlete can lose between 455-3630 mL per day⁹. This yields a net loss of about 1550-6730mL per day when urinary loss, fecal loss, and insensible losses are totaled⁹. With beverage consumption lending to the majority of water intake and sweat lending to the majority of water lost for athletes, understanding what fluids athletes' consume is important for determining their fluid balance.

Impact of Hydration Status on Physical and Cognitive Performance

Dehydration of 2%, the definition of hypohydration, was previously thought to negatively affect physical performance in athletes^{10,11}. However, more recent studies have yielded different results using other factors, including environmental factors and stricter controls for certain extraneous factors^{10,11}. In these studies, athletes could experience greater than 2% fluid losses before performance is decreased, however, mental faculties could be affected at lower fluid losses¹²⁻¹⁴.

Physical Performance

The impact of severe dehydration seems to be lessened on triathletes competing outdoors in a mild environment compared with those studied in a laboratory environment¹². Even with significant weight loss due to fluid losses and increased serum sodium concentrations, there tend to be lower rates of medical diagnoses among triathletes competing outdoors in comparison with athletes studied indoors¹². Surprisingly, athletes who suffer the most weight loss actually have a slight but significant correlation with faster times. These findings overturn the previous belief that 2% weight loss causes severe detrimental effects to endurance athletes; this does not suggest a causation, however, that the greater weight loss actually caused the faster times¹².

The change in weight that occurs in athletes during exercise only accounts for about 5% of the variability in overall performance time¹². Some of the criticisms researching individuals racing outside include that when an individual starts to fatigue from dehydration and suffer from overheating, their effort levels decrease in response.

Following the findings with triathletes, others researched what would happen if participants were studied outside of the lab but with more controlled factors. In submaximal tests, researchers found that a difference of 2.5% fluid loss during the effort, while keeping finishing time constant between the tests, resulted in a post run body core temperature increase of 0.5°C and an increase in heart rate of 15 beats/min¹⁵. Heart rate was also 10 beats/min higher at the ten minutes post run time point, leading to the belief that dehydration may affect recovery from exercise even more than it affects heart rate during the bout of exercise¹⁵. Dehydration negatively impacts performance in a lab setting; however, when endurance athletes are allowed to adjust speed and effort levels freely, such as during a competition, then these negative impacts are reduced^{12,15}.

There is some controversy regarding the effects of hypohydration on strength performance¹⁶. In a short-term, maximal effort type exercise there are several studies^{17,18} that show a decrease in performance while most others show no difference in muscular strength^{16,19,20}. Testing a vertical jump test where the mass lost through hypohydration improved performance may account for the differences in results; some studies measured muscle force directly while others measured vertical jump height¹⁶. One suggested reason that there is no observed difference in muscular performance with anaerobic testing is due to the fact that levels of ATP, the molecule responsible for supplying energy to cells, and phosphocreatine, a molecule that rapidly restores ATP when energy demand is high, remain similar even with larger water losses from the body¹⁹. Exercise sessions that require multiple repetitions and sets of a strength movement, which is typical in resistance training, showed a significant difference in performance following hypohydration¹⁶.

Hydration status also plays an important role in thermoregulation. As hypohydration in athletes increases, core temperature also increases between 0.10°C and 0.40°C for each percent of body weight lost²¹. This increase in temperature is associated with a decrease in sweat rate of hypohydrated individuals and is more severe in hot environments over temperate ones²¹.

Cognitive Performance

Hydration status plays a role in athlete's cognitive performance as well. Previous studies claimed cognitive effects at 2% weight loss from dehydration but more recent studies are finding that as little as 1-2% weight loss, defined as mild dehydration, can impair cognition^{11,14}. Those detriments in their cognitive function are measured by moodiness, increased fatigue, slower reaction times, increased anxiety levels, and poor concentration^{13,14}. To many athletes, these mental functions, especially reaction time and concentration, are critical to optimum performance in their respective sports.

Impacts of Hyperhydration

A less common but more severe altered hydration status is hyperhydration, which can lead to hyponatremia and potentially death²². One of the first symptoms of hyperhydration is intracranial pressure due to the swelling of the brain cells from electrolyte imbalances and if balance is not restored then seizures or death may result²². Hyperhydration can occur in athletes when they consume more water than their kidneys can process, which is about 800-1000mL per hour, while not consuming enough sodium to replace losses through the sweat glands²³. Cases of exercise-associated hyponatremia have increased since 1981,

when athletes were first advised to consume fluids during exercise instead of avoiding fluid consumption²³. When considering marathon and Ironman finishers, 11% of the endurance athletes finish the race in a hyperhydrated state²³. Of the hyperhydrated athletes, 11% develop clinically significant hyponatremia, 19% have asymptomatic hyponatremia, and 70% of the athletes remain hyper- or normonatremic²³.

Factors Affecting Fluid Intake and Needs

Sweat Loss

Fluid needs vary greatly due to athletes' unique sweat rates and environmental factors, which cause sweat rates to vary from 0.5-2.0 L/hour^{24,25}. Factors contributing to sweat loss include the type and length of exercise, the environmental temperature, and the individual's unique sweat rate²⁴. Even while maintaining similar environmental factors, individuals may have differing sweat rates from fellow athletes²⁵. This variation in fluid loss makes maintaining adequate hydration more challenging for athletes²⁴. Therefore, it is important to study this population's fluid intake habits.

Thirst Cues

Losing greater than 2% of an individual's body weight during exercise may lead to decreased performance^{9,24,25}. However, athletes may not recognize their states of dehydration because thirst will not cue drinking until 1-2% of body mass is lost from a water deficit²⁶. The new guidelines by the International Olympic Committee suggest that athletes drink enough to maintain their starting weight during exercise or replace the weight lost during exercise post workout; in addition, athletes should take a sodium

supplement to help retain the fluids consumed²⁷. This strategy may help ensure that athletes replace fluid before they reach a level of hypohydration that impedes performance.

Gender

Male athletes are more likely to be hypohydrated when compared to their female counterparts²⁸. The prevalence of dehydration has been reported to be higher in male (47%) compared to female (28%) NCAA Division I athletes, with urine specific gravity (USG) via refractometry as the defining measurement²⁸. The differences in beverage consumption between genders are one possible explanation for the different hypohydration rates. Male athletes are more likely to consume juice during the week, as well as sports drinks and energy drinks on the weekends than their female counterparts²⁹. Male athletes are also more likely to consume alcohol during the competitive season than females at roughly 25% compared to 14% respectively²⁹. Female athletes were more likely to consume water an hour before a practice or competition than males²⁹. Women have a higher threshold for the onset of perspiring when compared to men which may also contribute to the difference of hypohydration rates³⁰. This suggests that the core temperature threshold for perspiration during exercise is higher in women compared with men and the female's body does not maintain its core temperature as low as a male's body³⁰.

Differing Sports' Rules and Environment

The type of sport in which an athlete participates and the availability of fluids during that sport impacts their hydration status³¹. Endurance sports, for example, often have aid stations at designated locations for participants to utilize. Many individuals also decide to carry their own water between aid stations. Within endurance competitions, there is great variance between individuals on finishing times, leading to a large potential difference in the change of body mass experienced by the competitors³². Some individuals may lose up to about 10% body mass in a marathon and still perform well enough to be leading where other individuals finishing closer to the back of the pack may actually gain up to 5% body mass, placing them at a higher risk for hyponatremia³². Individuals finishing at the slower times have more time to drink water but typically do not consume sodium, which is what places them at higher risk for hyponatremia³². Another important factor for endurance athletes is the duration of the race which gives the potential for varied temperatures and terrains throughout the event which then influences sweat rate³². Endurance athletes may meet energy and carbohydrate needs but typically do not meet their fluid intake recommendations³³.

Team sports' demands are different than the continuous effort of endurance sports and as such yield different fluid needs for the athletes. The short and unpredictable bursts of energy required for team sports means that sweat rate within a game can change throughout³¹. Outdoor team sports, such as football, soccer, and rugby, can take place in a variety of temperatures, also contributing to changes in sweat rates for athletes. Indoor team sports, such as volleyball, have more constant temperatures and climates than outdoor sports leading to more consistent sweat rates between games³¹. The smaller

setting of the indoor sports compared to field sports yield higher energy output for quicker changes in pace and direction. Rules of the game can influence when athletes are allowed to drink; some sports have many time outs during which time athletes can consume fluids while others only let athletes drink at the end of 45-minute quarters³¹.

Athletes' knowledge and attitude regarding hydration and nutrition positively correlates with their behaviors concerning their hydration practices³⁴. Observing specific knowledge, attitude, and behavior statements and rankings demonstrates that knowledge positively correlates with hydration behaviors in collegiate athletes but that hydration knowledge tends to be low³⁴. Endurance athletes tend to test better on knowledge and subsequent behavior scores than their skilled athlete counterparts³⁴. With improved knowledge of fluid intake and hydration status, athletes could demonstrate improved behavior outcomes towards proper hydration³⁴. Monitoring behaviors and reinforcing positive ones should improve athletes hydration status³⁴.

Gastric Emptying Rate

Another factor that contributes to athletes' fluid intake is their gastric emptying rate²⁵. If fluids are consumed faster than the gastric emptying rate can clear them of the athlete's stomach then abdominal discomfort may deter the athlete from consuming more fluids³⁵. Hot climates may reduce an individual's gastric emptying rate for fluids³⁵. An individual in a hypohydrated state in mild climates may also experience a reduced gastric emptying rate from dehydration's impact on the digestive system³⁵. Athletes often experience discomfort when consuming greater than 1.25 L/hour of fluid as this is generally the maximal gastric emptying rate for fluids³⁵. With common sweat rates of 2.0L/hour it can be difficult for

athletes to keep up with their fluid losses during exercise²⁴. Starting exercise in a euhydrated state and drinking early in a workout session are both very important for individuals with calculated sweat rates greater than their gastric emptying rate; this will at least delay the onset of hypohydration in the individual.

All of these variables influence an athlete's intake of fluids and their hydration status, giving cause to study this specific population separate from their similarly aged but less active counterparts. Fluid consumption during exercise also makes athletes of interest to study because their fluid intake, and therefore their answers on a beverage questionnaire, may vary from day to day.

Fluid Recommendations for Athletes

Before Exercise

Fluid recommendations for athletes are higher than those set for the general population. Athletes are recommended to begin training or competition in the euhydrated state²⁴. This can be challenging for athletes, especially during the height of the season when athletes may have multiple workouts each day. If an athlete has not replenished his or her fluids since the last training session, then the athlete should slowly drink 5-7 mL per kilogram of their body weight in fluids at least four hours prior to their workout³⁶. If the athlete's urine is dark or no urine is produced, then another 3-5 mL per kilogram of his or her body weight should be consumed two hours out from the competition³⁶. Incorporating 20-50 mEq/L of sodium with the fluids will help to stimulate thirst, as well as retain the fluids consumed and restore plasma osmolality³⁶. Pre-exercise hyperhydration through

water and glycerol solutions has not demonstrated any physical advantage over euhydration^{37,38}.

During Exercise

During exercise, athletes are recommended to consume fluid at a rate that prevents hypohydration and excessive changes in their electrolyte balance. Indeed, athletes should consume fluids during exercise to prevent greater than 2% changes in body weight; to determine these changes, athletes are recommended to weigh themselves throughout exercise to determine water losses²⁴. Athletes' sweat rates vary by the size of the athlete as well as the sport and climate in which the athlete is training or competing³⁹. This variability in sweat rates among athletes makes it imperative for each individual to weigh himself during exercise to determine water loss instead of using a standard recommendation. When exercising for longer than 3 hours, athletes should be more mindful in the specific amount and ratio of fluids and electrolytes consumed, as there is a greater chance of hypohydration or hyponatremia due to accruing errors of intake³⁹.

During prolonged sessions, like ultra-endurance events or physical activity in hot climates, athletes should consume sports drinks or other sources of electrolytes in order to prevent or slow the onset of hyponatremia³⁹. Sports drinks should contain a 5-10% carbohydrate concentration and provide between 20-30 mEq/L of sodium, as well as 2-5 mEq/L of potassium⁴⁰. Consuming a 6% carbohydrate ratio beverage has shown to yield faster times for cyclists when compared to more concentrated beverages of 40% carbohydrates or those containing no carbohydrates⁴¹.

Post Exercise

After exercise, athletes should replace lost fluids and electrolytes before the onset of their next exercise session⁴². Athletes should consume 150% of the weight they lost from exercise in fluid; this volume equates to about 1.5L/kg of mass lost⁴². Beverages containing high sodium concentrations aid fluid balance restoration when compared to beverages lacking sodium⁴². Athletes who consume beverages containing at least 100mmol/L sodium retain 71% of the fluid consumed compared with just 37% of the fluid consumed when no sodium is present⁴². In cases of severe dehydration, providing fluids intravenously may be warranted; however, there are no significant performance advantages to rehydrating with fluids provided intravenously over consuming fluids orally⁴³. Intravenous (IV) fluids provide an advantage to severely dehydrated individuals because it speeds the recovery process. Hence, IV fluids are also warranted for those experiencing diarrhea or those who cannot consume fluids orally⁴³.

Sport-Specific Considerations

Sports with weight categories should check hydration status to ensure proper hydration before competitions¹⁰. Upper limits of 1.020 and 4.000 should be set for USG and urine color, respectively¹⁰. Hydration checks can reduce athletes' usage of diuretics, rubber suits, or exercise in a sauna, all of which are dangerous practices for athletes¹⁰. Beverage questionnaires could be useful to help determine which athletes meet fluid needs and which do not.

Urine and Hydration Assessment

Urine specific gravity is a measurement that compares the density of an individual's urine against water, which has a density of 1.000 g/mL¹⁰. Urine will be denser than water, so the values should be greater than 1.000¹⁰. Measures of 1.010 signify a well-hydrated individual, while values greater than 1.020 may indicate hypohydration of an individual¹⁰. A study comparing methods of urine analysis and hydration reported that all the urine measurements taken were highly correlated with one another¹⁰. Three methods of obtaining USG were used, including a test strip, Refractometry, and laboratory testing, all which had r-values of 0.8 at $P < 0.01$ ¹⁰. USG was only moderately correlated ($r = 0.4$, $P < 0.05$) with urine color¹⁰.

Refractometry appears to be more reliable than the use of hydrometers and reagent strips for assessing hydration⁴⁴. A refractometer is an instrument that gives a precise measure of USG¹⁰. There is excellent inter-test and intra-test reliability for measurement of urine specific gravity using refractometry⁴⁴. In comparison, the hydrometer only demonstrated intra-test reliability and the reagent strips lacked reliability for both⁴⁴. From this finding, refractometers are recommended to determine the USG in collegiate sports with weight-certification practices⁴⁴. The three types of refractometers all exhibit acceptable reliability with no statistically significant differences between readings⁴⁵.

Urine color is an inexpensive and rapid estimate of hydration status which may be particularly useful as an assessment in the field⁴⁶. There is a strong correlation between urine color, USG, and urine osmolality except when water turnover rates are high, such as observed during heavy training in Olympic athletes in the summer heat⁴⁷. However,

observing cyclists showed that urine color and USG may still be correlated even during times of exercise-induced high water turnover rates²⁶.

Urine color is influenced by other factors besides hydration status. For example, medication use, illness, and supplements can all affect urine color, which may make this tool less effective for athletes, especially for the athletes taking supplements²⁶. When an eight-color scale is used to assess urine color, however, there is a strong correlation between color and urine osmolality²⁶. This provides a useful index for athletes to assess their hydration status when they cannot directly determine their USG or urine osmolality²⁶.

If hypohydrated athletes try to rehydrate themselves with a large amount of pure water consumed rapidly, then a large amount of very pale urine may be excreted initially²⁶. It then becomes important for the athlete to take several urine samples consecutively to ensure that the body was rehydrated at the cellular level instead of the water simply passing through the system without being entirely absorbed²⁶. This is an instance when urine color may be misleading because the color of the urine may indicate a hydrated individual even though the athlete is recovering from a hypohydrated state. While there are several barriers to utilizing urine color charts in athletes, it is still an inexpensive and possibly helpful tool to give a basic estimate of hydration status when more exact methods are not available.

Dietary Assessments

24-hour Recall

Twenty-four hour recalls are a validated assessment tool used to collect data about individuals' dietary habits and intake⁴⁸. To estimate usual intake, two or three repeated

tests over the course of several days, including at least one weekend day, are required⁴⁸. Several benefits of the 24-hour recall include its ability to be used in low literacy populations and very little time required by the participant, so there is a low burden placed upon them⁴⁸. However, this method is not recommended for use in children or the elderly because it relies on the participant's memory of what they consumed 24 hours prior to the interview session⁴⁸. Of note, 24-hour recalls administered over the phone have been found to be as effective and accurate as those conducted in person⁴⁹. Phone interviews could be useful in certain populations where meeting in person proves difficult and thus would limit participation by the desired target population.

Dietary Records

Dietary records are another form of dietary assessment. They are often viewed as the reference when validating other methods of dietary intake assessments⁵⁰. Dietary records require the participant to record all foods, beverages, and supplements consumed for a specific period of time, in great detail⁵⁰. This specificity makes it precise but also adds limitations to the assessment tool; participants may alter what they consume in order to make the recording process easier or in order to present a more socially acceptable food intake record⁵⁰. This method may capture the participant's current diet precisely but miss their usual diet if the record is too short or administered when the individual is not consuming their typical foods, such as over a holiday or during religious fasting periods⁵⁰. This method places a high level of burden on the participants to record but does not require remembering past meals, which reduces the amount of omissions from the intake record⁵⁰. Even so, in a study with collegiate athletes, the seven-day diet record was found to

underestimate intake by 15% when compared to energy expenditure as assessed by doubly labeled water⁵¹.

BEVQ Background

Beverage consumption is the largest contributor of fluid intake in an individual's diet, with food accounting for the remainder of fluids from the diet; as such, it is important to know the quantity of different beverages an individual consumes⁵². To assess beverage intake rapidly and in an affordable fashion, a beverage questionnaire, called the BEVQ-19, was created. The BEVQ-19 was condensed from 19 beverage categories to 15 categories, thus creating the current BEVQ-15⁵². The BEVQ-15 today takes about five minutes for an individual to complete and is a quick assessment to evaluate an individual's typical beverage consumption over the past 30 days⁵².

The categories that contributed less than 10% of the participant's daily calories or grams were condensed or eliminated from the BEVQ-19⁵². Three categories were eliminated including vegetable juice, mixed alcoholic drinks, and meal replacement drinks⁵². Light beer was combined with regular beer to create the current 15 categories⁵². After the changes were made, a follow up study was conducted to evaluate the validity of the new questionnaire⁵². All the categories were strongly correlated with food intake records (FIR) with the exception of the whole milk category⁵². The total calorie and gram values were consistent across the BEVQ-19 and the reduced BEVQ-15⁵². Another change made to the current BEVQ-15 was the addition of the phrase sports drinks to the energy drink category⁵². This category was among the bottom 10% of energy contribution until the phrase sports drinks was added to the original BEVQ-19⁵². Before this addition, many adult

participants reported uncertainty about where to classify sports drinks in the questionnaire because there was no specific category for this beverage class⁵³. The addition of this phrase is an important change to help correct the underreporting of energy containing beverages among the adult population⁵². However, sports drinks are currently paired with energy drinks, which are not the same in composition and may skew results in a population where sports drinks are consumed frequently. In an athlete population, there may need to be adjustments made to the BEVQ-15 to create a more specific measurement tool in order to obtain valid results⁵³.

Hedrick et al.⁵⁴ demonstrated that the BEVQ-15 is sensitive enough to detect changes in an individual's beverage intake over time. With the exception of energy drinks, the beverage categories had significant test-retest correlations ($R=0.52-0.95$) between visits; as such, the BEVQ-15 was found to be a reliable method for beverage intake measurement⁵⁴.

Fluids and Substances Found on the BEVQ

The types of fluids consumed by individuals are of interest because they affect the risk for certain diseases and contribute to total energy intake³. Flavonoids in tea and cocoa have been suggested to help reduce the risk of cardiovascular disease³. Red wine may reduce the risk for cardiovascular disease in moderation; however, alcohol can increase blood pressure when consumed in excess and thus be detrimental to one's health³. Many fluids also increase the number of calories consumed in a day by an individual, which may contribute to undesired weight gain.

Sugar-Sweetened Beverages

Sugar-sweetened beverages (SSBs) can be defined as those that contain caloric sweeteners and include carbonated soft drinks, fruit drinks including punches, sweetened tea and coffee, and sweetened milks or milk substitutes⁵⁵. On average, about half of the U.S. population ages two and over consume SSBs⁵⁵.

Sugar-sweetened beverage intake appears to be higher in males (55%) compared with females (40%)^{55,56}. Males between 18-84 years old consume an average of 302 kcal/day from SSB compared with 158 kcal/day for females⁵⁶. Males also consume more calories per day compared to females across all age groups, even as young as 6-11 year olds⁵⁵. According to the NCHS, males consume 178 kcal/day from SSBs as an average of all age groups compared to 103 kcal/day consumed by females⁵⁵.

African Americans consume more calories per day from SSBs than non-Hispanic whites consume. African Americans take in about 224 kcal/day compared with whites who consume about 129 kcal/day on average⁵⁶. Mexican Americans over the age of 20 consume a statistically higher percent of their total calories per day from SSBs than Non-Hispanic whites consume⁵⁵. Calories consumed from SSBs tend to decrease with an increase in education; individuals who complete grad school consume the least calories (87 kcal/day) from SSBs and individuals with only some high school but did not receive a degree consume the most calories (277 kcal/day) from SSBs⁵⁶.

Individuals aged 12-19 of both genders consume the most calories per day from SSBs⁵⁵. After this peak, each age group, grouped by 20 years thereafter, consumes fewer calories from SSBs than the age group prior⁵⁵. By age 60, individuals' average caloric intake from SSBs drops to slightly fewer calories than the average intake for 2-5 year olds⁵⁵. This

prevalence in the young adult population gives reason to look at college students' consumption of such beverages.

Lower-income individuals tend to consume a higher percent of their total daily calories from SSBs when compared to higher-income individuals⁵⁵. Individuals below 130% of the poverty line consume 8.8% of their calories from SSBs, those between 130-350% of the poverty line consume 6.2% of their calories from SSBs, and those above 350% of the poverty line consume just 4.4% of their calories from SSBs⁵⁵.

Reducing liquid calories is correlated with more weight loss per 100 kcal when compared to reducing solid calories⁵⁷. Liquid calories also appear to impact weight gain more in black individuals than white individuals⁵⁷. Excess sugar consumption is correlated with an increased risk for type 2 diabetes and leads to obesity; SSBs are among the top contributors of sugar consumption in the U.S. diet⁵⁸ These facts can all influence athletes health and performance.

Artificially Sweetened Beverages

In an attempt to reduce the calories consumed from SSBs another form of beverages called artificially sweetened beverages (ASB) were created⁵⁹. These beverages contain very few, if any, calories and are often termed diet beverages in the market⁵⁹. In the U.S., about 80% of the population does not consume diet beverages on a daily basis, about 3% consume some but no more than 8 fluid ounces, and about 11% consume 16 fluid ounces or more daily⁵⁹.

Females tend to drink more diet beverages than men⁵⁹. Non-Hispanic white individuals drink more diet beverage than other race/ethnic groups⁵⁹. This is statistically higher than either African Americans, at 10.1%, or Hispanics, at 14.1%, in the same age group⁵⁹.

Household income has a significant impact on diet beverage consumption⁵⁹. A greater percentage of higher-income individuals consume diet beverages when compared to lower-income individuals⁵⁹. A total of 32.6% of those living at or above 350% of the poverty line aged 20 and over consume diet beverages compared to 12.2% of those living below 130% of the poverty line and 20.1% of those living between 130-350% of the poverty line⁵⁹. The percentage of individuals consuming diet beverages increases with age for both males and females⁵⁹. The 40-59 year olds have the highest percentage of their population consuming diet beverages and then this decreases slightly in the 60 and over age group population⁵⁹.

Aspartame, which is found in many ASBs, taken in a pill form can decrease the amount of calories consumed in the following meal when taken one hour pre-prandial⁶⁰. Other low calorie sweeteners do not have the same significant effect size on calorie reduction as Aspartame; it is hypothesized that Aspartame raises the blood phenylalanine concentration, which increases satiety rather than the gut signaling the sweet taste of the encapsulated sweetener⁶⁰. The amount of Aspartame used is similar to one to two diet sodas⁶⁰.

Alcoholic Beverages

Alcoholic beverages may contribute significant calories to an individual's diet and oftentimes is an overlooked area of calorie consumption⁶¹. There are many factors that contribute to an individual's consumption of calories from alcohol⁶¹. About one third of

men consume alcohol when only about 18% of women consume alcohol on any given day⁶¹. Men also tend to consume more calories from alcohol than women at about 150 calories on average per day versus just over 50 calories on average per day for women⁶¹. Beer tends to contribute the greatest number of calories for men's alcohol consumption over liquor or wine⁶¹. Women's calories are spread more evenly between those three types of alcohol⁶¹.

The number of calories consumed from alcohol does not differ among racial/ethnic groups⁶¹. Income correlates with the amount of calories consumed from alcohol⁶¹. Women above 350% of the poverty line consume significantly more calories from alcohol at 75 kilocalories compared to those below 130% at 42 kilocalories and those between 130% and 350% of the poverty line at 37 kilocalories⁶¹. Both genders aged 20-39 consume the most calories from alcohol and the older age groups tend to consume fewer calories progressively⁶¹. Men aged 20-39 consume an average of 174 kilocalories per day and women from the same age group consume 61 kilocalories per day on average⁶¹. Typical college students fall nearest to the age group that consumes the most calories from alcohol, making college students of interest to study number of calories consumed from alcohol⁶¹.

Coffee, Tea, and Energy Drinks

Caffeine can be found in several different categories across the BEVQ-15, including energy drinks, and the two coffee and tea categories¹⁰. In the past, athletes were recommended to avoid caffeine due to its potential diuretic effects¹⁰. However, caffeine does not significantly change fluid retention, urine output, relative dehydration, or sweat rate in athletes⁶². Caffeine may have a diuretic effect. However, caffeine does not appear to influence exercise-induced hypohydration⁶³. Caffeine can, however, impair rehydration

following exercise in a hot climate when compared to water or a non-caffeinated sports beverage⁶⁴.

Conclusion

Maintaining fluid balance and hydration status is extremely important for individuals, especially those in an athletic population. Beverage consumption is the largest contributor to water intake and as such is of particular interest where hydration status is concerned. Dehydration can decrease an athlete's ability to regulate heat properly, increase oxidative stress from exercise, and can decrease an athlete's recovery time, measured using heart rate, from exercise. Athlete's sweat rate is highly variable and can affect their hydration status. Sweat rate and water availability are also influenced by the sporting event; indoor sports tend to be more environmentally controlled and as such athletes sweat more consistently. Outdoor sports' environments can vary, which leads to more varied sweat rates and subsequent water losses. The method of hydration assessment can impact results; there is no gold standard for assessing hydration meaning that each method has its own advantages and shortcomings depending on the situation. Choosing dietary assessments can also prove difficult and depends greatly on the situation and the population. The goal of this study is to determine the validity of the BEVQ-15 in collegiate athletes so that it can serve as an effective tool in the future to help determine beverage intake among athletes.

PURPOSE

The purpose of this study is to determine the validity and reliability of the BEVQ-15 in assessing beverage intake in collegiate athletes when compared with 24-hour recalls. The BEVQ-15 was validated in adult populations but not in an athlete population. Collegiate athletes have many factors influencing their beverage intake including training, traveling, their school schedules, and financial and mental stressors. These factors can influence their resulting hydration status, which makes them a population of interest to study.

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CHAPTER 2. Validation of a Beverage Intake Tool in Collegiate Athletes

ABSTRACT

Background: Training, travel, and competition can make an athlete's fluid needs different from the general population. As such, there is a need for an acceptable tool to determine the unique beverage intake habits of athletes. The BEVQ-15 is one such tool to determine beverage intake over time but has not yet been confirmed for accuracy in college athletes.

Objective: The purpose of this study is to evaluate the validity and reliability of the beverage questionnaire (BEVQ-15) for measuring fluid intake in collegiate NCAA athletes.

Design: Athletes were recruited from two NCAA Division I universities. The individuals in this study (n=61) completed two short BEVQ-15 surveys plus three dietary recall interviews administered by trained diet technicians to compare the surveys against. The two surveys were administered at least three days apart and the 24-hour dietary recalls included two weekdays and one weekend day.

Results: This study included 61 athletes at the conclusion. Comparing the BEVQ-15 to the 24-hour recall standard, Spearman's rho correlation tests found that 7 of the 15 categories are significant at $P \leq 0.01$ when comparing fluid ounces, while 5 of the 14 categories are significant at $P \leq 0.01$ when comparing kcal consumed. An additional 3 categories for both ounces and kcal consumed are significant at $P \leq 0.05$. With these findings, validity criteria are met. Fruit juice, sweetened fruit juice, low fat milk, diet soft drinks, sweetened tea or coffee, and hard liquor are not strongly correlated between testing methods in the collegiate athlete population. Pearson correlations demonstrated significant reliability comparing BEVQ-15 responses of test one and two for all but one category for ounces

consumed and three for calories consumed at $P \leq 0.01$. The results of Bland-Altman suggested acceptable limits of agreement between the two measures. Follow up linear regression models indicated no proportional bias.

Conclusions: The BEVQ-15 is a valid tool for the assessment of beverage intake in an NCAA Division I athlete population. As such, the BEVQ-15 may be a useful tool for assessing beverage intake and patterns in collegiate athletes.

INTRODUCTION

An athlete's fluid consumption habits affect their hydration status, which in turn may impact their performance. As such, valid and reliable tools for assessing beverage intake in athletes is needed¹. In order to determine an individual's habitual beverage consumption, a short questionnaire called the BEVQ-19 was created². This tool had 19 different categories of beverages, which were later condensed into 15 categories to create the currently used BEVQ-15². The BEVQ-15 takes about five minutes for an individual to complete and is a quick assessment to evaluate the typical beverage consumption over the past 30 days². This tool has been validated in the general adult population but no tool like this has been validated for collegiate athletes³. An athlete's needs within the questionnaire may differ from the general population in the sports drinks category or the other category where athletes can write in beverages they consume which are not otherwise reflected in the BEVQ-15³.

Many differing factors can affect an athlete's day-to-day fluid needs. Athletes' needs vary greatly between individuals due to their unique sweat levels and environmental factors, which cause sweat rates to vary from 0.5-2.0L/hour^{4,5}. Type and length of exercise,

an athlete's sport, environmental temperature and conditions, and individual sweat rates all contribute to the overall amount of sweat lost by an athlete on a given day⁴. This variation in day-to-day fluid loss makes maintaining adequate hydration more challenging for athletes than non-athletes⁴. This makes an accurate tool to assess fluid intake even more crucial in the collegiate athlete population when compared to the general population. However, there are currently no valid tools for assessing beverage intake among collegiate athletes. As such, efforts to establish the validity and reliability of any such tool is needed.

METHODS

Participants and Design

Participants for this study were recruited via email and flyers distributed to Division I NCAA sports teams at Virginia Tech and Radford and their members after approval from the Athletics Department and the teams' coaches. The inclusion criteria encompassed both men and women 18 years of age and older who are members of a Virginia Tech or Radford University Division I NCAA intercollegiate athletic team. Those experiencing an injury or acute illness that precludes their participation in regular training and or competition were excluded from this study. The Virginia Tech and Radford Institution Review Boards both approved the study protocol. The Athletics Department also approved the study protocol for their athletes' participation. Written and verbal informed consent was obtained from all the participants.

Dietary Assessment

Subjects were interviewed in person by a trained diet technician to assess and record their 24-hour dietary intake of the previous day. On the same day as the first in person interview a beverage questionnaire (BEVQ-15) was administered. The participants completed the short food frequency questionnaire specifically addressing habitual beverage consumption. The trained diet technician met with the participant two additional times in person over the following two weeks to acquire three total 24-hour dietary recalls, which included one weekend day and two weekdays. The participants completed a second BEVQ-15 on either the second or third interview session. The dietary data was analyzed using NDS-R version 2011 (University of Minnesota, Minneapolis MN).

Statistical Analysis

Statistical analyses were performed using the statistical analysis software SPSS (v. 24 for Mac OS, 2016, SPSS, Chicago, IL). The descriptive statistics (mean \pm standard error of the mean; frequencies) are reported as an average of the total consumption across the beverage categories in both ounces and kilocalories for the given sports and gender demographics. To assess the validity of the BEVQ-15 in an athlete population, each response item on the questionnaire was compared to the averaged of the corresponding item from the three 24-hour recall using Spearman's rho correlation analyses. Bland-Altman plots were used to assess the limits of agreement on certain categories of interest between the BEVQ-15 and the 24-hour recall. Linear regression models were used to assess proportional bias. Pearson Product Moment correlations were used to assess reliability of the BEVQ-15 questionnaire trials.

RESULTS

Subject Characteristics

The characteristics of the participants (n=61) are summarized in Table 1. The majority of participants were female at 60.7% of the sample. Soccer players represented the largest portion of the sample at 37.7%. All participants attended either Virginia Tech or Radford Universities at the time of the study, and were enrolled NCAA DI athletes. Age ranged from 18-23 years old (mean 19.80 ± 1.53). BMI ranged from 19.04 to 29.49 (mean 22.62 ± 1.85). Less than 10% of the participants were in the overweight category with 0% lying within the obese category.

Validity

To evaluate the validity of the BEVQ-15 in an athlete population, major outcomes were compared with the outcomes from the 24-hour dietary recalls. Spearman's rho correlations comparing the BEVQ-15 and the 24-hour recall are outlined in Tables 2-3. These correlations show that 7 of the 15 individual beverage categories are significant at $P \leq 0.01$ when comparing ounces, while 5 of the 14 categories are significant at $P \leq 0.01$ when comparing kcal consumed. An additional 3 categories for both ounces and kcal consumed are significant at $P \leq 0.05$. The BEVQ-15 was correlated ($R^2=0.275$; $p \leq 0.05$) with the standard when determining calories consumed from all SSB categories combined. However, the BEVQ-15 is not significantly correlated with the standard when evaluating fluid ounces consumed across all SSB categories. Fruit juice, sweetened fruit juice, low fat milk, diet soft drinks, sweetened tea or coffee, and hard liquor are not significantly correlated between the BEVQ-15 and 24-hour recall in the target population. Bland-Altman

plots, shown in Figures 1-7, were performed for several categories of interest, including the fluid ounces and kilocalories consumed. Strong limits of agreement existed for water (oz), energy/sports drinks (oz, kcal), total SSBs (oz, kcal), and total beverages (oz, kcal). Several outliers exist within the Bland-Altman graphs; likely causes for these values include the participants' misunderstanding of questionnaire directions given or poor understanding regarding portion sizes of beverages consumed. Follow up linear regression models were run on each Bland-Altman plot and the results are summarized in Table 5. The linear regression models verify that there was no proportional bias of the scatter plot points, thus showing an equal distribution about the average mean line with no trends favoring one side or direction.

Reliability

Pearson correlations demonstrated significant reliability comparing BEVQ-15 responses of test one and two for total beverage ounces ($R^2=0.641$; $P\leq 0.01$) and total beverage calories ($R^2=0.783$; $P\leq 0.01$). Both the nut milk and black tea or coffee categories are significantly correlated for ounces consumed but not for calories consumed. The diet soft drink category is not significantly correlated for either ounces or kcal between the two tests. All other categories are significantly correlated between tests one and two at $P\leq 0.01$. These correlations are summarized in Table 4.

Fluid Intake Patterns

The percentages contributed to overall fluid ounces consumed from each category are shown in Figure 8. By comparing Figure 8 and Figure 9, one can see the differences in fluid

ounces contributed and kilocalories contributed by each beverage category. The differences between the two graphs are related to the energy density of the beverage. Water, for example, makes up a large portion of the total ounces consumed but does not contribute to calories consumed. Sports drinks make up roughly one third of an athlete's overall calories consumed from beverages on a given day. Whole milk and juice combined make up another third of total calories consumed. Nine additional beverage categories contribute to the remaining third of calories consumed.

DISCUSSION

The overall finding from this study was that the BEVQ-15 is a valid survey to determine fluid ounces and kilocalories consumed by collegiate athletes. The correlation of the two testing trials with the majority of the categories was strong, thus supporting that the survey is a reliable tool in an athletic population. The correlations with fluid ounces reported in the surveys versus the 24-hour recall appear stronger across more categories than the correlations with the two collection methods when comparing kilocalories. The lower calorie beverage categories, including diet soda, black tea or coffee, and low fat milk, or those that do not contribute a significant percentage of the athletes' daily intake, including both juice categories, sweetened tea or coffee, and hard liquor, are all more likely to disagree between the two collection methods. Fruit juice, sweetened fruit juice, low fat milk, diet soft drinks, sweetened tea or coffee, and hard liquor may be categories to eliminate altogether or combine like categories to create a specific questionnaire for an athletic population.

Further investigation into the scoring process of the BEVQ-15 as compared to NDSR's nutrition output data may be warranted to evaluate for discrepancies among calorie allocation to different beverage categories. Discrepancies among the calorie calculations by each tool may account for some of the variation in the final calorie average intakes between the two methods.

This study is based upon the original work of Hedrick et al. and Davy et al.⁶ developing the BEVQ-19, which was later condensed to the BEVQ-15 and validated in a general population. Other studies have expanded on the original project to validate the questionnaire in more specific populations; one such study validated the use of the BEVQ-15 in children and adolescents⁷. In the study validating the BEVQ-15 in adolescents and children, similar results of weak correlations with the categories consumed in small amounts were found. For the adolescent/children population this meant the correlations were weak among the alcoholic beverages and sweetened coffee with milk⁷. Among the collegiate athlete population, the validity correlations were weak among the juice categories, low-fat milk, diet soda, sweetened tea/coffee, and hard liquor, which are the categories least consumed by the athletes.

Other studies modified the BEVQ-15 to assess their target population more accurately. One such study looked at the beverage intake among Hispanic pre-school children and found that the new survey was valid when compared to the original BEVQ-15, and reliable in all categories except the flavored milk and tea with or without artificial sweetener categories⁸.

Strengths

There are several strengths of this study. First, athletes from a variety of sports and two different universities are represented in the data collected and reported. Also, there was a good distribution of both males and females. Given these two strengths, the findings for this study appear to be generalizable to many NCAA Division I athletes.

Limitations

There are several limitations to this study, which are acknowledged here. The two universities where athletes were selected are both located in rural Southwest Virginia. The participants were limited to collegiate DI athletes; therefore, further work may be necessary to evaluate the generalizability of this tool for athletes across a wider spectrum of geography, age, and training intensities. Second, inter-rated reliability was not established between the three individuals who administered the 24-hour recalls and the surveys. The exact wording and style of the recalls may vary slightly between researchers. Lastly, race was not a consideration in this study nor recorded, so analyses based on cultural or racial preferences for beverage intake are not included.

CONCLUSIONS

The BEVQ-15 demonstrates acceptable levels of validity in an athlete population on 10 of the 15 categories for ounces consumed and 8 of 15 for contribution to calories consumed. When SSBs are totaled, this category demonstrates acceptable levels of validity for contribution to calories consumed but not for fluid ounces consumed. The BEVQ-15 is reliable for 14 categories of fluid ounces consumed and 12 of the categories for calories

contributed. Additional research is needed to investigate why the lower calorie and less frequently consumed beverages are neither reliable nor valid in this study. This study has shown that the BEVQ-15 would be an appropriate tool to estimate NCAA Division I collegiate athlete's habitual beverage intake patterns. This tool would be useful for large teams where the coaches are unable to examine each individual's beverage intake through a more lengthy process. The BEVQ-15 would allow the coach to accurately determine his or hers team's athletes' beverage intake in a five-minute survey and could help coaches and researchers determine possible correlations between typical beverage choices and an athlete's performance.

TABLES AND FIGURES

Table 1. Participant Characteristics

Characteristic	n	%
Participants		
Total	62	100
Men	25	40.3
Women	37	59.7
Age (yr)		
Mean age ± standard error	19.81±1.51	
BMI* Status		
Underweight	0	0
Normal Weight	57	91.9
Overweight	6	9.7
Obese	0	0
BMI Mean ± standard error	22.70±1.94	
Year of Eligibility		
Freshman	18	29
Sophomore	14	22.6
Junior	14	22.6
Senior	13	21
Graduate School	3	4.8
College Attended		
Virginia Tech	21	33.9
Radford University	41	66.1
Sport		
Tennis	10	16.7
Cross Country	10	16.7
Swimming	3	4.8
Baseball	2	3.2
Volleyball	8	12.9
Basketball	3	4.8
Dance	1	1.6
Soccer	23	37.1
Track and Field	1	1.6
Football	1	1.6
*BMI = body mass index; calculated as kg/m ²		

Table 2. Validity of BEVQ-15 as Compared to 24-hr Recall Standard, Individual Categories

Beverage Category	BEVQ-15	24-hour recall	Spearman's rho
	← mean standard error →		
Water			
oz	75.7±4.8	93.0±5.6	0.443**
100% Fruit Juice			
oz	2.4±0.5	1.3±0.5	0.212
kcal	42.0±9.3	23.0±9.1	0.212
Sweetened Fruit Juice			
oz	1.4±0.5	1.5±0.7	0.109
kcal	19.8±6.6	21.9±10.3	0.109
Whole Milk, 2% Milk			
oz	4.6±0.9	3.4±0.6	0.369**
kcal	90.5±18.2	68.2±12.4	0.363**
Low Fat Milk			
oz	1.3±0.3	0.6±0.2	0.187
kcal	15.9±3.8	7.7±2.7	0.188
Nut Milk			
oz	1.7±0.6	0.7±0.2	0.697**
kcal	2.7±2.0	6.8±2.3	0.398**
Soft Drinks, Regular			
oz	1.0±0.2	1.1±0.8	0.300*
kcal	13.0±3.2	15.2±10.7	0.298*
Energy & Sports Drinks			
oz	8.7±2.2	7.7±1.7	0.592**
kcal	122.5±31.2	107.9±23.2	0.591**
Soft Drinks, diet			
oz	0.5±0.2	0.3±0.3	-0.071
kcal	0.2±0.1	0.1±0.1	-0.071
Sweet Tea			
oz	0.7±0.3	0.6±0.6	0.317*
kcal	6.8±3.0	5.5±5.5	0.317*
Tea or coffee, black			
oz	2.9±0.6	5.0±1.0	0.343**
kcal	1.4±0.6	1.8±0.3	0.021
Tea or coffee, sweetened			
oz	4.0±0.7	0.1±0.1	0.184
kcal	20.9±4.6	0.4±0.4	0.211
Wine			
oz	0.5±0.2	0.8±0.4	0.531**
kcal	10.2±3.7	15.9±7.8	0.531**
Hard Liquor			
oz	0.2±0.1	0.0±0.0	0
kcal	16.8±6.3	0.0±0.0	0
Beer			
oz	1.2±0.3	1.8±1.1	0.500**
kcal	12.6±3.2	18.9±11.2	0.487**
*Correlation is significant at the 0.05 level			
**Correlation is significant at the 0.01 level			

Table 3. Validity of BEVQ-15 as Compared to 24-hr Recall Standard, Category Totals

Totalled Beverages	BEVQ-15	24-hour recall	Spearman's rho
	← mean standard error →		
Total Milk			
oz	7.6±1.1	4.8±0.7	0.239
kcal	109.2±18.1	82.8±12.3	0.270*
Total Alcohol			
oz	2.0±0.4	2.6±1.1	0.494**
kcal	39.6±10.1	34.9±13.3	0.443**
Total Sugar-Sweetened Beverages			
oz	15.2±2.5	5.4±1.6	0.233
kcal	185.6±33.6	61.7±19.1	0.275*
Total Beverages			
oz	108.7±6.8	118.1±5.8	0.264*
kcal	401.2±54.0	293.5±30.4	0.262*
*Correlation is significant at the 0.05 level			
**Correlation is significant at the 0.01 level			

Table 4. Reliability Between BEVQ-15 Testing Administrations

Beverage Category	Correlations (oz)	Correlations (kcal)
Water	0.558**	
100% Fruit Juice	0.804**	0.804**
Sweetened Fruit Juice	0.369**	0.369**
Whole Milk, 2% Milk	0.849**	0.849**
Low Fat Milk	0.545**	0.544**
Nut Milk	0.474**	0.13
Soft Drinks, Regular	0.444**	0.444**
Energy & Sports Drinks	0.704**	0.704**
Soft Drinks, diet	0.123	0.124
Sweet Tea	0.733**	0.733**
Tea or coffee, black	0.457**	-0.009
Tea or coffee, sweetened	0.807**	0.831**
Wine	0.851**	0.851**
Hard Liquor	0.798**	0.799**
Beer	0.760**	0.760**
Total SSBs	0.534**	0.572**
Total Beverages	0.641**	0.783**
*Correlation is significant at the 0.05 level		
**Correlation is significant at the 0.01 level		

Table 5. Linear Regression Model of BEVQ-15 vs. 24-hour Recall

Beverage Category	t value	Significance
Water, fl oz	2.870	0.006
Sports drinks, fl oz	2.983	0.004
Sports drinks, kcal	2.983	0.004
Total SSBs, fl oz	-0.49	0.624
Total SSBs, kcal	-1.142	0.258
Total beverages, fl oz	2.197	0.032
Total beverages, kcal	-0.905	0.369

Figure 1. Bland-Altman of Water BEVQ-15 vs. 24-hour Recall, fluid ounces

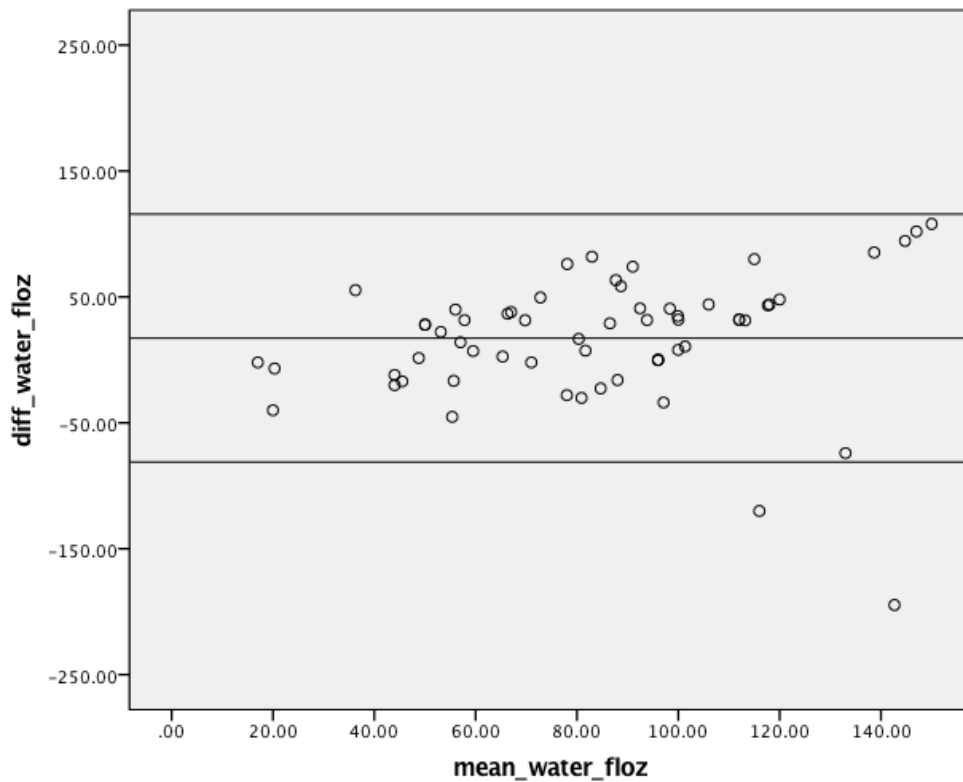


Figure 2. Bland-Altman of Energy Drinks BEVQ-15 vs. 24-hour Recall, fluid ounces

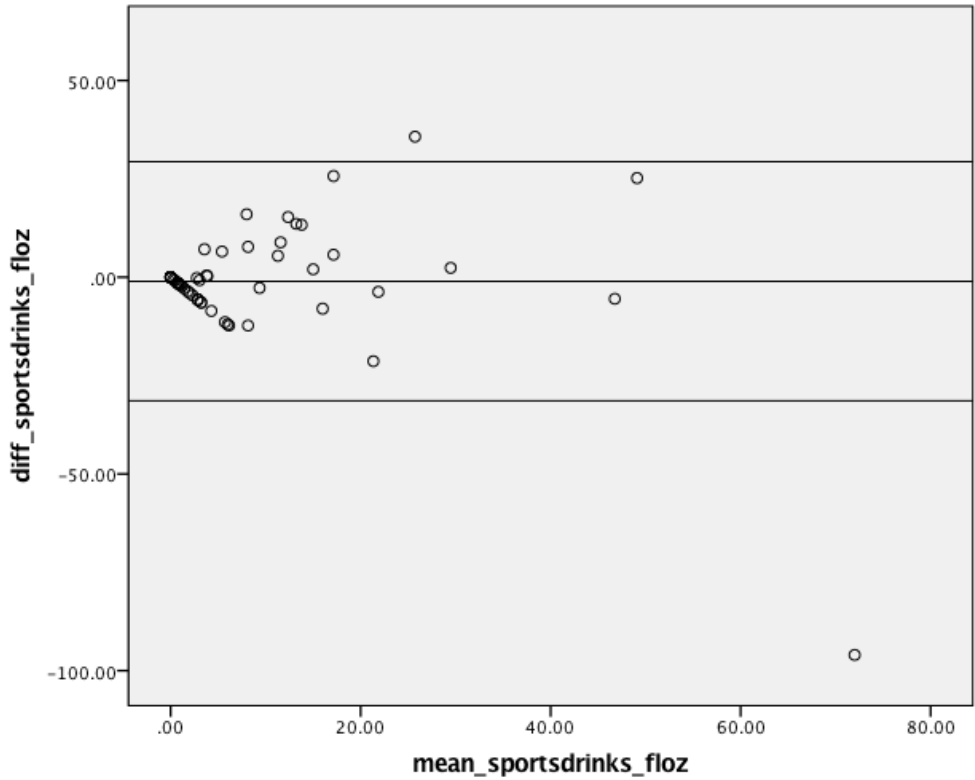


Figure 3. Bland-Altman of Energy Drinks BEVQ-15 vs. 24-hour Recall, kcal

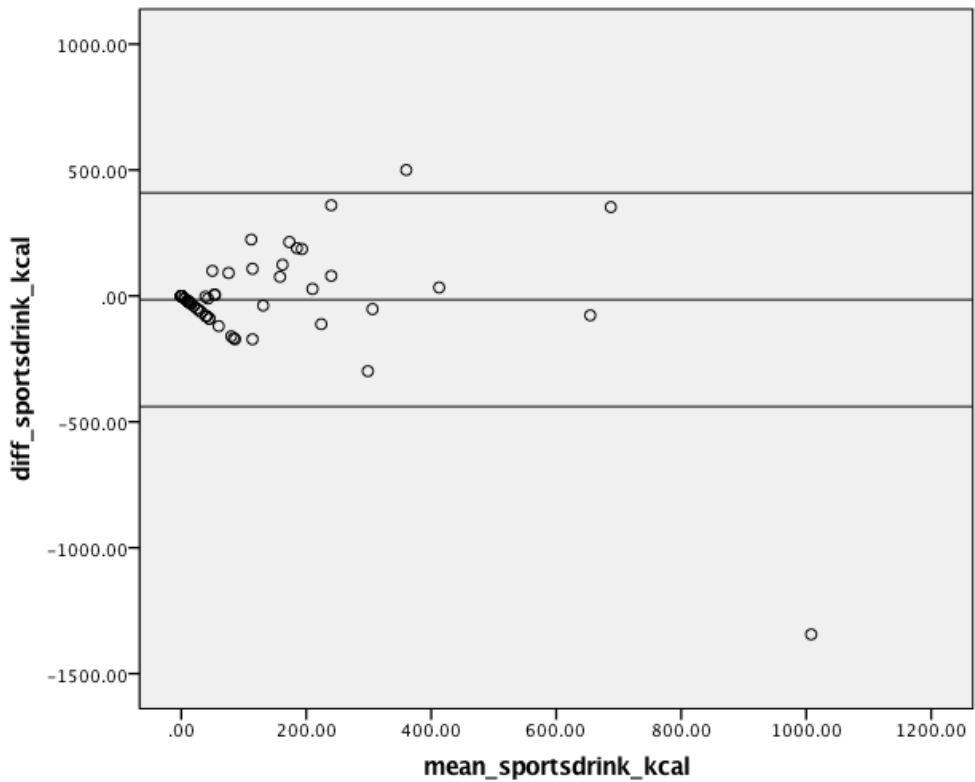


Figure 4. Bland-Altman of Total SSBs BEVQ-15 vs. 24-hour Recall, fluid ounces

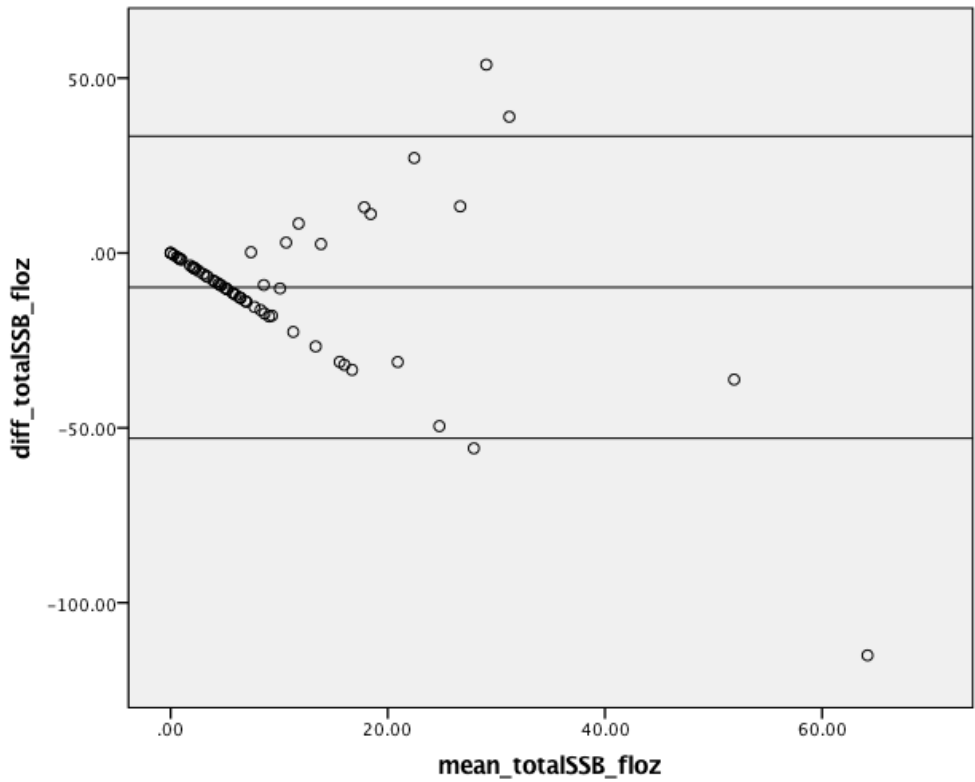


Figure 5. Bland-Altman of Total SSBs BEVQ-15 vs. 24-hour Recall, fluid ounces

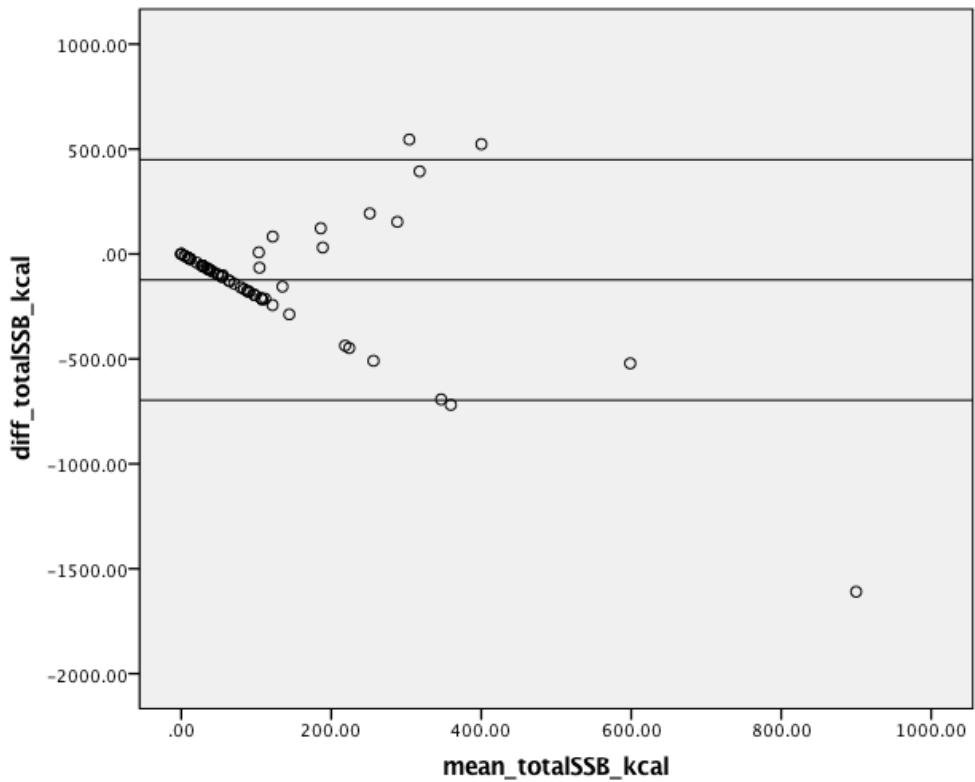


Figure 6. Bland-Altman of Total Beverages BEVQ-15 vs. 24-hour Recall, kcal

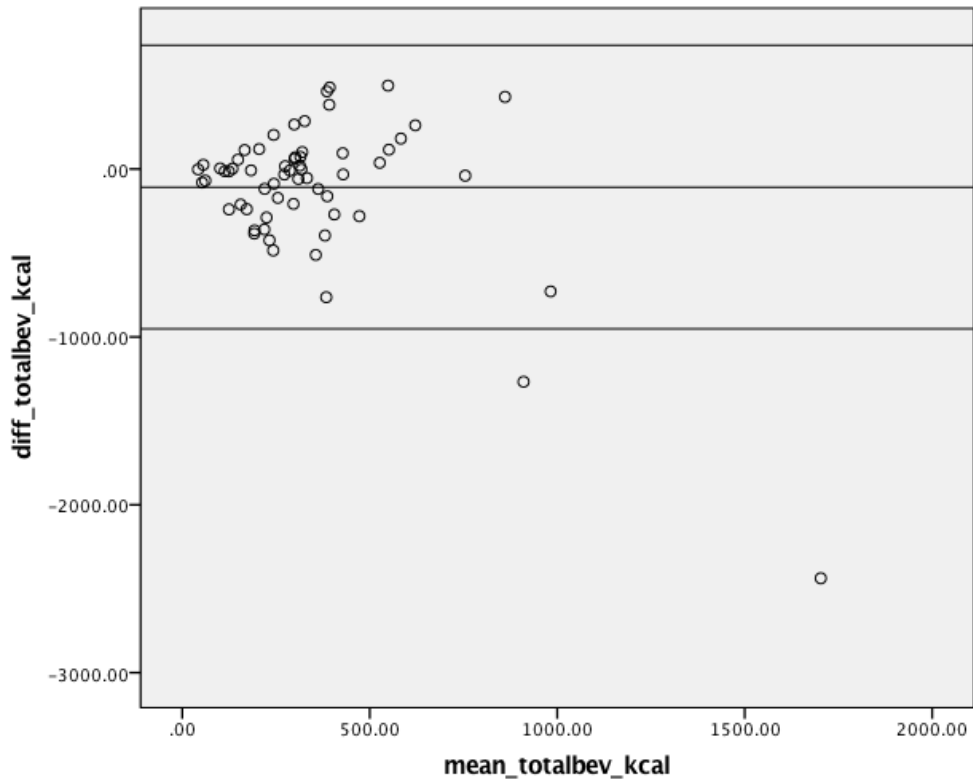


Figure 7. Bland-Altman of Total Beverage BEVQ-15 vs. 24-hour Recall, fluid ounces

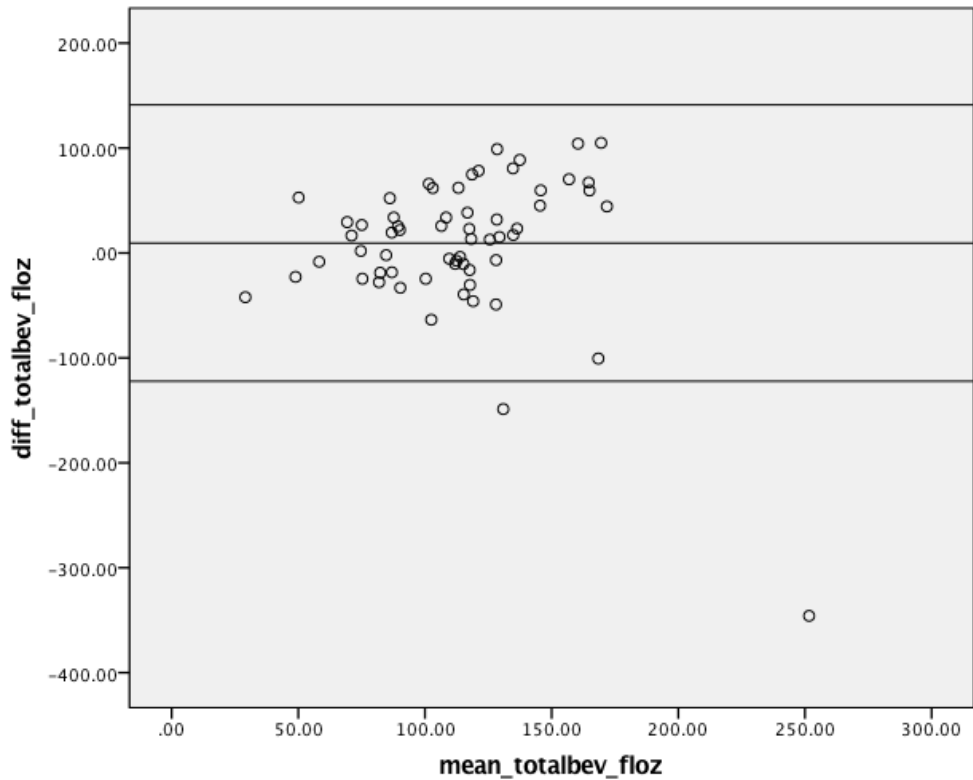


Figure 8. Percent Fluid Ounces from Beverage Categories

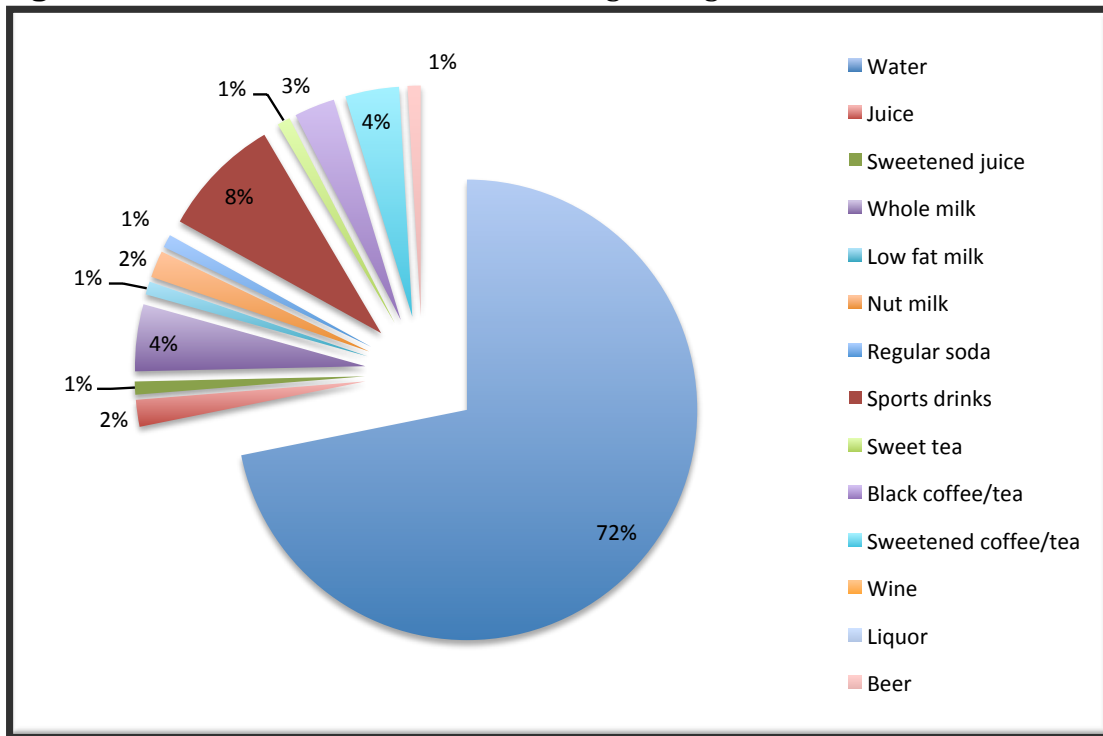
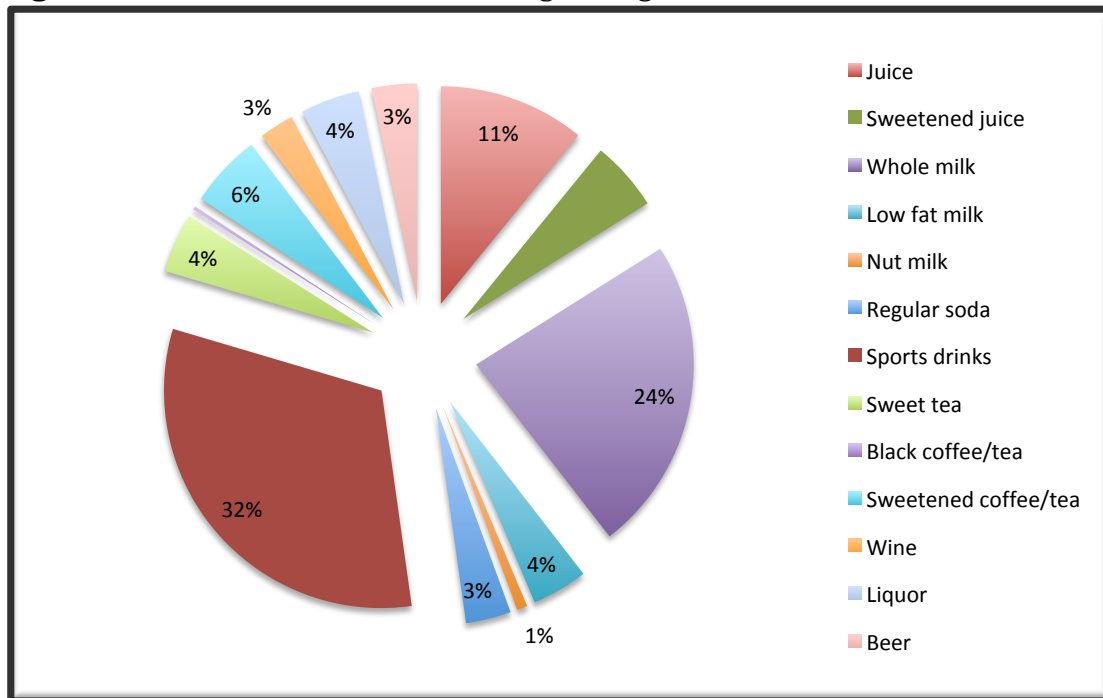


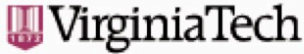
Figure 9. Percent Calories from Beverage Categories



References:

1. Mahan LK, Escott-Stump S, Raymond JL, Krause MV. *Krause's food & the nutrition care process*. 13th ed. St. Louis, Mo.: Elsevier/Saunders; 2012.
2. Hedrick VE, Savla J, Comber DL, et al. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *J Acad Nutr Diet*. 2012;112(6):840-849.
3. Hedrick VE, Comber DL, Estabrooks PA, Savla J, Davy BM. The beverage intake questionnaire: determining initial validity and reliability. *J Am Diet Assoc*. 2010;110(8):1227-1232.
4. American College of Sports M, Sawka MN, Burke LM, et al. American College of Sports Medicine position stand. Exercise and fluid replacement. *Med Sci Sports Exerc*. 2007;39(2):377-390.
5. Murray B. Hydration and physical performance. *J Am Coll Nutr*. 2007;26(5 Suppl):542S-548S.
6. Hedrick VE, Savla J, Comber DL, et al. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *J Acad Nutr Diet*. 2012;112(6):840-849.
7. Hill CE, MacDougall CR, Riebl SK, Savla J, Hedrick VE, Davy BM. Evaluation of the Relative Validity and Test-Retest Reliability of a 15-Item Beverage Intake Questionnaire in Children and Adolescents. *J Acad Nutr Diet*. 2017;117(11):1757-1766 e1755.
8. Lora KR, Davy B, Hedrick V, Ferris AM, Anderson MP, Wakefield D. Assessing Initial Validity and Reliability of a Beverage Intake Questionnaire in Hispanic Preschool-Aged Children. *J Acad Nutr Diet*. 2016;116(12):1951-1960.

APPENDIX A



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: February 3, 2017
TO: Kevin Davy, Michelle S Rockwell, Catherine Whitaker Cockrill, Brittany Ryann Thorpe, Brenda Davy
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE: Validation c Athletes  Beverage Intake and Hydration Status in Collegiate
IRB NUMBER: 17-048

Effective February 2, 2017, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at: <http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 3,4,7**
Protocol Approval Date: **February 2, 2017**
Protocol Expiration Date: **February 1, 2018**
Continuing Review Due Date*: **January 18, 2018**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

APPENDIX B

Consent Document Department of Human Nutrition, Foods and Exercise Virginia Tech

TITLE: Validation and Measurement of Hydration in College Athletes

INVESTIGATORS: Catherine W. Cockrill; Brittany Thorpe; Brenda M. Davy, PhD, RD; Michelle Rockwell, MS, RD, CSSD; and Kevin Davy, PhD

PURPOSE

The dietary habits and fluid intake of collegiate athletes are a crucial determinant of both athletic performance and overall health. However, training, travel, and school schedules in addition to financial, emotional and mental stressors associated with the collegiate environment are all barriers to optimal dietary intake. Currently, there are limited resources to accurately assess fluid intake among athletes. In addition, urine color is commonly used to identify an athlete's hydration level, but there is limited information regarding if this as an accurate measure of hydration status. The the purpose of the present study is to determine: 1) the accuracy of a beverage intake questionnaire called the BEVQ15 and 2) if urine color is an accurate measure of hydration status. Sixty college athletes, aged 18 years and older will be studied.

You will be asked to complete a dietary intake recall three times, a beverage intake questionnaire two times, and provide two pre-practice urine samples over a two-week period.

PROCEDURES

You will be required to attend three in person testing sessions within two weeks in a team meeting room or another location (e.g., media room) in the Dedmon Center for Radford athletes or in the Merriman Athletic Facility for Virginia Tech athletes.

Session 1 and 2 (Time Commitment ~ 1.5 hour)

General Information Questionnaire: You will be asked to complete a questionnaire which includes information about your age, sex, year of eligibility, sport, and role on your team. You will only complete this questionnaire one time.

Body Weight/Height: Your weight will be measured on a digital scale and will include the weight of light indoor clothing without your shoes. Your height will be measured using a stadiometer (ruler on the wall).

Dietary intake analysis (24-hour recall): You will be asked you to recall all the food and beverages you consumed in the previous 24-hour period.

Beverage Questionnaire: You will complete a short food frequency questionnaire specifically asking about your usual beverage consumption.

Urine Collection: You will be asked to provide a 2-3 teaspoon urine sample in a cup provided approximately 20 min before practice. The color of your urine will be assessed using a chart and the urine specific gravity (the amount of particles dissolved in your urine) will also be measured using a handheld device called a refractometer.

The total time commitment for session 1 and 2 will be approximately XX

Session 3: (Time Commitment ~1 hour)

Dietary intake analysis (24-hour recall): You will be asked you to recall all the food and beverages you consumed in the previous 24-hour period.

The total time commitment for this study will be ~2.5 hours.

SUMMARY OF SUBJECT RESPONSIBILITIES

- Be on time and attend all scheduled sessions.
- Follow all participant instructions for each session.

RISKS OF PARTICIPATION

- **Dietary Intake Assessment:** As part of a complete dietary intake assessment you will be asked to report any alcohol you may have consumed. This information is confidential and will not be shared with anyone outside the research team.**Dietary intake analysis (24-hour recall):** You will be asked you to recall all the food and beverages you consumed in the previous 24-hour period.
- It is not possible to identify all potential risks. However, the staff will take all possible safeguards to minimize any known and potential risks to your well-being. All of the procedures are will established and used routinely in the investigator's laboratory.

EFFORTS TO REDUCE RISKS

- **Alcohol Intake for Those under the Age of 21:** Dietary intake information will be collected using study participant identification codes and will not be associated with your name. Therefore, this risk is minimal.

BENEFITS OF PARTICIPATION

Your participation will provide you with:

- A detailed nutritional analysis of your food and beverage consumption
- Information on your hydration status

CONFIDENTIALITY

The data from this study will be kept strictly confidential. No identifiable data will be released to anyone but those working on the project. Subject numbers without anything to identify your name will identify data. De-identified team and overall summary results may be shared with coaches, sports medicine staff, athletic directors, and other members of the Virginia Tech and/or Radford athletic departments.

FREEDOM TO WITHDRAW

You are free to withdraw from the study at any time for any reason. Simply inform the researchers of your intention to cease participation. Circumstances may come up that the researcher will determine that you should not continue as a subject in the study. For example, lack of compliance to instructions, failure to attend testing sessions and illness could be reasons for the researchers to stop your participation in the study.

INJURY DURING PARTICIPATION

Neither the researchers nor the university have money aside to pay for medical treatment that would be necessary if injured as a result of your participation in this study. Any expenses that you incur including emergencies and long-term expenses would be your own responsibility.

You should consider this limitation before you consider participating in this study.

APPROVAL OF RESEARCH

This research has been authorized, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Tech, and by the Department of Human Nutrition, Foods and Exercise. You will receive a copy of this form to take with you.

SUBJECT PERMISSION

I have read the informed consent and fully understand the procedures and conditions of the project. I have had all my questions answered, and I hereby give my voluntary consent to be a participant in this research study. I agree to abide by the rules of the project. I understand that I may withdraw at any time.

If you have any questions, you may contact:

- Principal Investigators: Catherine Cockrill, Master's Student, Department of Human Nutrition, Foods, and Exercise. (571) 271-9308 (cell) OR Brittany Thorpe, Master's Student, Department of Human Nutrition, Foods, and Exercise. (810) 965-4845 (cell).
- Advisor: Kevin Davy, PhD, Professor, Department of Human Nutrition, Foods, and Exercise. (540) 231-3487.
- Chairman, VT Institutional Review Board for Research Involving Human Subjects: David Moore (540) 231-4991

Name of Subject (please print)_____

Signature of Subject _____ **Date** _____

Name of Person Obtaining Consent (print) _____

Signature of Person Obtaining Consent _____ **Date** _____

APPENDIX C

**Virginia Tech
Department of Human Nutrition, Foods, and Exercise**

Athlete Anthropometric & General Information Data Collection Form

SUBJECT ID # _____

DATE _____

TIMEPOINT(1st or 2nd visit): _____

Age: _____

Sex: _____

Sport: _____

Year of Eligibility (Freshmen, Sophomore, etc): _____

How would you classify your current role on the team (Circle 1)?

Starter

Regular Substitute

Sporadic Substitute

Bench/Practice Player

Classification Definitions:

Starter- Starts and plays majority of games/matches.

Regular Substitute- Makes an appearance in >50% of games/matches.

Sporadic Substitute- Makes an appearance in <50% but >5% of games/matches.

Bench/Practice Player- Makes appearances in ≤5% of games/matches or is a (nonmedical) redshirt.

To Be Completed By Research Staff:

Height (cm): _____

Weight (kg): _____

BMI (kg/m²): _____

Research Staff Initials: _____

APPENDIX D

Beverage Questionnaire (BEVQ-15)

Participant ID: _____

Instructions:

Date: _____

- For the past month, please indicate your intake for each beverage type by marking an "X" in the bubble for "how often" and "how much each time".
1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.
 2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under "how much each time". If applicable, indicate the specific type of beverage by marking an "X" in the bubble by the one used (i.e., type of nut milk).
 3. When trying to estimate your intake throughout the day, (i.e., water) think about the total amount you drink. For example, 3 times per day and 20 fl oz each time = 60 fl oz per day. If you consume more 60 fl oz per day select "1 time per day" and write the total amount in the last column.
 4. Do not count beverages used in cooking or other preparations, such as milk in cereal.
 5. Count milk/creamer added to tea and coffee in the tea or coffee with creamer beverage category, NOT in the milk categories; this includes non-dairy creamer. Please indicate the type of creamer and sweetener used by marking an "X" in the bubble by the one used, if applicable.

Type of Beverage	HOW OFTEN (MARK ONE)							HOW MUCH EACH TIME (MARK ONE)					
	Never or less than 1 time per week (go to next beverage)	1 time per week	2-3 times per week	4-6 times per week	1 time per day	2 times per day	3+ times per day	Less than 6 fl oz (¾ cup)	8 fl oz (1 cup)	12 fl oz (1½ cups)	16 fl oz (2 cups)	20 fl oz (2½ cups)	More than 20 fl oz (specify amount below)
Water or unsweetened sparkling water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
100% Fruit Juice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Sweetened Juice Beverage/Drink (fruit punch, juice cocktail, Sunny Delight, Capri Sun)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Whole Milk: red cap, Reduced Fat Milk 2%: purple cap, or Chocolate Milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Low Fat 1%: green cap, Fat Free/Skim Milk: light blue cap, Buttermilk or Soy Milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Nut Milk (almond, cashew, coconut) <input type="radio"/> Flavored, Original, or Plain <input type="radio"/> Unsweetened	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Soft Drinks, Regular	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Energy & Sports Drinks, Regular (Red Bull, Gatorade, Powerade)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Diet or Artificially Sweetened Soft Drinks, Energy & Sports Drinks (Diet Coke, Crystal Light, artificially sweetened sparkling water, Sugar-Free or Total Zero Red Bull, Powerade Zero)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Sweet Tea (with sugar)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Tea or Coffee, black (no creamer or milk) <input type="radio"/> Sugar, <input type="radio"/> Artificial Sweetener, <input type="radio"/> N/A	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Tea or Coffee (with creamer) <input type="radio"/> Sugar <input type="radio"/> Artificial Sweetener <input type="radio"/> N/A <input type="radio"/> Milk <input type="radio"/> Half & Half or Cream <input type="radio"/> N/A Creamer: <input type="radio"/> Flavored <input type="radio"/> Reg. <input type="radio"/> Sugar-Free <input type="radio"/> N/A	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Wine (red or white)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Hard Liquor (vodka, rum, tequila, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____
Other (list): _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____

Virginia Tech, 2016.

APPENDIX E

Expanded Methods

Participants and Design

Participants for this study will be recruited via email and flyers distributed to NCAA sports teams at Virginia Tech and Radford and their members after approval from the Athletics Department and the teams' coaches. The inclusion criteria encompass both men and women 18 years of age and older who are members of a Virginia Tech or Radford University NCAA intercollegiate athletic team. Those experiencing an injury or acute illness that precludes their participation in regular training and or competition will be excluded from this study. There are currently no valid tools for assessing beverage intake amongst collegiate athletes, which gave cause to study this specific set of individuals. The Virginia Tech and Radford Institution Review Boards both approved the study protocol as well as the athletic departments. The Athletics Department also approved the study protocol for their athletes' participation. Written and verbal informed consent will be obtained from all the participants. Study ID's will be used on all forms following the consent document to de-identify the data and consent forms will be locked in a separate location from the subject files.

Procedures

After informed consent forms are collected the participant's will be brought in for three remaining sessions. During the first session subjects will complete a general information form, which includes anthropometric measurements such as height, weight, and BMI. This form also includes the participant's age, gender, team sport to which the subject belongs, and year of eligibility within the sport. Subjects will be interviewed in person by a trained diet technician to assess and record their 24-hour dietary intake of the

previous day. On the same day as the first in person interview a beverage questionnaire (BEVQ-15) will be administered in a group setting. The participants will complete the short food frequency questionnaire specifically addressing habitual beverage consumption over the previous 30 days. The trained diet technician will meet with the participant two additional times in person over the following two weeks to acquire three total 24-hour dietary recalls to include one weekend day and two weekdays. The participants will complete a second BEVQ-15 on either the second or third interview session. The dietary data will be analyzed using NDS-R version 2013 (University of Minnesota, Minneapolis MN).

The participants will provide a midstream urine sample of 2-3 teaspoons using a collection cup for urine specific gravity (USG) and urine color assessment by the researchers. Urine collection will occur within 20 minutes of the onset of the participant's team practice. Two urine samples will be collected over the course of the study, once at the first interview session and will be repeated at the conclusion of the study. USG will be measured using a pocket refractometer. Urine color will be analyzed using the eight-point color chart developed by Armstrong (1994). The participant will analyze their own urine sample against Armstrong's color chart and record their observation without the researcher knowing the participant's choice. The researcher will then analyze the participant's urine sample using the same color chart and record their observation.

Statistical Analysis

Statistical analyses will be performed using the statistical analysis software SPSS (v. 24 for Mac OS, 2016, SPSS, Chicago, IL). The descriptive statistics (mean \pm standard error of the mean; frequencies) will be reported as an average of the total consumption across the beverage categories in both grams and kilocalories for the given sports and gender demographics. To assess the validity of the BEVQ-15 in an athlete population, the responses from the questionnaire will be compared to the results gained from the 24-hour recall in a paired sample t-test. This t-test will compare the energy intake in kilocalories and the grams of specific beverages consumed between the two assessment tools. Pearson correlational analyses will assess any correlations among variables. Bland-Altman analysis will be used to assess the limits of agreement between the two measures.

APPENDIX F

